CROP SCIENCE SOCIETY OF NIGERIA (CSSN)

BAYERO UNIVERSITY, KANO (BUK)

9th NATIONAL CONFERENCE & ANNUAL GENERAL MEETING

BOOK OF PROCEEDING

Theme: **"Transforming Crop Production in the Face of Insecurity and Economic Crisis: Challenges and Opportunities".**

13th - 18th October, 2024

Faculty of Agriculture Bayero University Kano

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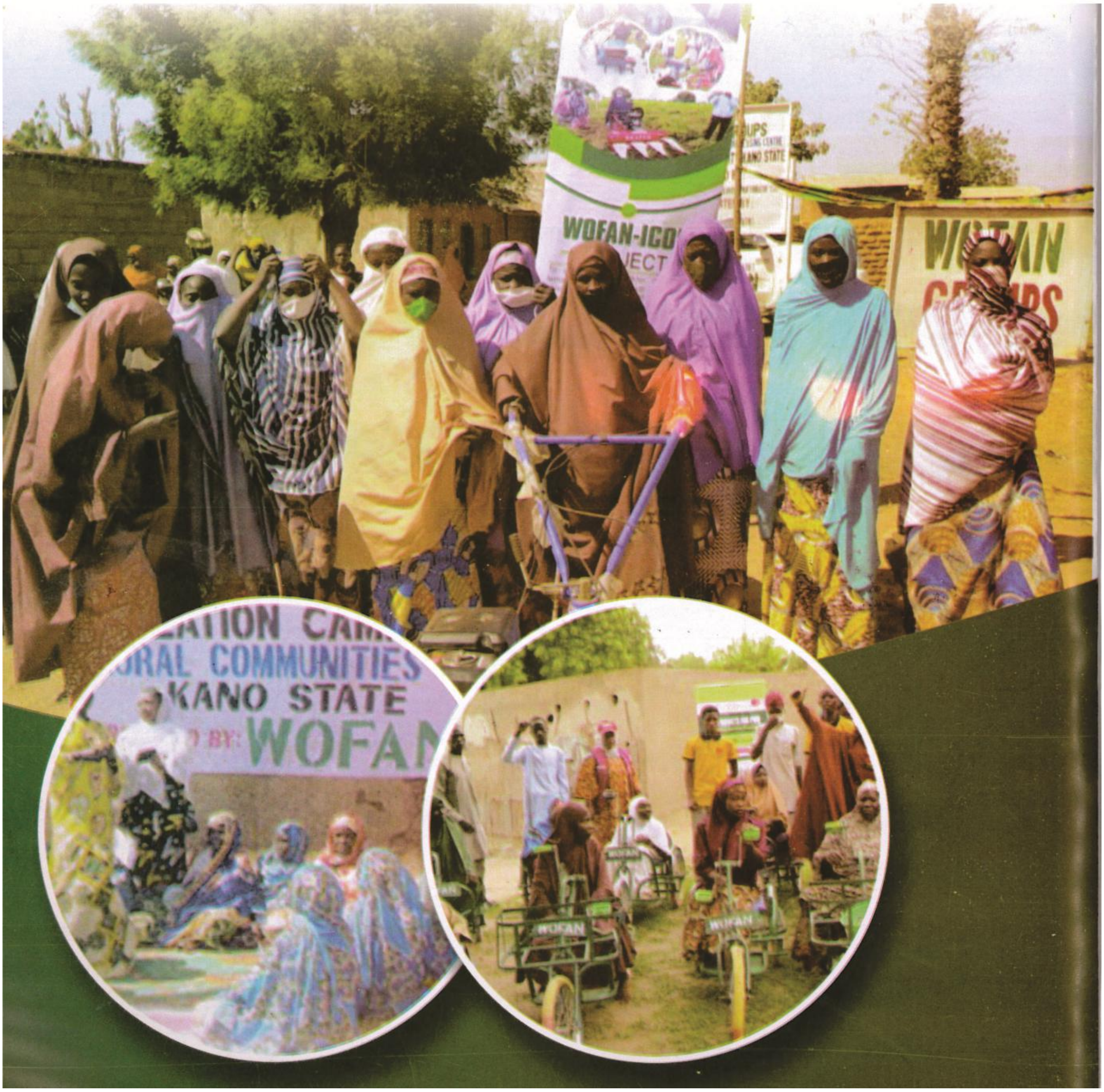
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WELCOME ADDRESS BY THE DEAN, FACULTY OF AGRICULTURE, AT THE OPENING CEREMONY OF THE 9TH NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING OF THE CROP SCIENCE SOCIETY OF NIGERIA HELD AT BAYERO UNIVERSITY, KANO ON 14TH OCTOBER, 2024

Ladies and gentlemen, distinguished guests, esteemed members of the Crop Science Society of Nigeria, and fellow stakeholders in the agricultural sector; on behalf of the Local Organizing Committee and the Faculty of Agriculture, Bayero University Kano, I am honoured to welcome you to the 9th National Conference and Annual General Meeting of the Crop Science Society of Nigeria.

The Theme of the Conference is "Transforming Crop Production in the Face of Insecurity and Economic Crisis: Challenges and Opportunities"

We are gathered here today to share knowledge, innovations, and best practices in crop science, with the ultimate goal of enhancing food security, sustainable agriculture, and national development.

I extend special gratitude to:

- The President and Executive Council of the Crop Science Society of Nigeria

- Our Special Guests, Keynote Speakers and Panelists

- Participants from across Nigeria and beyond

- Our sponsors and partners

Mr Chairman, permit me to say a few words about our Faculty. The Faculty was established in the year 2001 after receiving approval of the National Universities Commission (NUC) in August 2001 and a financial support from MacArthur Foundation. For initial take off, the Faculty started with three (3) Departments i.e. Department of Agricultural Economics and Extension, Department of Agronomy and Department of Animal Science. In May 2002, a set of one hundred and nine (109) pioneer students were admitted into the 100 level of the new Faculty of Agriculture for a five (5) year B. Agriculture Degree programme. In 2009, Department of Agronomy was split into Agronomy, Soil Science and Crop Protection Departments; while in 2016, three (3) other new Departments i.e. Fisheries and Aquaculture, Food Science and Technology, and Forestry and Wildlife were established. Thus, currently the Faculty has eight (8) Departments, and is running five (5) undergraduate degree programmes as follows;

1. B. Agriculture
2. B. Fisheries and Aquaculture
3. B. Food science and Technology
4. B. Forestry and Wildlife Management
5. B. Sc Agricultural Extension

In addition, the Departments are offering postgraduate courses (PGD, M. Sc and Ph.D) in various areas of specialization.

As per the end of last session we had a total enrolment of 1977 undergraduate students (676 female and 1301 male) and 374 postgraduate students (110 female and 264 male) with a staff strength of 205 (32 female and 173 male).

In line with the objectives of Bayero University, Kano for a higher level training, the University established the Centre for Dryland Agriculture (CDA) in 2012 to produce highly skilled manpower and research products that will address the challenges of agricultural development, especially within the West and Central Africa dryland areas, and expand capacity to deal with the regional issues of food security, natural resources management, climate change, livelihoods, and the broader development challenges. The University mobilized human and material resources and provided the necessary support for the Centre to take-off. An initial grant from MacArthur Foundation facilitated the smooth take-off of the Centre. In 2014, the Centre won a grant to specialize as a regional Centre of excellence under the ACE (Africa Centre of Excellence) I project of the World Bank. The grant provided the Centre with an opportunity to upgrade its teaching and learning facilities and train staff to acquire key competences. The Centre won another grant in 2018 from the World Bank under the ACE Impact Project and many other grants which have justified its position as a Centre of Excellence.

In 2022 the Faculty was designated as a TETFund Centre of Excellence (CEO) in Sustainable Food Systems and Products. The goal of the Centre is to address the challenges in food systems through harnessing partnerships, trainings, entrepreneurship, and productivity for sustainable food security in Nigeria. It is a partnership with FARA (Forum for Agricultural Research in

Africa) under the ARIFA (Agricultural Research and Innovation Fellowship for Africa) initiative.

Let me say that this Conference is the 6th time the Faculty of Agriculture is hosting a National Conference of Agricultural Societies since establishment in 2001.

Over the next few days, we will engage in plenary sessions, technical presentations, and interactive discussions focused on:

i. *Crop Germplasm Resource Harnessing and Utilization for Improved Crop Production.*
ii. *Smart Crop Production Technologies for Resilience and Adaptation to Climate Change.*
iii. *Appropriate Mechanization for Transforming Crop Production.*
iv. *Crop-Livestock Integration: A strategy for Improved Agricultural Production and Healthy Environment Sustainability.*
v. *Modern Approaches in Integrated Soil, Pests and Diseases Management for Sustainable Crop Production and Food Security.*
vi. *Improved Handling Practices and Value Addition for Reduction of Postharvest Losses and Income Generation.*
vii. *Value Chain and Advisory Services through Digital Innovations and Climate-Smart Technologies.*
viii. *Forestry Practices and their Impacts on Crop Productivity.*
ix. *Gender Mainstreaming for Improved Crop Production*

This Conference offers a unique opportunity for networking, collaboration, and capacity building among researchers, policymakers, farmers, and industry stakeholders.

I would like to express our profound gratitude to the management of Bayero University Kano, particularly the Vice Chancellor Professor Sagir Adamu Abbas for accepting to host this Conference. We are indeed grateful for the tremendous support we received from our sponsors which enabled us to be where we are today. Similarly, I would like to thank the Local Organizing Committee of the Conference under the leadership of Professor B. M. Auwalu for working tirelessly to make this conference a reality. Their efforts towards successful hosting of the 9th Conference is highly commendable. Finally, I would like to thank all members of the

Crop Science Society of Nigeria for sparing their time to attend this conference particularly at this very trying moment.

Distinguished Ladies and Gentlemen, I thank you for listening and I wish you fruitful deliberations and a memorable stay in Kano.

Thank you.

Prof M. A. Hussaini
Dean
Faculty of Agriculture
Bayero University, Kano
October 14th, 2024

WELCOME ADDRESS PRESENTED BY THE VICE CHANCELLOR BAYERO UNIVERSITY KANO PROFESSOR SAGIR ADAMU ABBAS *FMAN* AT THE 9TH NATIONAL CONFERENCE OF THE CROP SCIENCE SOCIETY OF NIGERIA (CSSN) HELD AT BAYERO UNIVERSITY, KANO FROM 13TH TO 16TH OCTOBER 2024

PROTOCOL

Your Excellency, the Executive Governor of Kano State, Engineer Abba Kabir Yusuf,

The Honourable Minister of Agriculture and Food Security and Guest Speaker, Senator Abubakar Kyari CON,

The Chairman of the Occasion, Honourable Munir Babba DanAgundi,

The Keynote Speaker and Vice Chancellor Capital City University, Kano, Professor Yusuf B. Daraja,

The Lead Paper Presenter and Director General, National Agricultural Seed Council, Abuja, Dr. Ishiak Othman Khalid,

The Lead Paper Presenter and Executive Director, Women Farmers Advancement Network (WOFAN), Hajia Dr. Salamatu Garba,

The President-in-Council, CSSN, Prof. M. I. Uguru,

Members of NEC, CSSN,

The Dean of Agriculture, and other Deans and Directors,

Members of LOC,

Members of CSSN,

Invited Guests,

Staff and Students of BUK,

Members of the Press,

Distinguished Ladies and Gentlemen,

Good morning!!!

Dear distinguished guests, esteemed members of the Crop Science Society of Nigeria, and fellow stakeholders in the agricultural sector, I am honoured to welcome you to the 9th Annual Conference of our great Society. This Conference provides a unique platform for us to share knowledge, ideas, and experiences on the latest developments in crop science, with the ultimate goal of improving food security, nutrition, and sustainable agricultural practices in Nigeria. Over the next few days, we will engage in plenary sessions, technical presentations, and networking opportunities that will stimulate innovative solutions to the challenges facing our Country. Our theme, "**Transforming Crop Production in the Face of Insecurity and Economic Crisis: Challenges and Opportunities"**, reflects our commitment to addressing the complex issues affecting crop production, processing, and marketing in Nigeria. I would like to express my gratitude to our keynote speaker, lead paper presenters, and all participants for their contributions to this Conference. Your expertise and insights are invaluable to our collective progress. Let us work together to advance the frontiers of crop science in Nigeria and beyond.

The Faculty of Agriculture and the Centre for Dryland Agriculture (African Centre of Excellence) are among our vibrant units in Bayero University. They have been forefront in the generation of agricultural technologies for increased productivity and food security.

I would like to conclude this address by acknowledging once more all institutions and individuals for their significant financial contributions that made this Conference a great success.

Mr. Chairman Sir, Your Excellency, Distinguished participants, ladies and gentlemen, many thanks indeed for your attention.

Prof. S. A. Abbas
Vice Chancellor, BUK

WELCOME ADDRESS PRESENTED BY THE PRESIDENT, CROP SCIENCE SOCIETY OF NIGERIA, PROFESSOR M. I. UGURU AT THE 9TH NATIONAL CONFERENCE OF THE CROP SCIENCE SOCIETY OF NIGERIA (CSSN) HELD AT BAYERO UNIVERSITY, KANO FROM 13TH TO 16TH OCTOBER 2024

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Your Excellency, the Executive Governor of Kano State, Engineer Abba Kabir Yusuf,

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The Chief Host and Vice Chancellor, Bayero University, Kano, Professor Sagir Adamu Abbas *FMAN*

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Members of LOC,

Members of CSSN,

Invited Guests,

Staff and Students of BUK,

Members of the Press,

Distinguished Ladies and Gentlemen,

Good morning!!!

I am extremely glad to welcome all of you to the 9th National Conference of the Crop Science Society of Nigeria. To be frank, I never knew that this conference will hold this year because of the extreme conditions we have found ourselves in our dear country. Lo and behold, we are gathered here in our numbers irrespective of the difficult circumstances. I must sincerely appreciate the sacrifice you have made.

The entire members of the Society are grateful to the administration of Bayero University, Kano (BUK) for availing us space and the facilities for this year's meeting. Our thanks go especially to the Vice Chancellor, Professor Sagir Adamu Abbas *FMAN* who has not only approved the use of the University facilities but has also spared some time to be physical present at the opening ceremony. We sincerely welcome His Excellency, The Executive Governor of Kano State, His Excellency Abba Kabir Yusuf and his entourage to the opening ceremony of the Conference. The Society is aware of the noble strides; the Executive Governor is making in Agriculture in Kano State. The great achievement by the Kano State Agro-Pastoral Development Project in poverty reduction and strengthening food and nutrition security of vulnerable population is commendable. Honour must be given to whom honour is due. It is therefore not surprising that His Excellency is the one recommended for this year's award of excellence. Similarly, the Executive Director of WOFAN, Hajia Dr. Salamatu Garba is recommended for the Merit of Excellent award for the advancement of women and vulnerable youth in Agriculture.

I would like to thank all the members of the Local Organizing Committee (LOC) for being able to organise this year's Conference in spite of all the odds and challenges. The support of the Dean of the Faculty of Agriculture, Bayero University, Kano is highly acknowledged.

The current global food crisis has hit our Country hard. Food prices have soared and many communities are facing acute food shortages. There are discernible signs of Starvation and malnutrition in Nigeria. The solution to this challenge is to increase crop and animal production at both local and national levels. Food importation cannot resolve the current food scarcity. We have to brace up and contend with this monster head long. Therefore, this Conference is timely as CSSN is occupying a pivotal position to reverse the trend with new agricultural technologies. Research papers on these new technologies tailored towards improving crop yield per unit area will be presented during this year's conference.

Government agencies, researchers and farmers will benefit from such research works. The representatives of the relevant government institutions should harness the wealth of knowledge that will be shared during the technical session. It is important to state at this point that the current economic down turn in Nigeria will be resolved if the government can pay honest attention to Crop Agriculture. Poverty and unemployment will disappear; youth restiveness will become a thing of the past as many of them will be meaningfully engaged. Many of the industries in Nigeria are crop-based. Their abysmal failure to perform in recent years is largely due to lack of raw materials (i.e farm produce). A clear example is the sudden rise in prices of poultry products due to inadequate production of Maize. It is sad and embarrassing that Nigerian with huge human and land resources is unable to produce maize to feed the local industries.

I think we need to do something and very quickly too. We cannot neglect Crop Agriculture which used to be the main stay of the economy in 1960s and at the same time, hope to feed our industries and citizens. Policies must therefore be redirected to favour Crop Agriculture. Now is the time to act. The starting point is to accord some recognition to those entrusted with the science and skill of crop production. For instance, the establishment of Nigerian Institute of Crop Science and Food Production is long overdue. Such a body will help to co-ordinate the necessary measures required for increased and sustained crop production. It is the absence of such a body that has kept and will continue to keep the agricultural status of Nigeria on the lower rungs of the ladder. I therefore implore our guests particularly His Excellency to add his voice to this proposition with a view to establishing the Nigerian Institute of Crop Science and Food Production. The establishment of the Institute will change the agricultural landscape of Nigeria for the better and will add to the score card of the ruling party.

I appreciate and thank the following institutions and individuals for their significant financial contributions that made this Conference a great success:

1. Women Farmers Advancement Network
2. Federal Ministry of Agriculture and Food Security
3. Bayero University, Kano
4. Centre for Dryland Agriculture
5. Yusuf Maitama University, Kano
6. Alhaji Ahmed Idris, Ajiyan Hausa
7. Kano State Agro-Pastoral Development Project
8. Alhaji Salmanu Tukur

9. Federal University of Kashere
10. Rahama Integrated Farms
11. Humane Agrovet
12. OCP Africa
13. Value Seeds
14. Silvex International
15. Sasakawa Africa Association
16. Federal College of Agricultural Produce Technology, Kano
17. Audu Bako College of Agriculture, Dambatta
18. Bayero University Microfinance Bank
19. Katsina State Government
20. National Agency for the Great Green Wall

I would like to conclude this address by acknowledging once more the huge support by the Vice Chancellor of this great University. I admire the courage, doggedness and hard work of the members of the LOC.

Mr. Chairman Sir, Your Excellency, Distinguished participants, ladies and gentlemen, I thank you immensely for your attention.

Prof. M. I. Uguru
National President.

KEYNOTE ADDRESS DELIVERED BY THE HON. MINISTER OF AGRICULTURE AND FOOD SECURITY, SEN. ABUBAKAR KYARI, CON AT THE 9TH ANNUAL CONFERENCE OF THE CROP SCIENCE SOCIETY OF NIGERIA HELD AT BAYERO UNIVERSITY KANO (BUK), KANO STATE ON 14TH OCTOBER, 2024.

Theme: "Climate Change and Nigerian's Food Security: The Role Of Federal Ministry of Agriculture and Food Security"

I am honoured to be part of this esteemed gathering at the 9th Annual Conference of the Crop Science Society of Nigeria. The conference theme is particularly timely, given the pressing challenges facing agricultural development globally. Climate change has wrought havoc on crop production worldwide, exacerbating food insecurity, especially in Africa and other developing regions. The converging challenges of climate change and the global economic downturn have created a perfect storm, triggering soaring prices, severely impacting agricultural production, and putting our most vulnerable citizens at risk of extreme hardship.

In recent years, the COVID-19 pandemic has severely disrupted supply chains, causing widespread shortages and price hikes. Concurrently, climate change has unleashed unpredictable weather patterns, including droughts, floods, and torrential rains, which have ravaged crops and livestock, destroying farmers' hard work and imperiling food availability. This in turn has exacerbated poverty and malnutrition, affecting a significant portion of the population in the sub-region, further entrenching vulnerability and food insecurity.

Meanwhile, Nigeria has enormous potential for Agricultural production with vast arable land, fertile soils, favourable weather and climate and the teeming population to produce food that feeds ourselves and the entire West African sub-region if these potentials are effectively harnessed.

The Federal Ministry of Agriculture and Food Security has been the driving force behind Nigeria's agricultural transformation, with consistent investments in agricultural value chains and the promotion of a resilient food system. In partnership with state governments, the private sector, stakeholders, and development partners, the Ministry has been working diligently to address various aspects of the agricultural sub-sector, ensuring sustainable agricultural development and a robust food production system in the country.

To mitigate the impacts of climate change and food insecurity, the Federal Government of Nigeria is taking decisive action through the following initiatives:

1. Investing in Agricultural Research and Development to boost productivity, increase yields, and develop climate-resilient crop varieties suitable to Nigerian conditions.
2. Promoting climate-resilient agriculture by supporting drought-tolerant crops and innovative farming practices.
3. Empowering smallholder farmers through subsidies, training, and market access to enhance their productivity and livelihoods.
4. Establishing effective early warning systems to predict and prepare for climate-related disasters and pest outbreaks.
5. Encouraging private sector investment in agricultural infrastructure, processing, and storage to enhance efficiency and reduce losses.
6. Implementing policies to minimize post-harvest losses and ensure food safety, thereby reducing waste and ensuring a stable food supply.

In response to the current demand gap, the Federal Government of Nigeria introduced a 150-day duty-free importation window in July 2024, applicable for certain commodities through land and sea borders. Under the agreement imported food commodities, including Maize, Husked Brown Rice, Wheat and Cowpea, will be subjected to a Recommended Retail Price (RRP). The importation by the private sector of 250,000 metric tons of Wheat and 250,000 metric tons of Maize at their semi-process stage will target supplies to small-scale processors and millers nationwide.

In realizing food sufficiency and sustainable agricultural productivity in Nigeria, several critical gaps need urgent attention from all stakeholders, notably in accessing affordable and efficient farm implements and spare parts, high-quality inputs such as fertilizers, seeds, and pesticides, and flexible financing options, which are vital to unlocking the full potential of Nigeria's agricultural sector and ensuring a sustainable and food-secure future.

I would like to take this opportunity to express my sincere gratitude to the Crop Science Society of Nigeria and all stakeholders present at this important gathering for your unwavering commitment to research and development and support toward the success of this conference.

Thank you for your contributions, I wish you all a productive and fruitful deliberation.

VOTE OF THANKS PRESENTED BY THE CHAIRMAN, LOCAL ORGANIZING COMMITTEE, PROFESSOR B. M. AUWALU *FHSN* AT THE 9TH NATIONAL CONFERENCE OF THE CROP SCIENCE SOCIETY OF NIGERIA (CSSN) HELD AT BAYERO UNIVERSITY, KANO FROM 13TH TO 18TH OCTOBER, 2024

Introduction

In the Name of Allah, Most Beneficent, Most Merciful. All praises are for Allah alone. We praise Him and seek for His help and beg for His forgiveness. We seek the refuge of Allah (SWT) from the evil of our souls and from the wickedness of our deeds.

May Peace and Blessing of Allah (SWT) be with you all.

Protocol

The Honourable Minister of Agriculture and Food Security and Guest Speaker, Senator Abubakar Kyari CON,

The Chairman of the Occasion, Honourable Munir Babba DanAgundi,

The Chief Host and Vice Chancellor, Bayero University, Kano, Professor Sagir Adamu Abbas *FMAN*

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Members of NEC, CSSN,

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Members of LOC,

Members of CSSN,

Invited Guests,

Staff and Students of BUK,

Members of the Press,

Distinguished Ladies and Gentlemen,

Good morning!!!

There is nothing that is easy except that which the Almighty Allah (SWT) makes it easy.

Dear esteemed guests, distinguished speakers, and fellow participants. We are grateful for your presence and contributions to the 9th National Conference of the Crop Science Society of Nigeria. I would like to thank and appreciate **all** those who contributed towards the success of this Conference. Specifically, I would like to acknowledge the following:

Allahu (SWT) for the gift of life and health to witness the successful commencement of this Conference,

The Honourable Minister of Agriculture and Food Security and Guest Speaker, Senator Abubakar Kyari CON,

The Chairman of the Occasion, Honourable Munir Babba DanAgundi,

The Chief Host and Vice Chancellor, Bayero University, Kano, Professor Sagir Adamu Abbas *FMAN*

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Members of the Press

The following institutions and individuals made significant financial contributions that made this Conference a huge success:

1. Women Farmers Advancement Network
2. Federal Ministry of Agriculture and Food Security
3. Bayero University, Kano
4. Centre for Dryland Agriculture
5. Yusuf Maitama University, Kano
6. Alhaji Ahmed Idris, Ajiyan Hausa
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17. Audu Bako College of Agriculture, Dambatta
18. Bayero University Microfinance Bank
19. Katsina State Government
20. National Agency for the Great Green Wall

Thank you all and may Peace and Blessing of Allah (SWT) be with you all.

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PLENARY PRESENTATIONS

INNOVATIVE AGRICULTURAL PRACTICES FOR RESILIENCE BUILDING IN NIGERIA'S ECONOMY AND SECURITY LANDSCAPE

YUSUF B. DARAJA, *PhD*
PROFESSOR OF AGRONOMY
(VICE CHANCELLOR, CAPITAL CITY UNIVERSITY, KANO, NIGERIA)

INTRODUCTION

Nigeria, known as the "Giant of Africa," has the continent's largest population and economy (until recently), enriched by oil, gas, and fertile land. Despite these assets, the country faces ongoing challenges, particularly in its economy and security.

Economically, Nigeria's dependence on oil, which accounts for over 90% of foreign exchange earnings, makes it vulnerable to global oil price fluctuations. Economic recessions in 2016 and 2020, exacerbated by the COVID-19 pandemic, exposed the nation's overreliance on oil. High inflation, partly driven by the depreciation of the naira, rising global prices, and poor infrastructure, continues to burden Nigerians. The country also struggles with unemployment, especially among its youth, due to a mismatch between available skills and job opportunities.

Agriculture, which employs most Nigerians, remains underdeveloped, with small-scale farmers relying on outdated techniques. Despite government efforts to diversify the economy, progress has been slow due to corruption and inefficiencies. Nigeria's rising debt levels also pose fiscal sustainability concerns.

Security-wise, the country is beset by various issues, including Boko Haram's insurgency in the northeast, armed banditry in the Northwest and North Central regions, and herders-farmers conflicts across the country. Additionally, separatist movements in the southeast and militancy in the oil-rich Niger Delta add to the instability in the country. These security problems exacerbate economic challenges, displacing people, disrupting agricultural production, and deterring investment.

Nigeria's path to progress requires economic diversification, better governance, and tackling security crises through military, dialogue, and economic measures. Only by addressing these challenges can Nigeria build a more resilient and prosperous future.

Role of agriculture in Nigeria's socio-economic development

Agriculture plays a crucial role in Nigeria's socio-economic development. It is the largest employer, providing jobs for over 70% of the population, primarily in rural areas. The sector is key to reducing unemployment, alleviating poverty, and supporting Nigeria's broader development goals. The Nigerian government has increasingly emphasized agriculture to diversify the economy away from oil dependency. Through agribusiness promotion and value-added production, agriculture has the potential to drive economic growth. It is also essential for food security, with staple crops like maize, cassava, rice, and yams being widely produced and consumed locally, reducing reliance on food imports.

Agriculture is critical for poverty alleviation, particularly for smallholder farmers who form the bulk of Nigeria's producers. With improved access to technology, markets, and services, these farmers can boost productivity, income, and living standards

Agriculture, therefore, remains central to Nigeria's socio-economic progress, offering pathways to employment, economic growth, food security, and environmental sustainability. By modernizing farming techniques, expanding value chains, and embracing sustainability, Nigeria can fully harness its agricultural potential for a prosperous future.

Current State of Agriculture in Nigeria

According to the National Bureau of Statistics in its Q4 2023 Report, Agriculture, especially crop production remains vital to Nigeria's economy, contributing around 23.86% to its GDP and serving as the largest employer, engaging about 70% of the rural population. The sector is diverse, with crop production leading, including staples like cassava, rice, sorghum, millet yams, maize, and cocoa, the latter being an essential export commodity.

Agriculture also ensures food security for Nigeria's rapidly growing population, which is expected to reach over 400 million by 2050 at the current rate of growth. Local farmers produce the bulk of food consumed, though food security remains a challenge due to climate change, insecurity, poor infrastructure, and limited access to financing for smallholder farmers.

The agricultural sector faces a myriad of challenges that threaten its sustainability and productivity. Chief among these is climate change, which is disrupting traditional farming practices worldwide. Unpredictable weather patterns, extreme temperatures, and the increasing frequency of droughts, floods, and storms are making it harder for farmers to maintain consistent yields. Droughts leads to water shortages, while excessive rainfall causes soil erosion and crop damage, significantly affecting food security.

Resource degradation is another critical issue. Agriculture relies heavily on natural resources such as soil and water, but unsustainable farming practices, including overuse of chemical fertilizers and deforestation, have led to soil fertility loss and water contamination. Improper irrigation further exacerbates the degradation of these vital resources, making lands less productive over time; this is the case with the Kano River Project, situated at Kadawa.

In many regions, insecurity poses a serious threat to agricultural activities. Conflicts, terrorism, and banditry disrupt farming operations, force farmers to abandon their land, and damage supply chains. This not only reduces agricultural output but also makes it difficult for farmers to access markets and necessary inputs like seeds and fertilizers.

The adoption of modern technology in agriculture is also limited. While advances in mechanization, precision farming, and digital tools have the potential to transform agricultural practices, many farmers are unable to access or afford these innovations. The lack of infrastructure, training, and financial support further hampers technological progress in the sector.

Post-harvest losses are another significant issue, with a substantial portion of agricultural produce being lost due to inadequate storage, poor processing facilities, and inefficient transportation systems. In many developing countries such as Nigeria, up to 40% of food produced is lost post-harvest, contributing to food insecurity and reducing farmers' income.

Pest and disease outbreaks continue to challenge agricultural productivity. Changing climatic conditions have led to the spread of pests and diseases, such as locust swarms and maize lethal necrosis and Fall Army Worms, which can devastate crops and wipe out entire harvests, further threatening food supplies.

Land tenure and fragmentation are also key challenges, particularly in regions where land ownership is insecure. Farmers without secure land rights are less likely to invest in long-term improvements like soil conservation or irrigation infrastructure. Fragmented landholdings make farm operations inefficient and limit economies of scale, making it harder for farmers to increase productivity.

Finally, inadequate infrastructure—such as poor roads, limited access to electricity, and underdeveloped irrigation systems—continues to hinder agricultural growth. Inaccessible rural areas make it difficult for farmers to transport their goods to markets, while unreliable power supply limits the use of modern farming equipment.

Resilience in Agriculture

Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt and transform in response to adverse events (OECD, 2020). Resilience in agriculture, therefore, is vital for sustaining productivity, ensuring food security, and promoting sustainability in the face of challenges like climate change and market volatility. Climate change has led to unpredictable weather patterns, such as erratic rainfall and frequent droughts, making it crucial for farmers to adopt resilient farming techniques. Methods like drought-resistant crops and efficient irrigation help maintain food production during adverse conditions.

Resilient agriculture is key to food security, ensuring a stable supply of food despite environmental shocks or market disruptions, preventing hunger, and supporting communities during crises. Economically, resilience shields farmers from market and environmental risks, enabling them to sustain their livelihoods through practices like crop rotation and sustainable soil management, which also strengthen rural economies.

Sustainability is another benefit, as resilient farming conserves natural resources like soil and water thereby protecting ecosystems for future generations. Resilient agriculture also promotes technological innovations like climate-smart farming and precision agriculture, enhancing productivity while minimizing environmental impact.

Additionally, resilience supports social and economic equity by empowering smallholder farmers, women, and marginalized communities, providing them with resources and opportunities for sustainable development. Overall, resilience in agriculture ensures a more stable, sustainable, and inclusive future for farming systems.

Concept of Agricultural Resilience

Agricultural resilience embodies the ability of farming systems to endure, recover from, and adapt to various challenges while maintaining their essential functions and productivity. These challenges can range from environmental stressors like droughts, floods, and pest infestations to socio-economic pressures such as conflicts, market fluctuations and policy changes.

At its core, resilience in agriculture involves three main aspects:

1. **Resistance** refers to the system's capacity to withstand adverse conditions without significant disruption. For instance, drought-resistant crops exemplify resistance by maintaining productivity even in the face of water scarcity.
2. **Recovery** focuses on the ability to bounce back after a disturbance. This means that after an event such as a flood or pest outbreak and security challenges, the agricultural system should be able to return to its original state or even improve. Recovery involves restoring crop yields and rebuilding livelihoods.
3. **Adaptation** is about evolving to meet new challenges. It goes beyond merely recovering to include adjusting practices and strategies to better cope with future risks. This might involve adopting new technologies, diversifying crop varieties, or implementing sustainable land management practices to handle changing conditions.

Several factors influence agricultural resilience:

- **Diverse Farming Systems** enhance resilience by reducing the risk of total crop failure. Practices such as crop rotation, polycultures, and integrating livestock into crop production contribute to soil health and reduce vulnerability.
- **Innovative Agricultural Practices** play a critical role. Techniques like conservation agriculture, agroforestry, and the use of drought-resistant crop varieties bolster resilience by improving soil fertility, water retention, and biodiversity.
- **Institutional Support** is crucial for resilience. Effective government policies, access to credit, agricultural extension services, and social safety nets provide farmers with the resources, education, and infrastructure needed to withstand and recover from shocks.
- **Technology and Innovation** also contribute significantly. Advances in biotechnology, such as genetically modified crops, digital agriculture tools like precision farming, and climate-smart practices help optimize resource use and boost productivity even under stress.

Agricultural resilience is vital for several reasons such as food security, economic stability and environmental sustainability. Agricultural resilience is essential for maintaining functional and productive food systems amid changing climate, insecurity, environmental degradation, and economic shifts. By embracing adaptive practices, leveraging technological innovations, and ensuring robust institutional support, farmers and agricultural communities can navigate future challenges effectively and sustainably.

The need for innovation in agriculture

Agriculture has always been central to human existence, providing food, raw materials, and livelihoods for billions of people. Over the centuries, agricultural innovations have played a crucial role in advancing societies, from the development of irrigation systems in ancient Mesopotamia to the Green Revolution of the 20th century. However, the challenges of the modern world—rapid population growth, climate change, soil degradation, insecurity and dwindling natural resources—are placing unprecedented pressure on Nigeria's food supply systems. To address these challenges, there is an urgent need for innovation in agriculture to ensure food security, environmental sustainability, and economic resilience.

Innovative Agricultural Practices: An Overview

Innovative agricultural practices are essential for addressing the growing challenges in agriculture, such as climate change, increasing population, dwindling resources, and the need for environmental sustainability. As the global demand for food rises, driven by population growth, traditional farming methods are becoming less effective. Issues like soil degradation, water scarcity, and pest resistance are making it difficult for conventional practices to meet the demands of modern agriculture. This has created an urgent need for new approaches that can improve productivity while minimizing environmental impact.

One key area of innovation is precision agriculture, which involves the use of technologies such as GPS, sensors, drones, and satellite imagery. These tools enable farmers to closely monitor crop health and optimize the use of resources like water and fertilizers. By applying these inputs only where they are needed, precision agriculture reduces waste and improves efficiency.

Sustainable farming practices are another vital component of innovation in agriculture. Techniques like conservation tillage, crop rotation, agroforestry, and organic farming help maintain soil health, prevent erosion, and promote biodiversity. These methods are designed to minimize the use of chemical inputs and reduce the environmental footprint of farming.

In response to the challenges posed by climate change, climate-smart agriculture has emerged as a crucial strategy. This approach seeks to increase agricultural productivity and resilience while reducing greenhouse gas emissions. Farmers adopting climate-smart practices may use drought-resistant crop varieties, integrated pest management, and water-efficient irrigation systems to cope with changing weather patterns and resource constraints.

Urbanization and limited access to arable land have led to innovations like vertical farming and controlled environment agriculture (CEA). These methods allow crops to be grown in stacked layers or controlled indoor environments, maximizing space and resources. Vertical farming is especially useful in urban areas, where land is scarce, and it allows for year-round production of fresh produce.

Advances in biotechnology and the development of genetically modified organisms (GMOs) have also played a significant role in agricultural innovation. Crops engineered to resist pests, diseases, and environmental stresses can improve yields and reduce the need for chemical inputs, making farming more sustainable and productive.

In addition to these biological and mechanical innovations, the rise of digital agriculture and the use of data analytics are transforming how farmers manage their operations. Through mobile applications, big data, and artificial intelligence, farmers can access real-time information on weather, soil conditions, and market trends. These tools enable them to make informed decisions that optimize production and enhance profitability.

In summary, the adoption of innovative agricultural practices is crucial for the future of farming. These practices not only help increase efficiency and productivity but also ensure that agriculture becomes more sustainable and resilient. To fully realize the benefits of these innovations, investments in agricultural research, farmer education, and supportive government policies are essential. Only through widespread adoption of these practices can we ensure a secure and sustainable food supply for future generations.

Categories of innovations and their Role in Enhancing Resilience

Innovation is essential in addressing the complex challenges that agriculture face today. These innovations can be grouped into four main categories: technological, ecological, social, and policy-based. Each category plays a crucial role in driving progress, improving efficiency, and promoting sustainability.

Innovation plays a critical role in enhancing resilience in agriculture. Resilience, in this context, refers to the ability of individuals, communities, systems, or industries to withstand, adapt to, and recover from disruptions, challenges, or shocks. Whether facing natural disasters, economic downturns, climate change, security challenges or pandemics, resilience is essential for long-term stability and progress. Innovations in technology, ecology, social systems, and policy are key to building this resilience.

1. Technological Innovation and Resilience

Technological innovation is a powerful tool for strengthening resilience by providing solutions that enable individuals and systems to anticipate and adapt to challenges more effectively. In agriculture, innovations such as development of drought-resistant crop varieties, precision farming tools, early warning systems and smart irrigation systems help farmers cope with climate variability and resource scarcity. These technologies not only improve productivity but also enable farmers to mitigate risks associated with extreme weather events.

2. Ecological Innovation and Resilience

Ecological innovations are essential for enhancing the resilience of natural systems and ensuring the sustainability of ecosystems in the face of environmental threats. These innovations focus on protecting and restoring ecosystems, conserving resources, and reducing environmental degradation. In agriculture, sustainable farming practices like agroforestry, crop rotation, and conservation tillage help maintain soil health and prevent erosion, making agricultural systems more resilient to climate change and extreme weather events. By promoting biodiversity and reducing the reliance on chemical inputs, these ecological innovations also enhance the long-term viability of farming systems.

3. Social Innovation and Resilience

Social innovations address the human and community dimensions of resilience, creating systems and structures that promote social cohesion, inclusion, and support in times of crisis. Communities that are well-organized and supported by social innovations are better equipped to face disruptions and recover from shocks. Social innovations offer an effective pathway to build such resilience, addressing these challenges by integrating new methods, practices, and relationships within communities and agricultural systems.

4. Policy-Based Innovation and Resilience

Policy-based innovations create the regulatory frameworks and governance structures necessary to enhance resilience across sectors. Effective policies enable the adoption of innovative solutions while providing the support needed to manage risks and promote recovery. Governments can foster resilience through climate adaptation policies that encourage sustainable land use, water conservation, and disaster preparedness. For example, policies promoting the use of climate-smart agricultural practices help farmers adapt to changing weather patterns and resource constraints, reducing their vulnerability to climate shocks.

Examples of Specific Innovations for Resilience

A. Climate-Smart Agriculture (CSA)

Climate-Smart Agriculture (CSA) is an integrated approach to managing agricultural systems that seeks to address the challenges posed by climate change while simultaneously improving productivity, enhancing resilience, and reducing greenhouse gas emissions. CSA is not a single set of practices; rather, it encompasses a broad range of strategies that help farmers and agricultural systems adapt to the impacts of climate change, increase productivity sustainably, and mitigate climate-related risks.

The three key principles of CSA are:

1. **Sustainably increasing agricultural productivity and incomes**: CSA aims to increase food production while ensuring that farmers can generate income from their activities. This involves adopting practices that enhance crop yields, improve livestock productivity, and increase the efficiency of inputs like water and fertilizer.
2. **Building resilience and adapting to climate change**: CSA enhances the capacity of farming systems to cope with climate shocks, such as droughts, floods, and heat waves. This includes using resilient crop varieties, diversifying farming practices, and managing natural resources like soil and water in ways that reduce vulnerability to climate risks.

3. **Reducing greenhouse gas emissions where possible**: While agriculture is a significant contributor to greenhouse gas emissions, CSA seeks to reduce these emissions through practices such as agroforestry, improved livestock management, and conservation agriculture. This contributes to climate change mitigation, helping to curb the sector's impact on global warming.

CSA Practices Suitable for Nigeria

Given Nigeria's diverse agro-ecological zones and the increasing threats of climate change, a range of CSA practices are appropriate for the country. These practices help farmers cope with challenges like drought, erratic rainfall, and soil degradation, while improving productivity and sustainability.

1. **Drought-Resistant Crop Varieties**:

One of the most effective CSA practices in Nigeria is the use of drought-resistant crop varieties. These varieties are bred to withstand periods of low rainfall, making them suitable for arid and semi-arid regions, particularly in northern Nigeria, where drought is a frequent occurrence. For example, drought-tolerant maize varieties have been introduced through the Drought Tolerant Maize for Africa (DTMA) project, helping farmers achieve better yields in challenging conditions. Similarly, drought-resistant sorghum, millet, and cowpea varieties are crucial for areas prone to water scarcity.

2. **Water-Efficient Irrigation Systems**:

Water-efficient irrigation systems, such as drip irrigation and sprinkler irrigation, ensure that water is applied directly to the roots of plants, minimizing wastage and evaporation. These systems are particularly important in Nigeria’s northern regions, where water resources are limited, and traditional irrigation methods are often inefficient.

3. **Agroforestry**:

Agroforestry involves integrating trees and shrubs into agricultural systems. This practice provides multiple benefits, including improved soil fertility, enhanced water retention, and protection against soil erosion. Trees also capture carbon from the atmosphere, contributing to climate mitigation. In Nigeria, agroforestry is particularly beneficial in combating desertification in the northern states and enhancing biodiversity in farming systems.

4. **Conservation Agriculture**:

Conservation agriculture focuses on minimal soil disturbance, permanent soil cover (through mulch or cover crops), and crop rotation. These practices improve soil health, reduce erosion, and help retain moisture, making them particularly suited to Nigeria’s climate-vulnerable regions.

5. **Diversified Farming Systems**:

Diversifying farming systems by integrating crops, livestock, and fish farming increases resilience to climate change by spreading risks and creating multiple sources of income. In

Nigeria, integrating crop and livestock farming has become common, especially in rural areas, where smallholder farmers benefit from both the produce and livestock resources, reducing vulnerability to climate-induced crop failures.

6. **Climate Information Services**:

Providing farmers with access to reliable climate and weather information is critical for making informed decisions about planting and harvesting. In Nigeria, projects like SERVIR West Africa under ICRISAT provide farmers with real-time climate data, helping them adapt to changing weather patterns and mitigate the risks of extreme climate events.

B. Conservation Agriculture

Conservation Agriculture (CA) is a sustainable farming approach that promotes the long-term health and productivity of agricultural systems while minimizing environmental degradation. It is built on three fundamental principles: minimal soil disturbance, maintaining soil cover, and crop diversification. This approach aims to boost soil health, enhance resilience to climate change, and improve water efficiency, making it an effective strategy for building climate-resilient agricultural systems, particularly in regions like Nigeria where environmental challenges are prevalent.

The first principle is no-till or minimum tillage, which emphasizes reducing or eliminating soil disturbance. By avoiding traditional ploughing, which often leads to soil erosion and the loss of organic matter, the natural soil structure is preserved. This helps the soil retain moisture, prevent erosion, and promote the buildup of organic matter, improving fertility over time. In regions in Nigeria, where soil erosion is a significant issue, no-till farming is essential for maintaining productivity.

The second principle is soil cover maintenance. Farmers achieve this by using cover crops such as legumes and cereals or by leaving crop residues on the field as mulch. These practices protect the soil from erosion, retain moisture, and suppress weeds. By maintaining a continuous soil cover, farmers also promote water infiltration and reduce the impact of droughts, which are common in Nigeria.

The third principle is crop rotation and diversification. This involves planting different crops in a sequence to maintain soil fertility, reduce pest and disease pressure, and enhance biodiversity. Crop rotation helps balance nutrient demands and prevents the depletion of specific nutrients. For instance, rotating nitrogen-fixing crops like cowpea with cereals improves soil fertility naturally, benefiting smallholder farmers who face challenges like declining soil health in Nigeria.

C. Precision Agriculture and Digital Farming

Precision agriculture (PA) is an advanced farming approach that utilizes data and technology to optimize agricultural practices, ensuring efficient use of resources and enhancing productivity. It leverages tools such as GPS (Global Positioning System), remote sensing, drones, and IoT (Internet of Things) devices to monitor field variability and manage crops more precisely. By providing farmers with accurate, real-time data, precision agriculture enables more informed decision-making and tailored interventions at a micro-level, helping improve yields while minimizing waste.

Some of the key tools and techniques in precision agriculture include:

1. **GPS-Guided Equipment**: GPS technology is used to guide tractors and other machinery with precision, ensuring accurate planting, fertilizing, and harvesting. This reduces overlapping and gaps, thereby optimizing field operations.
2. **Remote Sensing**: Remote sensing technologies, including satellite imagery and drones, are employed to monitor crop health, detect pests and diseases, and assess soil conditions. Multispectral or hyperspectral imaging allows farmers to visualize crop stress, moisture levels, and nutrient deficiencies.
3. **Variable Rate Technology (VRT)**: VRT allows farmers to apply inputs like water, fertilizer, and pesticides in precise amounts based on field data. With VRT, areas that require more resources get them, while areas that need less receive proportionally reduced inputs, preventing overuse and wastage.
4. **Soil Sensors**: Soil moisture sensors provide real-time data on water content in the soil, helping farmers manage irrigation more efficiently. Nutrient sensors also monitor soil fertility levels, ensuring targeted fertilization and reducing excessive use of chemicals.
5. **Yield Monitoring**: Yield monitoring systems track crop yields in real-time during harvesting, giving farmers insights into field variability. This data helps identify which areas of the field are performing well and which need improvement, facilitating better management strategies for future planting.
6. **Drones and UAVs**: Unmanned aerial vehicles (UAVs) or drones equipped with cameras and sensors provide high-resolution data on crop health, enabling early detection of issues such as pest infestations, diseases, and nutrient deficiencies. Drones are also used for precision spraying of pesticides and fertilizers.

Benefits of Precision Agriculture for Resource Optimization and Resilience

Precision agriculture offers a wide range of benefits for resource optimization and resilience in farming systems:

1. **Efficient Use of Inputs**: Precision agriculture allows farmers to apply water, fertilizer, and pesticides only where and when they are needed, reducing wastage and lowering costs. This targeted approach minimizes environmental pollution caused by overuse of chemicals and conserves natural resources, such as water and energy.
2. **Improved Crop Yields and Productivity**: By leveraging data-driven insights, precision agriculture helps farmers manage their fields more effectively, leading to increased crop yields. For example, early detection of diseases or pest outbreaks through drone surveillance or remote sensing allows for timely interventions, preventing significant crop losses.

3. **Enhanced Climate Resilience**: Precision agriculture enhances climate resilience by allowing farmers to adapt to changing weather conditions more effectively. Soil moisture sensors and weather data integration help farmers adjust irrigation schedules, ensuring optimal water use even during droughts. Additionally, the ability to apply inputs more efficiently helps mitigate the impacts of unpredictable rainfall patterns and other climate-related challenges.
4. **Reduced Environmental Impact**: With its emphasis on precise input application and data-driven management, precision agriculture reduces the environmental footprint of farming activities. By preventing the overuse of fertilizers and pesticides, PA reduces the risk of soil degradation, water contamination, and biodiversity loss.
5. **Cost Savings and Profitability**: Precision agriculture enables farmers to reduce operational costs by optimizing resource use. By applying fertilizers, water, and pesticides in precise amounts, farmers can lower input costs while maximizing crop yields. The reduction in input usage, coupled with better crop performance, leads to higher profitability.

Examples of Digital Farming Solutions in Nigeria

1. **Hello Tractor**: Known as the "Uber for Tractors," Hello Tractor is a digital platform that connects smallholder farmers with tractor owners, allowing farmers to access affordable mechanization services on-demand. This digital solution helps farmers optimize their land preparation and planting operations, improving productivity while reducing labour costs. Through the app, farmers can track tractor usage, receive alerts, and make data-driven decisions about farming operations.
2. **Farmcrowdy**: Farmcrowdy is an agri-tech platform that enables Nigerians to invest in agriculture by funding small-scale farmers. It uses digital tools to monitor farm activities, provide real-time updates, and support farmers with precision agriculture techniques. Farmcrowdy helps farmers access modern technologies like soil testing, weather forecasting, and market information,
3. **Crop2Cash**: Crop2Cash is a Nigerian fintech startup that provides digital financial services to smallholder farmers. By using mobile technology, Crop2Cash offers farmers access to digital credit and enables them to make payments for agricultural inputs, such as seeds and fertilizers. This solution helps farmers increase their productivity by providing the financial support needed to adopt precision farming practices.
4. **Zenvus**: Zenvus is a Nigerian precision agriculture platform that uses sensors and IoT technology to collect data on soil moisture, nutrients, and crop health. This data is analysed to provide actionable insights to farmers, helping them optimize irrigation, fertilization, and other field operations. Zenvus empowers farmers with the tools to make data-driven decisions, improving both resource efficiency and crop resilience.
5. **Digital Green**: Digital Green works with Nigerian farmers by using video technology to share agricultural best practices, including precision farming techniques. Farmers are trained on how to use digital tools for monitoring crop performance, managing inputs, and improving farm operations. This digital extension service helps scale up precision

agriculture practices across rural areas, where access to agricultural training and resources is often limited.

Precision agriculture and digital farming represent the future of sustainable agriculture by combining technology, data, and innovative practices to optimize farming operations. With the help of GPS-guided equipment, remote sensing, VRT, and soil sensors, farmers can improve resource efficiency, increase yields, and reduce environmental impacts. These innovations are vital for ensuring food security, economic growth, and environmental sustainability in the country's agricultural sector.

Importance of Indigenous Knowledge in Resilience Building

Integrating traditional knowledge with modern agricultural innovations offers valuable opportunities for enhancing resilience and promoting sustainable farming. By combining indigenous wisdom with scientific advancements, farmers can develop more effective and locally relevant solutions to modern agricultural challenges.

1. **Enhancing Climate Resilience**: Traditional practices like zai pits and agroforestry can be strengthened by modern technology. For example, pairing zai pits with modern soil moisture monitoring tools can improve water management in arid areas. Similarly, agroforestry systems benefit from modern knowledge on tree species selection and carbon sequestration, making them more effective in addressing climate change.
2. **Improving Soil and Water Management**: Traditional soil and water management methods such as terracing, mulching, and rainwater harvesting can be combined with modern techniques like drip irrigation and precision farming. In Nigeria, integrating indigenous water conservation practices with modern irrigation systems can help optimize water use, increase yields, and enhance drought resilience.
3. **Innovative Crop Varieties**: Modern crop breeding programs can collaborate with indigenous knowledge to develop crops better suited to local conditions. Traditional drought-tolerant crops like millet and sorghum can be genetically enhanced to produce higher yields and be more climate-resilient, fitting Nigeria's diverse agricultural environments.
4. **Participatory Research and Extension Services**: Involving local farmers in research is crucial for blending indigenous and modern practices. Participatory approaches that value farmers' knowledge can lead to practical, effective, and culturally appropriate solutions. Research institutions in Nigeria can collaborate with communities to document traditional practices while introducing complementary modern techniques.
5. **Policy Support for Indigenous Knowledge**: Governments and development organizations can support this integration through policies that recognize and promote the value of indigenous practices. This includes incentivizing sustainable traditional farming, funding research that bridges indigenous and scientific knowledge, and promoting biodiversity and cultural heritage conservation.

By combining traditional practices with modern innovations, farming systems in Nigeria and beyond can become more resilient, productive, and sustainable, particularly in the face of climate change.

Enhancing Market access and value chain

Market access is crucial for smallholders, enabling them to sell their products at profitable prices and connect to wider economic opportunities. Limited access restricts farmers to local markets with high competition and volatile prices. Improving access to regional and international markets allows diversification, better income stability, and reduced vulnerability to local shocks, such as weather or price fluctuations. This can also lead to higher product quality and transparency in pricing.

The key innovations in agricultural value chains, include:

1. **Value Addition** – Processing raw produce (e.g., turning cassava or maize into flour) increases shelf life, profitability, and job creation in rural areas.
2. **Aggregation Centres** – Centralized facilities for collective marketing reduce logistical costs and give farmers access to larger markets, such as supermarkets and export opportunities.
3. **Digital Market Platforms** – Mobile and online platforms connect farmers directly with buyers, improve price transparency, and streamline logistics.

Cooperatives enhance farmers' market access by leveraging collective bargaining power, offering technical support, and improving access to finance. Cooperatives also help smallholders negotiate better terms, provide financial services, and advocate for policies that benefit farmers.

Conclusion and Recommendations

1. **Innovative Agricultural Practices for Resilience**

The adoption of innovative agricultural practices is critical for building resilience in Nigeria's agricultural sector. These innovations, whether technological, ecological, or social, provide the foundation for addressing the challenges posed by climate change, market volatility, and food security. From value addition in supply chains to sustainable farming techniques, innovation will drive increased productivity, profitability, and sustainability for smallholder farmers in Nigeria.

2. **Multi-faceted Approach**

A holistic approach is needed to fully transform Nigeria's agricultural sector. This involves integrating technological innovations such as digital platforms and precision agriculture, ecological practices like sustainable land and water management, social innovations like farmer cooperatives, and supportive policies that promote investment and growth. Only by combining these elements can the sector achieve long-term resilience and contribute to national economic development.

Recommendations

1. For Government

Increase Investment in Agricultural Research and Development (R&D): The government should allocate more resources toward agricultural research to develop crop varieties that are resistant to climate change, pests, and diseases. Research should also focus on sustainable farming practices that protect ecosystems.

Strengthen Extension Services: Extension services need to be better equipped and expanded to reach more farmers, particularly in rural areas. By enhancing capacity-building efforts, farmers can adopt modern practices and technologies that improve productivity and resilience.

Improve Infrastructure: Investment in rural infrastructure, such as roads, storage facilities, and irrigation systems, is essential to connect farmers to markets, reduce post-harvest losses, and ensure more efficient production and distribution.

2. For the Private Sector

Collaborate with Smallholder Farmers: The private sector should partner with smallholder farmers to provide access to finance, markets, and technology. By offering affordable credit, high-quality inputs, and market linkages, businesses can help farmers improve productivity and profitability.

Invest in Agri-Tech Solutions: Private companies should invest in technological innovations that simplify farming processes and address specific challenges in Nigeria's agricultural value chains, such as post-harvest losses and inefficient logistics.

3. For Farmers

Adopt Innovative Practices: Farmers should embrace innovative practices that enhance productivity, sustainability, and resilience. This includes adopting climate-smart agricultural techniques, diversifying crops, engaging in value addition, and participating in farmer organizations or cooperatives to access shared resources and knowledge.

Leverage Digital Tools: Farmers should utilize digital platforms for accessing market information, weather updates, and extension services, helping them make informed decisions and improve efficiency.

To build a resilient agricultural sector that can drive economic growth and support food security in Nigeria, it is crucial for all stakeholders—government, researchers, private sector, civil society, and farmers—to collaborate. By working together, they can foster an environment that supports innovation, builds capacity, and ensures sustainable agricultural practices. This collective effort will not only strengthen Nigeria's agricultural sector but also contribute to national security and economic stability. Let us take action today to invest in the future of agriculture in Nigeria, ensuring that the sector becomes more resilient, sustainable, and prosperous for generations to come.

Thank you.

References:

FAO (2013). "Climate-Smart Agriculture: Sourcebook." *Food and Agriculture Organization of the United Nations*.

Food and Agriculture Organization of the United Nations (FAO). (2013). *Climate-Smart Agriculture: Sourcebook*. FAO, Rome. Available at: http://www.fao.org/climate-smart-agriculture-sourcebook/en/

Gebbers, R., Adamchuk, V. I. (2010). "Precision Agriculture and Food Security." *Science*, **327(5967), 828–831.**

Godfray, H. C. J., John, R, B., Ian, R.C., Lawrence, H., David, L., James, F.M., Jules, N.P., Sherman, R., Sandy, M.T., Camilla, T. (2010). "Food Security: The Challenge of Feeding 9 billion People." *Science*, **327(5967), 812–818.**

International Maize and Wheat Improvement Centre (CIMMYT). (2016). *Drought-Tolerant Maize for Africa (DTMA) Project*. Available at: https://www.cimmyt.org/projects/dtma/

International Water Management Institute (IWMI) (2017). Innovations in Irrigation Technologies.

Lal, R. (2020). Soil Health and Regenerative Agriculture. *Journal of Soil and Water Conservation*. **75 (5) 123A-124A**;

Nigerian Bureau of Statistics (2023). Nigeria Gross Domestic Report. Issue 40: Quarter Four, 2023.

OECD (2020). Strengthening Agricultural Resilience in the Face of Multiple Risks; OECD Publishing: Paris, France, 2020; ISBN 9789264335530

Pretty, J. (2008). "Agricultural Sustainability: Concepts, Principles, and Evidence." *Philosophical Transactions of the Royal Society B: Biological Sciences*, **363(1491), 447–465.**

Rockström, J., John, W., Gretchen, D., Andrew, N., Nathanial, M., Line, G., Hanna, W., Fabrice, D., Mihir, S., Pasquale, S., Charlotte, F., Nuhu, H., Olcay, U., Jeremy, B., Lindiwe, S., Jimmy, S. (2017). "Sustainable Intensification of Agriculture for Human Prosperity and Global Sustainability." *Ambio*, **46(1), 4–17.**

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). "Global Food Demand and the Sustainable Intensification of Agriculture." *Proceedings of the National Academy of Sciences*, **108(50), 20260–20264**.

World Bank. (2016). *Promoting Climate-Smart Agriculture in Nigeria: CSA Profiles*. Available at: https://climateknowledgeportal.worldbank.org/

Zhang, C., & Kovacs, J. M. (2012). The Application of Small UAVs for Precision Agriculture. *Remote Sensing*, **4(9), 1428-1443.**

SEEDING THE FUTURE: PROSPECTS AND CHALLENGES OF SEED PRODUCTION FOR SUSTAINABLE FOOD SECURITY IN NIGERIA

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1.0 INTRODUCTION

Seed production is a cornerstone of agricultural development and food security, serving as the foundation upon which the entire agricultural value chain is built. In Nigeria, a nation grappling with food insecurity and striving towards self-sufficiency, the significance of a robust and efficient seed industry cannot be overstated. High-quality seeds are fundamental not only for improving crop yields but also for enhancing the resilience and adaptability of the agricultural sector in the face of climatic variability and other challenges.

Nigeria's agricultural sector is pivotal to its economy, employing a significant portion of the population and contributing substantially to the nation's GDP. However, despite its potential, the sector is plagued by numerous challenges, including inadequate infrastructure, limited access to modern farming technologies, and a lack of high-quality seeds. These challenges have hindered productivity and worsened food insecurity in a country with a rapidly growing population.

The importance of seed quality in achieving sustainable food security is paramount. Quality seeds ensure higher germination rates, uniform crop growth, and resistance to pests and diseases, all of which are critical for maximizing agricultural output. Furthermore, the development and dissemination of improved seed varieties can play a vital role in promoting agricultural diversification, enhancing nutritional outcomes, and fostering economic growth.

2.0 OVERVIEW OF SEED PRODUCTION IN NIGERIA:

The development of seed production in Nigeria has undergone significant evolution over the decades, driven by a combination of local initiatives and international support. This progression reflects the nation's commitment to enhancing agricultural productivity and achieving food security. The seed industry in Nigeria is a complex ecosystem comprising various stakeholders, each playing a crucial role in its development and sustainability.

2.1 Historical Evolution and Current Landscape

The history of seed production in Nigeria dates back to the colonial era, with initial efforts focused on improving traditional farming practices through the introduction of better seed varieties. Post-independence, the Nigerian government established various agricultural research institutes and seed multiplication centers to bolster domestic seed production. Key milestones include the establishment of the National Seed Service (NSS) now known as the National Agricultural Seeds Council (NASC) and the introduction of the Seed Act, which laid the foundation for a more structured and regulated seed industry.

In recent years, there has been a noticeable shift towards the commercialization of seed production, with an increasing number of private seed companies entering the market notably 447 seed companies and many more waiting to be licensed. These companies, alongside public sector initiatives, have significantly contributed to the diversification and availability of high-quality seeds. Nigeria now produces a wide array of seeds, including hybrid, open-pollinated, and genetically modified (GM) seeds, each catering to different agricultural needs and contexts.

2.2 Key Stakeholders and Their Roles

I. Government Agencies:

The NASC is the primary regulatory body overseeing seed certification, quality control, and distribution. It plays a pivotal role in ensuring that seeds meet the required standards and are accessible to farmers.

The Federal Ministry of Agriculture and Food Security (FMAFS) formulates policies and provides strategic direction for the agricultural sector, including seed production.

II. Research Institutions:

Institutions such as the International Institute of Tropical Agriculture (IITA) and the National Root Crops Research Institute (NRCRI) conduct vital research on crop improvement and develop new seed varieties tailored to Nigeria's agro-ecological zones.

These institutions collaborate with international organizations to bring cutting-edge technologies and innovations to Nigerian agriculture.

III. Private Seed Companies:

Private enterprises are increasingly becoming major players in the seed industry. Companies such as Premier Seed, Seed Co Nigeria, Value Seed, and other local and multinational firms invest in seed breeding, production, and marketing.

These companies enhance seed availability and diversity, providing farmers with a range of options suited to different crops and climatic conditions.

IV. Farmers:

Farmers are both beneficiaries and active participants in the seed production ecosystem. They contribute to seed multiplication, preservation of local varieties, and the adoption of improved seeds.

Farmer cooperatives and associations such as community-based seed producers play a crucial role in disseminating information and facilitating access to quality seeds.

2.3 Types of Seeds Produced

Nigeria's seed industry produces various types of seeds, each playing a unique role in agriculture:

a. Hybrid Seeds:

Hybrid seeds result from the cross-breeding of two different parent plants to produce offspring with desirable traits such as higher yields, disease resistance, and improved quality.

These seeds are crucial for commercial agriculture, offering substantial productivity gains.

b. Open-Pollinated Seeds:

Open-pollinated seeds are naturally pollinated and can be saved and reused by farmers over multiple planting seasons.

They are essential for maintaining biodiversity and are often preferred by smallholder farmers for their cost-effectiveness.

c. Genetically Modified (GM) Seeds:

GM seeds are developed through genetic engineering to enhance specific traits such as pest resistance, herbicide tolerance, and nutritional content.

While still a subject of debate and regulatory scrutiny, GM seeds have the potential to address some of the critical challenges faced by Nigerian agriculture, such as pest infestations and low crop yields.

3.0 PROSPECTS OF SEED PRODUCTION IN NIGERIA

The prospects of seed production in Nigeria are promising, with numerous opportunities for growth and development that can significantly impact the agricultural sector and the broader economy. These prospects are underpinned by supportive government policies, technological advancements, economic benefits, and the potential for increased agricultural productivity.

3.1 Government Policies and Initiatives

The Nigerian government has taken proactive steps to support and regulate the seed production industry. Key initiatives include:

i. Establishment of the National Agricultural Seeds Council (NASC): The NASC plays a pivotal role in regulating the seed industry. It is responsible for seed certification, quality control, and the enforcement of seed standards. The council also facilitates the development and dissemination of improved seed varieties

ii. National Seed Policy: This policy framework aims to create an enabling environment for the seed industry, ensuring that high-quality seeds are available to farmers. It addresses various aspects, such as seed quality assurance, certification processes, and the promotion of private sector participation.

iii. Subsidy Programs and Incentives: The government has introduced subsidy programs and incentives to encourage farmers to adopt high-quality seeds. These programs aim to reduce the cost burden on farmers and promote the widespread use of improved seed varieties.

3.2 Technological Advancements

Innovations in seed technology are transforming the seed production landscape in Nigeria. Key advancements include:

a. Biotechnology: The application of biotechnology in seed development has led to the creation of genetically modified (GM) seeds with enhanced traits such as pest resistance, herbicide tolerance, and improved nutritional content. These seeds can significantly boost crop yields and resilience.

b. Precision Agriculture: Precision agriculture technologies, including satellite imagery, soil sensors, and data analytics, enable farmers to optimize seed planting and crop management practices. These technologies help in the efficient use of resources, leading to higher productivity and sustainability.

c. Seed Treatment and Coating Technologies: Advanced seed treatment and coating technologies improve seed germination rates, protect against pests and diseases, and enhance seedling vigor. These treatments ensure better crop establishment and growth.

3.3 Economic Benefits

A robust seed industry offers substantial economic benefits, including:

a. Job Creation: The seed industry generates employment opportunities across the value chain, from seed breeding and production to distribution and marketing. This contributes to economic growth and reduces unemployment rates.

b. Reducing Import Dependency: By developing a self-sufficient seed production industry, Nigeria can reduce its reliance on imported seeds. This not only saves foreign exchange but also ensures the availability of locally adapted seed varieties.

c. Increasing Agricultural Productivity: High-quality seeds lead to higher crop yields and improved agricultural productivity. This, in turn, enhances food security and supports the country's goal of achieving self-sufficiency in food production.

d. Poverty Alleviation and Improved Livelihoods: Improved seed varieties can increase farmers' incomes by boosting crop yields and reducing losses due to pests and diseases. This contributes to poverty alleviation and enhances the livelihoods of rural communities.

3.4 Potential for Increased Agricultural Productivity

a. High-quality seeds are fundamental to achieving higher agricultural productivity and ensuring food security. The potential benefits include:

b. Better Resistance to Pests and Diseases: Improved seed varieties are bred for resistance to common pests and diseases, reducing the need for chemical pesticides and lowering production costs.
c. Enhanced Tolerance to Environmental Stresses: Climate-resilient seed varieties can withstand adverse environmental conditions such as drought, flooding, and extreme temperatures. This ensures stable crop production even in challenging climates.
d. Higher Crop Yields: Improved seed varieties offer superior genetic traits that result in higher yields per hectare. This maximizes land use efficiency and contributes to meeting the food demands of Nigeria's growing population.
e. Promotion of Sustainable Farming Practices: The adoption of high-quality seeds encourages sustainable farming practices, as these seeds often require fewer inputs and support environmentally friendly agriculture.

4.0 CHALLENGES FACING SEED PRODUCTION IN NIGERIA

Despite the promising prospects, the seed production industry in Nigeria faces several challenges that hinder its full potential. Addressing these challenges is crucial for the development of a robust and sustainable seed sector.

a. **Infrastructural Deficiencies**

- **Inadequate Storage Facilities**: One of the primary challenges is the lack of proper storage facilities for seeds. Inadequate storage conditions can lead to the deterioration of seed quality, resulting in significant post-harvest losses. The absence of modern, temperature-controlled storage units exacerbates this issue.
- **Poor Transportation Networks**: Efficient seed distribution is hampered by the poor state of transportation infrastructure. Many rural areas, where most farmers are located, are difficult to access due to bad roads and lack of reliable transportation. This limits farmers' access to high-quality seeds and increases the cost of seed distribution.

b. **Regulatory and Policy Constraints**

- **Inconsistent Enforcement of Regulations**: Although policies such as the National Seed Policy and regulatory bodies like the NASC are in place, inconsistent enforcement of regulations remains a problem. This inconsistency undermines efforts to maintain seed quality and market integrity.
- **Bureaucratic Bottlenecks**: The seed industry faces bureaucratic hurdles that slow down processes related to seed certification, registration of new seed varieties, and other regulatory approvals. These delays discourage investment and innovation within the sector.

c. **Issues with Seed Quality and Availability**

- **Prevalence of Substandard Seeds**: The market is often flooded with substandard and counterfeit seeds, which can severely affect crop yields and erode farmer confidence. Ensuring the availability of high-quality seeds is critical but challenging due to the prevalence of these inferior products.

- **Limited Access to Improved Varieties**: Many farmers, especially smallholders, struggle to access improved seed varieties. This limitation is due to a combination of high costs, lack of awareness, and insufficient distribution networks.

d. **Financial Constraints and Access to Credit**

- **Lack of Affordable Credit**: Access to finance is a significant barrier for both seed producers and farmers. The high cost of borrowing and the lack of affordable credit options limit their ability to invest in quality seed production and necessary agricultural inputs.
- **Financial Institutions' Reluctance**: Financial institutions are often hesitant to lend to the agricultural sector due to perceived risks. This reluctance stifles the growth of the seed industry and hampers the ability of farmers to scale their operations.

e. **Environmental Factors and Climate Change**

- **Impact of Climate Change**: Climate change poses a substantial threat to seed production in Nigeria. Unpredictable weather patterns, increased frequency of extreme weather events, and shifting climatic zones affect crop viability and productivity. These changes necessitate the development of climate-resilient seed varieties.
- **Environmental Degradation**: Soil degradation, deforestation, and other forms of environmental degradation also impact seed production. Sustainable farming practices and environmental conservation efforts are needed to mitigate these impacts and ensure long-term agricultural productivity.

5.0 CASE STUDIES AND BEST PRACTICES

Examining successful programs and initiatives from both international and local contexts provides valuable insights into improving seed production in Nigeria. Learning from these experiences can inform strategic approaches and foster innovation within the seed sector.

5.1 Successful Programs in Developing Countries

Countries like India and Brazil have implemented robust seed production programs that serve as exemplary models for Nigeria:

- **India**: The Indian government has invested heavily in seed research and development through institutions such as the Indian Council of Agricultural Research (ICAR). Initiatives like the National Seeds Corporation (NSC) ensure the availability of high-quality seeds to farmers across the country. India's emphasis on farmer education, seed certification, and regulatory frameworks has contributed to significant improvements in agricultural productivity.
- **Brazil**: Brazil's success in seed production is attributed to its strong agricultural research institutions, such as Embrapa (Brazilian Agricultural Research Corporation). The country has developed advanced seed breeding technologies and stringent regulatory standards. Public-private partnerships have played a pivotal role in

disseminating improved seed varieties and enhancing agricultural productivity in diverse agro-ecological zones.

6.0 LESSONS FROM NIGERIAN INITIATIVES

Several local initiatives in Nigeria have demonstrated promising results and provide valuable lessons for scaling up seed production:

- **The National Agricultural Growth Scheme (NAGS-AP)**: The NAGS-AP has played a vital role in ensuring that wheat production is increased across the wheat production zone of the country. The initiative underscores the importance of integrated agricultural interventions that complement seed production efforts.
- **Partnerships with International Organizations**: Collaborations with international organizations, such as the Organization for Economic Cooperation and Development (OECD), International Seed Testing Association (ISTA), Food and Agriculture Organization (FAO) and the Alliance for a Green Revolution in Africa (AGRA), have facilitated knowledge exchange, technical assistance, and funding opportunities. These partnerships have enabled Nigeria to adopt best practices in seed production and agricultural development.

6.1 Collaboration Between Public and Private Sectors

Public-private partnerships (PPP) are pivotal in fostering a sustainable seed industry ecosystem:

- **Research and Development**: Joint ventures between public research institutions and private seed companies can accelerate the development of improved seed varieties tailored to local agro-climatic conditions. This collaboration ensures that research outcomes are effectively translated into practical applications for farmers.
- **Infrastructure Development**: PPPs can address infrastructural deficiencies by investing in modern storage facilities, transportation networks, and seed processing centers. These initiatives enhance seed quality preservation and distribution efficiency, reducing post-harvest losses.
- **Policy Advocacy and Regulatory Frameworks**: Engaging both sectors in policy formulation and advocacy ensures that regulatory frameworks are aligned with industry needs. Clear and consistent regulations promote transparency, trust, and compliance within the seed market.

7.0 STRATEGIES FOR ENHANCING SEED PRODUCTION

a. **Improving Infrastructure and Technology**: Investing in modern storage facilities, transportation networks, and advanced seed processing technologies is essential. These improvements will reduce post-harvest losses and enhance seed quality.
b. **Policy Reforms and Regulatory Improvements**: Streamlining regulatory processes and ensuring consistent enforcement of policies will create a more conducive environment for seed production. Simplified procedures will attract more investments into the sector.

c. **Ensuring Seed Quality and Availability:** Establishing stringent quality control measures and certification processes will improve seed quality. Additionally, creating seed banks and distribution networks will ensure that farmers have access to high-quality seeds.
d. **Financial Solutions and Funding Opportunities:** Providing access to affordable credit and funding opportunities for seed producers and farmers will boost investment in seed production. Government-backed loan schemes and partnerships with financial institutions can play a crucial role.
e. **Addressing Environmental Challenges:** Implementing climate-smart agricultural practices and developing drought-resistant and pest-resistant seed varieties will help mitigate the impacts of climate change. Research and development should focus on creating resilient seed varieties**.**

8.0 CONCLUSION

The future of seed production in Nigeria holds immense potential for transforming the agricultural sector and ensuring sustainable food security. A multi-faceted approach that includes improving infrastructure, enacting policy reforms, ensuring seed quality, providing financial solutions, and addressing environmental challenges is essential. By leveraging these strategies and learning from successful models, Nigeria can build a resilient seed industry that supports the nation's food security goals.

REFERENCES

1. National Agricultural Seeds Council (NASC) annual reports
2. Antônio Lopes, Maurício (2012), “The Brazilian Agricultural Research for Development (ARD) System”, in OECD, Improving Agricultural Knowledge and Innovation Systems: OECD Conference Proceedings, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9789264167445-27-en

EMPOWERING WOMEN AND VULNERABLE YOUTHS THROUGH POST-HARVEST VALUE ADDITION OF CROP PRODUCE: OPPORTUNITIES, CHALLENGES, AND STRATEGIES

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1.0 INTRODUCTION

Women and youths are strong pillars of agriculture. They play essential roles in crop production, harvest, and post-harvest activities, including value addition and marketing at varying degrees of participation. Women comprise about 37% of Nigeria's agricultural labour force (FAO 2016). They specialize in certain activities within the agricultural value chain, such as the transplanting of seedlings depending on the crop types, the drying of produce, and simple processing and preservation of farm produce after harvest. They are also involved in the marketing of agricultural products. The youth are also actively engaged in providing both labour and services within the value chains in agriculture at almost all stages, such as land cultivation, production, pesticide applications, irrigation activities, harvesting, aggregation, processing, storage, and transportation of produce from farms to aggregation/storage sites/ markets, etc., including marketing.

Post-harvest value addition is the process of improving the quality, shelf life, and market value of agricultural products. This includes activities such as processing, packaging, and branding, which result in new products that are more appealing to consumers. Effective post-harvest practices can significantly reduce food spoilage, which currently affects approximately 50% of food produced by farmers due to factors such as physical damage, inadequate storage, and microbial activity. Women and youths can increase profitability, extend product shelf life, and meet market demands by improving post-harvest handling and investing in value addition.

2.0 Opportunities for Women and Youth in Post-Harvest Value Addition.

Many opportunities exist for the value addition of agricultural products due to urbanization and increased consumer demand for food varieties. Consumers prefer convenience foods that ease the task and time to prepare meals. This is an advantage for many women in urban areas who are now employed outside the home. Moreover, value-added products have improved qualities and shelf life. Other benefits that come with post-harvest value addition, which are capable of improving the well-being of women and vulnerable youths in the agricultural sector, include:

i. Increased demand for value-added products due to population growth and urbanization. The increase in the number of urban dwellers translates to a rise in demand for value-added products to meet consumer needs in urban areas.

ii. Increase in incomes: Women dominate the food processing activities in agricultural value chains. They usually carry out preservation activities such as drying, salting, smoking, fermentation, etc. Both women and youth can seize opportunities to increase incomes through further value-addition of farm produce into value-added products that can be sold at higher-value markets in urban areas.

iii. Improved food quality: Most value-added products require compliance with quality standards, packaging, and branding. This process enhances food safety and enables the processor to sell their products at higher prices to generate more incomes.

iv. Market access: Value-added products, due to their increased quality and shelf life, have a broader market appeal and can open access to new markets both locally and internationally, thereby expanding the scope of women's and youths' market participation.

v. Diversification: Post-harvest value addition will enable smallholder farmers, including women and youth, to diversify their products by adequately utilizing their crops' products and by-products for the market. This will also reduce wastage, food loss, and environmental pollution.

vi. Job creation: Value-adding processes often require additional labour, thereby creating employment opportunities for youths and the local community.

vii. Product longevity: Processed value-added products typically have longer shelf lives, reducing waste and increasing product marketability. This also allows products to be available all year round.

3.0 CHALLENGES OF VALUE ADDITION FOR WOMEN AND VULNERABLE YOUTHS IN NIGERIA

3.1 Challenges of Women in Post-Harvest Value Addition

i. Limited access to assets and capital: Women often face barriers in accessing land and financial resources, hindering their ability to invest in post-harvest technologies and equipment. Inadequate capital restricts their engagement in value-addition practices. Access to assets and capital is critical in empowering women in agriculture, particularly in post-harvest value addition, a sector where women are most active. Despite women's significant contributions to agriculture in Nigeria, they face numerous barriers that limit their ability to acquire the resources necessary for effective value addition. Moreover, women frequently lack legal documentation to claim land, making it challenging to use land as collateral for loans. Without ownership titles, financial institutions are often unwilling to extend credit to women. Many banks and microfinance institutions also lack tailored financial products that address the specific needs of women farmers—leaving them with inadequate access to financial resources that can support their involvement in value addition.

ii. Limited financial literacy: Many women face challenges in financial literacy, which limit their ability to navigate financial systems, understand available credit options, and manage budgets effectively. Inadequate financial knowledge deter women from applying for loans or seeking financial assistance.

iii. Insufficient access to quality processing equipment, facilities, and infrastructure: Many women are confined to basic preservation techniques, such as drying, salting, and smoking, which yield minimal profits. While these techniques are culturally significant and can extend the shelf life of products, they often do not meet the quality standards required for higher-value markets. This also means they miss opportunities to create higher-value products as basic methods yield lower profits due to the inability to produce goods that meet market demands. Limited access to training and knowledge skills gap: Even when modern facilities are available, women may lack the necessary skills and training to operate advanced equipment or implement modern processing techniques effectively. This skills gap can prevent them from fully utilizing available resources and opportunities.

iv. The high cost of modern processing equipment and technologies is a challenge that deters women from investing in them, limiting their ability to scale up processing operations.

v. Market awareness: Women often have limited access to market information about trends and consumer preferences, which affects their ability to adapt their processing methods accordingly. This knowledge gap can lead to producing goods that do not meet market demands, causing them to miss opportunities for value addition and premium pricing. Additionally, women may not be aware of relevant market networks or platforms and how to engage with them. This lack of awareness can prevent them from seeking opportunities to enhance their knowledge and business opportunities.

vi. Limited access to networks and higher-value markets: Women are often underrepresented in professional networks that provide essential services, funding, and market insights. This lack of access stifles their ability to adopt new technologies and participate in higher-value markets. Access to professional networks and higher-value markets is crucial for empowering women in agriculture, particularly in the area of post-harvest value addition. Many women in Nigeria face significant barriers limiting their involvement in these essential networks, restricting their access to innovations, funding, and market insights. In addition, many women face challenges accessing international markets due to stringent quality standards, regulatory requirements, and a lack of knowledge about export procedures.

3.2 Challenges of Youths in Post-Harvest Value Addition:

i. Skill gaps in post-harvest techniques and value addition: Skill gaps among young people in Nigeria pose a significant barrier to their effective engagement in the agricultural sector, particularly post-harvest value addition. Young people lacking post-harvest training may not utilize available resources effectively, leading to higher post-harvest losses and reduced profitability. Without the necessary skills, young people may be less likely to innovate or adopt new technologies that could enhance value addition. This can prevent the agricultural sector from evolving to meet market demands. Youth with inadequate skills may also struggle to compete in higher-value markets, which increasingly demand quality, safety, and sustainability. This inability to compete can lead to lower incomes and limited market access.

ii. Youths also lack access to the training and knowledge necessary to adopt advanced techniques that could enhance productivity and profitability. This limitation not only affects their potential but also hinders the overall growth of the agricultural industry. Many rural areas in Nigeria lack educational institutions that provide specialized training in agriculture and post-harvest techniques.

iii. Limited Exposure to Modern Techniques: Youths in agriculture often grow up in environments that rely heavily on traditional agricultural practices. Without exposure to modern technologies and practices, they may be unaware of innovative methods that can significantly improve post-harvest processes.

iv. Lack of access to training programs: Even when training opportunities exist, many young people face barriers in accessing them. Financial constraints, transportation issues, or lack of information about available programs can limit their participation.

v. Inadequate Infrastructure: poor infrastructure, such as inadequate storage and transportation facilities, prevents youth involvement in effective post-harvest management. The lack of infrastructure means that many youths may not receive the education necessary for modern agricultural practices.

vi. Limited financial resources: Youth often struggle with access to financing, which restricts their ability to innovate and invest in value addition processes and ultimately affects their contributions to food security and economic growth. Like women, many youths also do not have assets to use as loan collateral. Since they often start with limited personal or family resources, financial institutions are hesitant to lend to youths. The high interest rates financial institutions offer also deters youths from pursuing loans. Many financial institutions may not provide tailored products for youth in agriculture.

4.0 STRATEGIES TO EMPOWER WOMEN AND VULNERABLE YOUTHS IN POST-HARVEST VALUE ADDITION.

Several strategies can be employed to empower women and youths in post-harvest value addition such as:

i. Legal reforms: Advocate for changes in land ownership laws to ensure equitable access for women.

ii. Financial education programs: Implement targeted financial literacy programs for women and youths to enhance their understanding of financial products and improve their borrowing capacity.

iii. Tailored financial products: Encourage banks and microfinance institutions to develop financial products that meet the specific needs of women farmers and youths, including flexible repayment plans aligned with agricultural cycles.

iv. Community support structures: Establish cooperatives and support groups that help women and youths collectively access resources, share knowledge, and leverage economies of scale for investments in post-harvest technologies.

v. Investment in infrastructure: Government and private sector investments in rural infrastructure, such as reliable electricity, transportation, and water supply, can help support the establishment of modern processing facilities, which women and youths can utilize for post-harvest value addition.

vi. Subsidized equipment programs: Subsidizing or granting the acquisition of modern processing equipment can enable women and youths to access the tools necessary for value addition.

vii. Training and capacity building: Training programs focusing on modern processing techniques, equipment operation, and quality control can empower women and youths to utilize facilities for post-harvest value-additon.

viii. Access to market information: Establishing platforms that provide women and youths with market insights and trends can help them adapt their processing methods to meet consumer demands.

ix. Creating women- and youth-focused networks: creating women- and youth-focused networks will facilitate knowledge sharing, training, and resource access. Thereby increasing their capabilities in post-harvest value-addition.

x. Partnerships with NGOs and development agencies: Collaboration with non-governmental organizations (NGOs) and development agencies can provide women and youths with the resources and information necessary to navigate markets and build networks.

xi. Market Information Systems: Develop market information systems that disseminates relevant information on prices, demand trends, and quality standards to women producers.

xii. Establishment of more agricultural training centers: Developing specialized training centers in rural areas that focus on modern agricultural practices, post-harvest technologies, and value addition can provide women and youths with the necessary skills to enhance post-harvest value-addition.

xiii. Partnerships with educational institutions: Collaborating with universities and vocational schools to create curricula that incorporate advanced agricultural practices and post-harvest techniques can ensure that youth are equipped with relevant skills for post-harvest value-addition.

xiv. Hands-on training and internships: Implementing hands-on training programs or internships with established agricultural businesses can provide youths with practical experience in post-harvest processes and value addition.

xv. Utilization of technology for learning: Leveraging digital platforms and mobile technology to provide training resources, tutorials, and webinars can also enhance women's and youths' access to information on innovations and techniques in post-harvest value addition.

Finally, ensuring the inclusion of women and youths in agriculture, including those living with disabilities, in the implementation of the above strategies will go a long way toward increasing efficiency in Nigeria's agricultural sector.

5.0 CONCLUSION

Empowering women and vulnerable youth through post-harvest value addition presents a significant opportunity to enhance livelihoods and foster economic growth in Nigeria. By addressing the challenges, they face and leveraging available opportunities, we can create a more inclusive agricultural sector that not only supports food security but also drives sustainable development. Through targeted strategies, we can ensure that women and youth become key players in transforming Nigeria's agricultural landscape, ultimately benefiting the broader economy.

REFERENCES

Amparo P. L., Luc C. and Talip K. (2015). How Much of the Labor in African Agriculture Is Provided by Women? World Bank Policy Research Working Paper.

European Commission (2023). Gender Gaps in Agriculture Productivity and Public Spending in Nigeria. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099091823113036874/p175095086510b001080e30d147463456d6

Fasakin, I. J., Adebayo I. O., Lateef O. B., Djana M., Razack A., Zoumana B., Tahirou A., and Bola A. A. (2022). "Impact of Intensive Youth Participation in Agriculture on Rural Households' Revenue: Evidence from Rice Farming Households in Nigeria" *Agriculture* 12, no. 5: 584. https://doi.org/10.3390/agriculture12050584.

Nordhagen, S. Gender equity and reduction of post-harvest losses in agricultural value chains. Global Alliance for Improved Nutrition Working Paper #20. Geneva, Switzerland, 2021. DOI: https://doi.org/10.36072/wp.20.

Romanus O., Oluwatoyin M., Isaiah O., and Busayo A. (2020). Agricultural transformation, youth participation, and food security in Nigeria[J]. AIMS Agriculture and Food, 2020, 5(4): 911-919. doi: 10.3934/agrfood.2020.4.911.

TECHNICAL PRESENTATIONS

CROP GERMPLASM RESOURCE HARNESSING AND UTILIZATION FOR IMPROVED CROP PRODUCTION

EVALUATING COWPEA [*Vigna unguiculata* (L.) WALP.] GENOTYPES RESISTANCE TO WITCH WEED (*Striga gesnerioides* (WILLD.) VATKE) AND LEAF SMUT [*Protomycopsis phaseoli*] (RAMAK AND SUBRAM) INFESTATION IN THE SUDAN SAVANNA ECOLOGY REGION OF NIGERIA

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ABSTRACT
The study aimed to evaluate the resistance of various cowpea genotypes to *Striga gesnerioides* and leaf smut under natural infestation. Field trial was conducted at the research farm of the International Institute of Tropical Agriculture (IITA) at Minjibir, Nigeria (12°10′42” N; 8°32′39″E). The study revealed a significant insight into the performance of cowpea genotypes under biotic stresses. While flowering time showed no significant (P≥>0.05) differences across genotypes, a highly significant differences (P≤ < 0.01) were observed in *Striga* and smut counts, indicating genotype-specific resistance. Genotypes SNQ 100, 103, 105, 106, 107, and 108 demonstrated delayed *Striga emergence* with lower *Striga* counts, while genotypes SNQ 10, 101, 105, 107, and 42 exhibited lower smut counts. The study did not find any significant difference among the tested genotypes in terms of nodule size and fodder weight. However, there was significant difference (P ≤ 0.001) in pod weight. Genotype SNQ 105 recorded the highest pod weight (1957.5 kg). Correlation analysis showed various relationships among the key parameters, with days to first flowering positively correlating with days to 50%, 95% flowering, and negatively correlating with pod and grain yield, although these correlations were not statistically significant. The study emphasizes the significance of selecting cowpea genotypes resistant to *Striga gesnerioides* and leaf smut for improved cowpea production and sustainable agricultural practices.
Keywords: Cowpea, genotype, biotic stress, *Striga gesnerioides*, leaf smut

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.], also known as black-eyed pea, is an important grain legume widely cultivated in Nigeria. This crop holds high agronomic, nutritional, and economic importance, particularly in the semi-arid tropics, where it is predominantly cultivated by resource-poor farmers (Timko and Singh, 2021). Cowpea, a member of the Fabaceae family and native to Africa, is valued for its nutritional content, adaptability to diverse agro-ecological zones, and its ability to fix atmospheric nitrogen (Timko & Singh, 2008). Its protein content ranges from 21% to 33% (Boukar *et al.*, 2019). Due to the ability to fix atmospheric nitrogen through symbiosis with Rhizobia it breaks pest and disease cycles, enhancing soil health and promoting agricultural sustainability in drought and heat stress regions (Timko and Singh, 2020; Kumar *et al.*, 2023). Nigerians rely heavily on cowpeas as a source of protein in their diet, and they are major producers and consumers of this grain legume worldwide. Despite its importance, cowpea crop is most attractive to pest and diseases. Biotic constraints to its cultivation include parasitic weed and leaf smut infestations (Runo and Kuria, 2018).

A parasitic weed called *Striga gesnerioides* clings to cowpea roots resulting in restricted development and decreased yields. It can stay in the soil for over 20 years making cowpea production very challenging particularly in low-fertility soils, where it forces farmers to give up their farmed areas (Parker, 2019). Another major biotic constraint to cowpea production is leaf smut, which is caused by *Protomycopsis phaseoli* (Adejumo *et al.*, 2001; Adejumo and Ikotun, 2003). Smut creates sooty-black to ash-grey, dark lesions that have a detrimental effect on yield and leaf photosynthetic efficiency, particularly in areas with high humidity and inadequate air circulation (Chikoye *et al.,* 2020). Those biotic stresses added to the drought and poor soil fertility cause significant yield losses and threaten food security and farmer livelihoods (Ejeta, 2007; Boukar *et al.,* 2016). The use of resistant varieties happens to be the most effective method of controlling these bedeviling parasite (Omoigui *et al.,* 2021). To address the challenges posed by *Striga* and smut infestations in cowpea, it is essential to develop and evaluate cowpea genotypes with inherent resistance. This research specifically seeks to pinpoint such resistant genotypes by carefully assessing the incidence and severity of both infestations. This approach aims to provide a sustainable and economically viable solution to manage these threats effectively.

MATERIALS AND METHODS

Experimental site

Field trial was conducted at the Research farm of the International Institute of Tropical Agriculture (IITA) Kano Station at Minjibir, located 45 km North of Kano in the Sudan savannah agro-ecological zone of Nigeria. The trials site lies approximately 12°10′42” N latitude and 8°32′39″E longitude, situated at an altitude 500 m above sea level. This trial took place during the 2023 rainy season, which typically spans from June/July to October,

Treatments and Experimental design

The cowpea seeds (F_5 generation) used for the study were obtained from the International Institute for Tropical Agriculture (IITA) Kano station. The experiment was laid out following the alpha lattice design, which featured a block structure with a 1.0 m width for each block and a 0.5-meter alley demarcating the individual plots. Within each block, a total of four plants were meticulously arranged, and a total of 96 plants were tagged for data collection.

The experimental field was first cleared of shrubs and other debris. It was later harrowed and ridged prior to planting. The seeds were sown at a depth of 3 - 5cm to prevent seed dormancy on 0.25 m (intra row) and 0.75 m (inter row) Ridges.

Pest and Disease Management

The experimental plots were manually two consecutive times using hand-held hoes at an interval of 3 weeks. The experimental plots were equally sprayed with a broad-spectrum insecticide (Cypermethrin) at a rate of 50 ml per 15 liters of water, applied using a 16L knapsack sprayer, to manage the population of flower thrips and pod-sucking insects such as *Maruca vitrata* and *Helicoverpa armigera*.

Fertilizer Application The fertilizer was applied manually by placing it beside the plant roots using band placement. A single application of SSP was made two weeks after sowing (WAS).

Observations and Data Collection

Data collection commenced when the plants initiated the flowering phase and continued until 90% of maturity. In each block, one plant was specifically chosen, tagged, and utilized for the purpose of easy block identification and streamlined data collection. Data were collected on the following parameters: number of days to first flowering, days to 50% flowering, days to 90% maturity, days to first *Striga* emergence, nodule size, pod weight, seed weight, and fodder weight, using standard agronomic procedures. Additionally, the incidence and severity of leaf smut was monitored and recorded. This systematic observation ensured comprehensive data collection on both growth parameters and biotic stress factors affecting the cowpea plants.

Data analysis

All data collected was subjected to analysis of variance (ANOVA) using SAS (Version 9.4) and significant means were separated using Student Newman-Keuls Test (SNK) at 5% probability level.

RESULTS AND DISCUSSION

The results from the analysis of variance in Table 1 did not show any significant difference among the tested genotypes in terms of days to first flowering, days to 50% flowering, smut count, nodule size, pod weight, grain yield, and fodder yield. In contrast, *Striga* count was highly significant.

Mean performance of cowpea genotypes on growth related characters

Table 2 presents the mean performance of various cowpea genotypes for the growth and agronomic characteristics, including the number of days to first flowering, 50% flowering, *Striga* count, and smut count. The result indicates that the number of days to first flowering and 50% flowering did not show significant differences (P ≥0.05) among the tested genotypes, with a range from 39.0 to 50.0 days. This is consistent with findings by Mussa et al. (2023), who reported similar flowering durations of 37 to 52 days for cowpea genotypes, suggesting variability in flowering time but no significant differences across genotypes. The number of days to first *Striga* emergence did not differ significantly (P ≥ 0.05) across the genotypes. However, there was a highly significant difference (P≥ 0.01) on *Striga* and smut counts. This finding also aligns with those of Chikoye *et al*. (2020) who reported similar significant variability in *Striga* and smut infestations, with some genotypes showing higher resistance. Genotypes SNQ 100, 103, 105, 106, 107, and 108 demonstrated delayed *Striga* emergence and lower *Striga* counts, suggesting a potential hypersensitive reaction indicative of *Striga* resistance. However, genotypes SNQ 10, 101, 105, 107, and 42 exhibited lower smut counts compared to the other genotypes.

Table 3 shows the mean performance of cowpea genotypes on yield related characters under natural *Striga* and Smut infestations. The nodule size did not show any significant variation (P≥ 0.05) across the genotypes. This result contradicts the findings of Kumar *et al.* (2023), who reported significant differences in nodule size among cowpea genotypes, suggesting that the study conditions especially the soils types and genetic material might be different. Pod weight exhibited a significant difference (P≥ 0.01) among the genotypes, ranging from a maximum of 1,838.0 kg in genotype SNQ 79 to a minimum of 829.5 kg in genotype SNQ 62. This aligns with findings by Adeyemo *et al.* (2022), who reported significant variability in pod weight among cowpea genotypes. Grain yield did not show any significant differences (P > 0.05), with values ranging from a highest of 1,357.0 kg seed weight in genotype SNQ 79 to a lowest of 474.0 kg in genotype SNQ 56. Similarly, fodder yield did not show any significant differences (P≥ 0.05), with values ranging from highest of 22,333.5 kg fodder yield in genotype SNQ108 to a lowest of 8,560 kg in fodder weight. This is consistent with the results of recent studies of Chikoye *et al*. (2020) who observed similar ranges in seed weight of cowpea genotypes.

Correlation Analysis

Table 4 offers a correlation co-efficient which highlights both positive and negative relationships among the primary parameters within the dataset. The correlation between days to first flowering and days to 50% flowering is positive, though statistically insignificant (r = 0.462**). This suggests that an increase in the time to first flowering may be associated with a similar increase in the time required for 50% flowering, a trend also observed by Nguyen and

Robinson (2022). Additionally, positive but statistically insignificant correlations are observed between days to first flowering and days to 95% flowering (r = 0.057) and Fodder Yield (r = 0.078). These findings imply that longer durations to first flowering might slightly extend the overall flowering period and possibly increase fodder production, as suggested by Patel *et al*. (2018).

Conversely, the correlation between days to first Flowering and pod weight (r = -0.105) as well as seed weight (r = -0.095) was negative but statistically insignificant, indicating a trend where longer times to first flowering could be associated with a reduction in pod and seed weights, which is consistent with the findings of Ramirez and Wilson (2017). Regarding *Striga* count, a positive yet statistically insignificant relationship existed with pod weight (r = 0.056) and a negative insignificant correlation with grain yield (r = -0.066) are observed. This indicates that higher *Striga* infestations is linked to a decrease in both pod and grain yield, suggesting a detrimental impact of *Striga* on yield components, which aligns with the conclusions of Hassan *et al* (2023). Similarly, Smut count exhibits a negative but statistically insignificant relationship with pod weight (r = -0.057) and seed weight (r = -0.038), implying that increased smut infestations might slightly reduce these yield components, a pattern observed in previous studies by Johnson et al (2019). Fodder weight shows a positive yet statistically insignificant association with days to first flowering (r = 0.078), showing that a longer time to first flowering might coincide with higher fodder yield, consistent with findings reported by Chen *et al*. (2016). However, pod weight demonstrates a negative yet statistically insignificant relationship with smut count (r = -0.057), suggesting that higher smut infestation could slightly reduce pod weight. These findings emphasize the potential adverse effects of *Striga* and smut infestations on key yield components, such as pod and grain yield, even if the correlations are mild and statistically insignificant. Effective management of these biotic stresses is crucial in optimizing yield, as any negative impact on pod and grain yield could significantly affect overall crop productivity (Smith *et al*., 2020).

CONCLUSION

The study revealed that while cowpea genotypes demonstrated uniformity in flowering time, significant variation exists in their resistance to Striga and smut infestations. Certain genotypes exhibited delayed Striga emergence and lower Striga and smut counts, suggesting potential resistance to these pathogens. Although no significant differences were observed in nodule size, fodder yield, and grain yield, variations in pod weight indicated that certain genotypes might have superior yield potential. The slight negative correlation between flowering duration and pod/grain yield suggests a trade-off between early flowering and yield components. These findings highlight the potential for breeding cowpea varieties with enhanced resistance to Striga and smut while maintaining desirable agronomic traits.

REFERENCES

Adejumo, T. O., Ikotun, T., & Florini, D. A. (2001). Identification and survival of the causal organism of leaf smut disease of cowpea in Nigeria. *Mycopathologia*, *150* (2), 85–90. https://doi.org/10.1023/a:1010838017610

Adejumo, T.O & Ikotun, T. (2003). Effect of planting date on incidence and severity of leaf smut of cowpea in northern Nigeria. *Moor Journal of Agricultural Research,* 4(1), 106-110. doi:10.4314/mjar.v4i1.31762

Boukar, O., Belko, N., Chamarthi, S., Togola, A., Batieno, J., Owusu, E., Haruna, M., Diallo, S., Umar, M. L., Olufajo, O., & Fatokun, C. (2019). Cowpea (*Vigna unguiculata*): Genetics, genomics and breeding. *Plant Breeding*, 138(4), 415-424. doi:10.1111/pbr.12669

Boukar, O., Christian, A. F., Bao-Lam, H., Philip, A. R., & Timothy, J. C. (2016). Genomic tools in cowpea breeding program; status and perspective. Frontiers in Plant Science, 7, 757. https://doi.org/10.3389/fpls.2016.00757

Chen, Y., Tang, H., & Li, J. (2016). Seed weight stability among different cowpea genotypes. *Field Crops Research*, 45(3), 278-285.

Ejeta, G. (2007). The *Striga* scourge in Africa: A growing pandemic. In G. Ejeta & J. Gressel (Eds.), Integrating New Technologies for *Striga* Control: Towards Ending the Witch- hunt (pp. 3-16). *World Scientific Publishing Co. Pte. Ltd*.

Hassan, A., & Ibrahim, N. (2023). Strategies for breeding cowpea varieties resistant to *Striga* and smut. *Food Security and Agricultural Development*, 12(1), 89-97.

Johnson, M., & Lee, R. (2019). Evaluation of cowpea genotypes for resistance to *Striga gesnerioides*. *Agricultural Research Journal*, 45(2), 134-142.

Nguyen, T., & Robinson, S. (2022). Correlation between flowering duration and seed weight in cowpeas. *Journal of Agricultural Science*, 60(2), 147-156.

Patel, S., Gupta, D., & Rao, V. (2018). Comparative study of nodule development and fodder weight in cowpea varieties. *Legume Research*, 41(1), 50-58.

Ramirez, P., & Wilson, K. (2017). Pod and seed weight variations in cowpea genotypes under different environmental conditions. *Plant Breeding*, 36(4), 324-330.

Smith, J., & Thompson, L. (2020). Analysis of flowering time in diverse cowpea genotypes. *Journal of Crop Science*, 56(3), 210-220.

Table 1: ANOVA Analysis

Source of variance	Degree of freedom	Days to first flowering	Days to 50% flowering	Striga count	Smut count	Nodule size	Pod Weight	Grain Yield	Fodder Yield
Genotype	20	41.53	55.29	4.692**	0.5146	1.1366	322942	203181	18611652
Replication	1	6.39	214.28	0.000	0.0678	0.2689	98630	14163	326044
Error	19	31.04	62.28	0.000	0.4951	1.0316	322236	205477	16538339

** Highly significant at **($p \leq 0.01$) and *Significant at ($p \leq 0.05$)**

Table 2: Mean performance of yield growth characters of cowpea genotypes under Natural *Striga* and Smut infestation

Genotype	Days to first flowering (#)	Days to 50% flowering (#)	*Striga* count (#)	Smut count (#)
SNQ10	43.0	48.75	1	1.00
SNQ40	39.0	42.5	1	1.00
SNQ41	44.0	48.0	1	1.80
SNQ42	47.0	50.0	1	1.00
SNQ45	42.0	40.5	1	2.50
SNQ56	42.0	46.5	5	1.00
SNQ59	42.0	46.0	1	1.75
SNQ62	44.0	48.0	3	2.50
SNQ65	45.0	48.5	1	1.00
SNQ71	37.0	41.5	1	1.00
SNQ79	38.0	43.0	1	1.75
SNQ100	47.5	55.00	0	1.75
SNQ101	39.0	42.25	1	1.00
SNQ102	39.0	43.75	1	1.75
SNQ103	39.0	43.00	0	2.50
SNQ104	44.0	51.25	1	1.75
SNQ105	44.0	49.00	0	1.00
SNQ106	44.0	49.50	0	1.75
SNQ107	42.0	48.50	0	1.00
SNQ108	44.0	50.50	0	1.75
FProb	0.057	0.7401	0.0002	0.418
SE ±	5.572	7.89	0.0060	0.49775

Table 3: Mean performance of yield characters of cowpea genotypes under Natural *Striga* and Smut infestation

Genotype	Nodule Size (g)	Pod weight (Kg ha^{-1})	Grain Yield (Kg ha^{-1})	Fodder Yield (Kg ha^{-1})
SNQ10	1.00	1610.5	1213.0	8560.0
SNQ40	1.75	1145.0	702.0	16686.5
SNQ41	2.00	1182.5	1068.0	19940.0
SNQ42	1.00	1243.5	986.5	16880.0
SNQ45	1.75	629.0	931.5	21726.5
SNQ56	1.00	677.5	474.0	22000.0
SNQ59	2.50	1478.0	1151.5	18586.5
SNQ62	3.50	829.5	531.0	19180.0
SNQ65	1.00	889.0	630.0	18740.0
SNQ71	2.00	1760.5	1386.5	22127.0
SNQ79	2.50	1838.0	1357.0	21573.5
SNQ100	1.75	1855.5	1470.5	17580.0
SNQ101	3.25	1601.5	1298.0	9966.5
SNQ102	2.75	1346.0	1039.5	18953.5
SNQ103	2.50	1314.0	775.0	21886.5
SNQ104	3.50	1773.0	982.5	18986.5
SNQ105	1.75	1957.5	1463.0	18480.0
SNQ106	3.50	1402.0	598.0	17573.5
SNQ107	2.00	1493.5	639.0	16500.0
SNQ108	2.50	1707.0	882.5	22333.5
FProb	0.299	0.0001	0.525	0.260
SE ±	0.001.0	568	453.30	4066.74

Means with different letter(s) are significantly difference according to SNK at 5% probability level.
Smut count on a scale of 1-5 with 1= 0-5, 2= 1-10, 3= 11-20, 4= 21-30 and 5= 31% + Infected Plants

Table 4: Correlation Coefficient between growth and yield related characters of cowpea genotypes to *Striga* and leaf smut count

	S1	S2	S3	S4	S5	S6	S7	S8	S9
S1	1								
S2	0.462	1							
S3	0.056	0.057	1						
S4	-0.105	0.003	0.088	1					
S5	-0.095	-0.105	0.110	0.918	1				
S6	-0.135	-0.281	0.013	0.021	0.011	1			
S7	0.078	-0.001	-0.068	0.143	0.092	0.126	1		
S8	-0.008	-0.017	0.010	0.056	0.066	0.067	0.015	1	
S9	-0.087	0.007	-0.055	-0.057	-0.038	-0.038	0.028	0.032	1

S1=Days to first flowering; S2=Days to 50% flowering; S3= Days to 95% Maturity
S4= Pod weight (kg ha^{-1}); S5= Seed weight (kg ha^{-1}); S6= Nodulation count
S7= Fodder weight (kg ha^{-1}); S8= Striga count; S9= Smut count.

PERFORMANCE OF SOYBEAN (*Glycine max* [Merill] L.) VARIETIES IN SUDAN SAVANNAH ENVIRONMENT

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ABSTRACT

A field experiment was conducted at the teaching and research farm of the Faculty of Agriculture, Bayero University Kano in 2023 cropping season to evaluate the performance of soybean varieties for growth and grain yield. The treatments consist of six varieties of soybean: TGX1448-2E, TGX1904-6F, TGX1951-3F, TGX2029-21F, TGX2029-22F, TGX2029-27F. The experiment was laid out in a Randomized Complete Block Design (RCBD) and it was replicated three times. Data was collected on days to 50% flowering, leaf area index, photosynthetic active radiation, days to physiological maturity, ambient temperature, relative chlorophyll, leaf thickness and grain yield. The data collected was subjected to analysis of variance (ANOVA) using Genstat software. The result reveals a significant difference in some of the studied traits; days to 50% flowering, days to 95% maturity, grain yield, leaf area index and intercepted photosynthetic active radiation. The highest grain yield was observed in the variety TGX1951-6F. The variety TGX1951-3F is therefore, recommended for optimum grain yield in the savannas of northern Nigeria. However, the late maturing variety TGX1904-6F is not recommended for the Sudan Savannah due to the short growing season in this zone.

Key words: Soybean, Varieties, Performance, Grain yield.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is a legume crop known for its substantial protein content (40%) and high-quality oil (20%). It holds a crucial position among leguminous crops in tropical countries' cropping systems (Anderson *et al.*, 2019). Demonstrating remarkable versatility, soybean finds approximately 365 applications in the formulation of human and animal foods, as well as various industrial uses (Singh *et al., 2008*). Among food crops, soybean boasts the highest protein content and is surpassed in oil content only by groundnut, ranking second among food legumes. The protein and amino-acid levels in soybean grains are comparable to those in cow milk. Notably, the fat derived from soybean grains is of the unsaturated type, making it a recommended choice for individuals with cardiovascular disorders (Adeleke and Babalola, 2020). Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. It is also a prime source of vegetable oil in the international market. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria (Hartman *et al*., 2011).

Soybean is also a prime source of vegetable oil in the international market. It has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria (Hartman *et al*., 2011). Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free. The rapid growth in the poultry sector in the past five years has also increased demand for soybean meal in Nigeria (Omotayo *et al*., 2007). There are several limitations to soybean production such as low yield, susceptibility to pests and diseases, adverse environmental conditions etc. (Hartman *et al*., 2011). Soybean production among smallholder farmers in the savannahs of Nigeria is notably constrained by poor fertile soil and unavailability of available soil phosphorus, diseases such as soybean rust and moisture stress as a result of drought (Ronner *et al*., 2022). Soil P levels in Nigerian savannahs are generally below critical levels (10-15 mg kg^{-1}) required for soybean production (Ekeleme *et al*., 2012). Because of very low soil available phosphorus and organic matter, soybean yield is limited (Almeida *et al*., 2018).

Water is also a limiting factor and an important management concern in soybean production (Grassini *et al*., 2015). The risk of drought is high in the Sudan savannah because rainfall is unreliable and its distribution is erratic (Boansi *et al*., 2019). This drought mostly coincides pod-filling and flowering, this causes serious instability at farm levels. Soybean requires the highest amount of water during its flowering stage but its sensitive to water deficit during its pod filling process. Soil water deficit causes as much as 20% flower abortion which reduces pod number. It can also affect seed sizes and seeds per pod but to a lesser extent than pod number (Liu *et al*., 2003). Severe loss of grain yield and quality is caused by high temperature which results to reduced fertilization (Krishnan *et al*., 2011).

There's a need to continuously try to improve soybean varieties mainly to improve yield and developed drought and disease resistant varieties (Dubey *et al*., 2019). Therefore, the objective of this study is to evaluate the performance of soybean varieties in Sudan savannah environment.

MATERIAL AND METHODS

Study location

The experiment was conducted in 2023 during the growing season at Bayero University Kano (BUK) (11°58'N, 8°24'E, 470.9m above sea level) in the Sudan savanna of Nigeria. The mean annual rainfall in Kano ranges between 600- 800 mm with a short growing season (3.5 months) and a long dry season of around 6-9 months (Ayanlade, 2009). The region also has high average annual minimum and maximum temperatures of around 22°C and 32°C, respectively.

Treatment and experimental design

The treatments consisted of six varieties of soybean (TGX1448-2E, TGX1904-6F, TGX1951-3F, TGX2029-21F, TGX2029-22F, and TGX2029-27F). The varieties were obtained from International Institute of Tropical Agriculture (IITA) Kano. The experimental design was a randomized complete block design (RCBD), which was replicated three times.

The experimental field was disk-harrowed and ridged before planting. The plots were then laid out using a measuring tape, peg, and sisal rope. The plot consisted of 4 ridges (spaced at 75cm apart, making a 3m width) of 5 m in length. Thus, the gross plot size was 15m^2 (3m x 5m). The net plots were the 2 inner ridges, making up a net plot size of 7.5m^2 (1.5m x 5m). There was a discard of 0.75m between each plot and 2m between each replicate to facilitate easy movement within the experimental field.

Field management

The soybean seeds were sown on the specified window at the respective experimental sites at a depth of 5cm using 6 seeds per hole and later thinned to 4 plants per hill at a spacing of 75cm x 10cm inter and intra-row spacing, respectively to have 533,333 plants/ha.

Fertilizer application was done at planting. Phosphorus and potassium were applied in the form of Triple Superphosphate fertilizer (TSP 46 % P_2O_5) and murate of potash (MOP 49.8 % K) to supply 40kg/ha of P_2O_5 and K_2O, respectively which is equivalent to 17 kg P/ha and 33 kg K/ha. Nitrogen fertilizer was not applied because it has no significant effect on the seed yield (Ohyama *et al.*, 2017). Gramaxone at a rate of 1 L ha^{-1} was applied immediately after sowing using a knapsack sprayer. This was followed by hoe weeding at 3 weeks after planting.

Harvesting was done when the plants reached physiological maturity. This was carried out from the two innermost middle rows in each plot by cutting the plants from the surface. The harvested plants were dried in the field and threshed manually.

Data collection and analysis

Days to 50% Flowering was measured by observing and recording the day in which half of the plant in the net plot flowered for each treatment. Leaf area index and Photosynthetic active radiation were measured at full flowering using AccuPAR model LP-80 PAR/LAI Ceptometer, five measurements within the net plot were randomly taken, averaged, and recorded for each plot for each parameter. Number of Days to Physiological Maturity was recorded as the number of days from sowing to when about 95% of the pods in the 2-middle rows of a plot had dried. Ambient temperature was measured using a temperature sensor by placing it mid-height of the plant in between rows, five random measurements were taken and the display, averaged and recorded. Relative chlorophyll was measured by placing the instrument SPAD-502 meter at a point one-half the distance from the leaf tip to the collar and halfway between the leaf margin or edge and the leaf midrib, five measurements within the net plot were randomly taken, averaged, and recorded for each plot. Leaf thickness was measured using a leaf area meter, this was done for five random leaves within the net plot the results was averaged and recorded.

Harvested pods from each net plot except the quadrant area was threshed and the grains were then weighed and added to those from the quadrant area, and final grain yield was adjusted to 12% moisture content and expressed in kg ha^{-1}.

The data collected was subjected to analysis of variance (ANOVA) using Genstat software. The differences among individual treatments and their interactions were determined using the Student-Newman Keuls test (SNK) at 5% level of significance. Correlation and principal component analysis were done using JMP software.

RESULTS AND DISCUSSION

Significant differences (P<0.05) were observed among the varieties on days to 50% flowering, days to 95% maturity, grain yield, leaf area index and intercepted photosynthetic active radiation (Table 1). Variety TGX2029-27F reach 50% flowering with a mean of 46.3 days, followed by TGX2029-22F and TGX2029-21F with a mean of 47 days and 48 days respectively, whereas TGX1448-2E, TGX1904-6F and TGX1951-3F flowered late with the mean of 59.7, 56.7 and 50.7 days respectively (Table 1). Variety TGX2029-21F matured earlier than the other varieties with a mean of 112.3 days, this is on par with TGX2029-27F, TGX2029-22F and TGX1951-3F with a mean of 113.3, 112.7 and 115 days respectively, whereas TGX1904-6F and TGX1448-2E matured late with an average mean of 123.3 and 129 days respectively (Table 1). The significant differences observed among the soybean varieties for days to 50% flowering and 95% maturity show that the varieties have different maturity groups. This goes in tandem with the findings of Kantolic & Slafer (2001) who reported that soybean varieties have different maturity groups which is as a result of different response to day length.

TGX1448-2E has the highest leaf area index with an average mean of 7.7 which was on par with TGX1904-6F with a mean of 7.5, the lowest leaf area index was observed in TGX2029-27F with a mean of 5.8 which was statistically the same with TGX2029-22F having a mean of 6.17 (Table 1). TGX1448-2E intercepted more photosynthetic radiation with a mean of 97.0 followed by TGX1904-6F and TGX1951-3F with a mean of 96.2 and 93.9 respectively, while the lowest photosynthetic radiation was intercepted by TGX2029-27F with a mean of 85.9 (Table 1). The significant differences observed among the soybean varieties for leaf area index and intercepted photosynthetic active radiation indicates that the wider the leaf area, the more the photosynthetic active radiation intercepted. Higher LAI probably contributes to suppression of weeds while higher photosynthetic active radiation (PAR) leads to more photosynthates assimilation, which ultimately results in higher grain yields and biomass. This goes in tandem with the findings of Pearce *et al*. (1967) who reported that as LAI increases, so does light interception.

TGX1951-3F has the highest yield, producing 2438kg/ha, followed by TGX2029-21F with an average yield of 2315kg/ha. The lowest yielding varieties were TGX1904-6F and TGX2029-27F yielding just 1931kg/ha and 1951kg/ha respectively (Table 1). The differences among the varieties on grain yield is significant, which indicates that TGX1951-3F is a high yielding variety while TGX1904-6F gave a lower yield. This can be due to the fact that TGX1951-3F is an early maturing variety which does better in the sudan savannah zone which has a shorter growing season. This goes in tandem with the findings of Bebeley *et al*. (2022) who reported that the variety TGX1951-3F performed better than TGX1904-6F in all agro-ecologies. No significant difference was observed among the varieties on ambient temperature, relative chlorophyll and leaf thickness (Table 1).

Days to 50% flowering had a significant positive correlation with days to 95% maturity (0.964**), LAI (0.814**) and IPAR (0.701**). Days to 95% maturity had a significant positive correlation with LAI (0.770**) and IPAR (0.681**). LAI had a significant positive correlation with IPAR (0.825**) (Table 2). No positive correlation effect was found among the other parameters (Table 2). Figure 1 shows Principal component analysis (PCA) of soybean accessions. The first and second PCs contributed about 62.1% of the total variability. The analysis revealed traits that are similar with superior genotype performance; for ambient temperature, TGX2029-27F, TGX2029-22F and TGX2029-21F had superior performance. Relative chlorophyll, grain yield and leaf thickness are similar with each other and TGX1951-3F had superior performance. Days to 95%

flowering and days to 50% flowering are similar and TGX1904-6F and TGX1448-2E had superior performance.

CONCLUSION

In conclusion, this comprehensive research sheds more light on the performance of soybean varieties in the Sudan Savannah environment. Through meticulous analysis, it became evident that TGX1951-3F performs best in the research area. The findings underscore the critical importance of identifying and promoting the best performing soybean varieties in the Sudan Savannah environment on basis for future exploitation. It also provides valuable insight for farmers, researchers and agronomists aiming to optimize soybean production through the selection of the best varieties suitable for their agro ecological zone.

REFERENCES

Adeleke, B. S., & Babalola, O. O. (2020). Oilseed crop sunflower (*Helianthus annuus*) as a source of food: Nutritional and health benefits. *Food Science & Nutrition*, *8*(9), 4666-4684.

Almeida, D. S., Rocha, K. F., de Souza, M., Delai, L. B., & Rosolem, C. A. (2018). Soil phosphorus bioavailability and soybean grain yield impaired by ruzigrass. *Agronomy Journal*, *110*(2), 654-663.

Anderson, E. J., Ali, M. L., Beavis, W. D., Chen, P., Clemente, T. E., Diers, B. W., ... & Tilmon, K. J. (2019). Soybean [*Glycine max* (L.) Merr.] breeding: History, improvement, production and future opportunities. *Advances in plant breeding strategies: legumes: Volume 7*, 431-516.

Ayanlade, A. (2016). Seasonality in the daytime and night-time intensity of land surface temperature in a tropical city area. Science of the total Environment, 557, pp. 415-424. Doi: 10.1016/j.scitotenv.2016.03.027.

Bebeley, J. F., Kamara, A. Y., Jibrin, J. M., Akinseye, F. M., Tofa, A. I., Adam, A. M., ... & Solomon, R. (2022). Evaluation and application of the CROPGRO-soybean model for determining optimum sowing windows of soybean in the Nigeria savannas. *Scientific Reports*, *12*(1), 6747.

Boansi, D., Tambo, J. A., & Müller, M. (2019). Intra-seasonal risk of agriculturally-relevant weather extremes in West African Sudan Savanna. Theoretical and Applied Climatology, 135, 355-373.

Dubey, A., Kumar, A., Abd_Allah, E. F., Hashem, A., & Khan, M. L. (2019). Growing more with less: breeding and developing drought resilient soybean to improve food security. Ecological Indicators, 105, 425-437.

Ekeleme, F., Omoigui, L. O., & AJEIGBE, H. A. (2012). Phosphorus and nitrogen fertilization of soybean in the nigerian savanna. *Experimental Agriculture*, *48*(1), 39-48.

Grassini, P., Torrion, J. A., Yang, H. S., Rees, J., Andersen, D., Cassman, K. G., & Specht, J. E. (2015). Soybean yield gaps and water productivity in the western US Corn Belt. *Field Crops Research*, *179*, 150-163.

Hartman, G.L., West, E.D., Herman, T.K. (2011). Crops that feed the world 2. Soybean - worldwide production, use, and constraints caused by pathogens and pests. Journ. Food Secur. Vol. 3, pp 5 -17

Kantolic, A. G., & Slafer, G. A. (2001). Photoperiod sensitivity after flowering and seed number determination in indeterminate soybean cultivars. *Field Crops Research*, *72*(2), 109-118.

Krishnan, P., Ramakrishnan, B., Reddy, K. R., & Reddy, V. R. (2011). High-temperature effects on rice growth, yield, and grain quality. Advances in agronomy, 111, 87-206.

Liu, F., Andersen, M. N., & Jensen, C. R. (2003). Loss of pod set caused by drought stress is associated with water status and ABA content of reproductive structures in soybean. Functional Plant Biology, 30(3), 271-280.

Ohyama, T., Tewari, K., Ishikawa, S., Tanaka, K., Kamiyama, S., Ono, Y., ... & Takahashi, Y. (2017). *Role of nitrogen on growth and seed yield of soybean and a new fertilization technique to promote nitrogen fixation and seed yield* (pp. 153-185).

Omotayo, A. M., Olowe, V. I. O., Fabusoro, E., Babajide, J. M., Ojo, D. K., & Adegbite, D. A. (2007). Commercial demand for soybean in Nigeria.

Pearce, R. B., Brown, R. H., & Blaser, R. E. (1967). Photosynthesis in Plant Communities as Influenced by Leaf Angle 1. *Crop Science*, *7*(4), 321-324.

Ronner, E., Franke, A. C., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., ... & Giller, K. V. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. *Field Crops Research*, *186*, 133-145.

Singh, P., Kumar, R., Sabapathy, S. N., & Bawa, A. S. (2008). Functional and edible uses of soy protein products. *Comprehensive reviews in food science and food safety*, *7*(1), 14-28.

Table 1: Evaluation of Soybean varieties for growth and grain yield in Sudan Savanna of Nigeria

Variety	Days to 50% flowering	Days to 95% maturity	Ambient Temperature	Relative Chlorophyll	Leaf Thickness	Grain Yield (kgha^{-1})	Leaf Area Index	Intercepted photosynthetic Active radiation
TGX1448-2E	59.7a	129.0a	36.2	37.6	1.20	2252.0ab	7.7a	97.0a
TGX1904-6F	56.7b	123.3b	36.1	45.1	1.17	1913.0c	7.5a	96.2a
TGX1951-3F	50.7c	115.0c	36.4	51.2	2.05	2438.0a	6.7ab	93.9a
TGX2029-21F	48.0d	112.3c	35.9	38.8	1.13	2315.0ab	6.6ab	91.7ab
TGX2029-22F	47.0de	112.7c	36.1	42.0	1.17	2150.0b	6.17b	90.1ab
TGX2029-27F	46.3e	113.3c	36.1	38.0	1.01	1951.0c	5.8b	85.9b
P value	<.001	<.001	0.783	0.116	0.462	<.001	0.006	0.008
S.E.D.	0.509	0.962	0.2775	4.86	0.533	85.00	0.412	2.395

Mean within same treatment column followed by different letters are significantly different using Student–Newman–Keuls (SNK) at 5% level of probability

Table 2: Correlation among soybean traits

	Days to 50% flowering	Days to 95% maturity	Ambient Temperature	Relative Chlorophyll	Thickness	Grain yield	LAI	IPAR
Days to 50% flowering	1.000							
Days to 95% maturity	0.964**	1.000						
Ambient Temperature	0.034	0.044	1.000					
Relative Chlorophyll	0.009	-0.088	0.002	1.000				
Thickness	0.072	-0.045	0.035	0.384	1.000			
Grain yield	-0.024	-0.111	-0.063	0.259	0.140	1.000		
LAI	0.814**	0.770**	0.200	0.097	-0.136	0.060	1.000	
IPAR	0.701**	0.681**	0.054	0.207	-0.211	0.171	0.825**	1.000

Leaf area index (LAI), and intercepted photosynthetically active radiation (IPAR). Significant correlations are indicated by ** ($p < 0.01$).

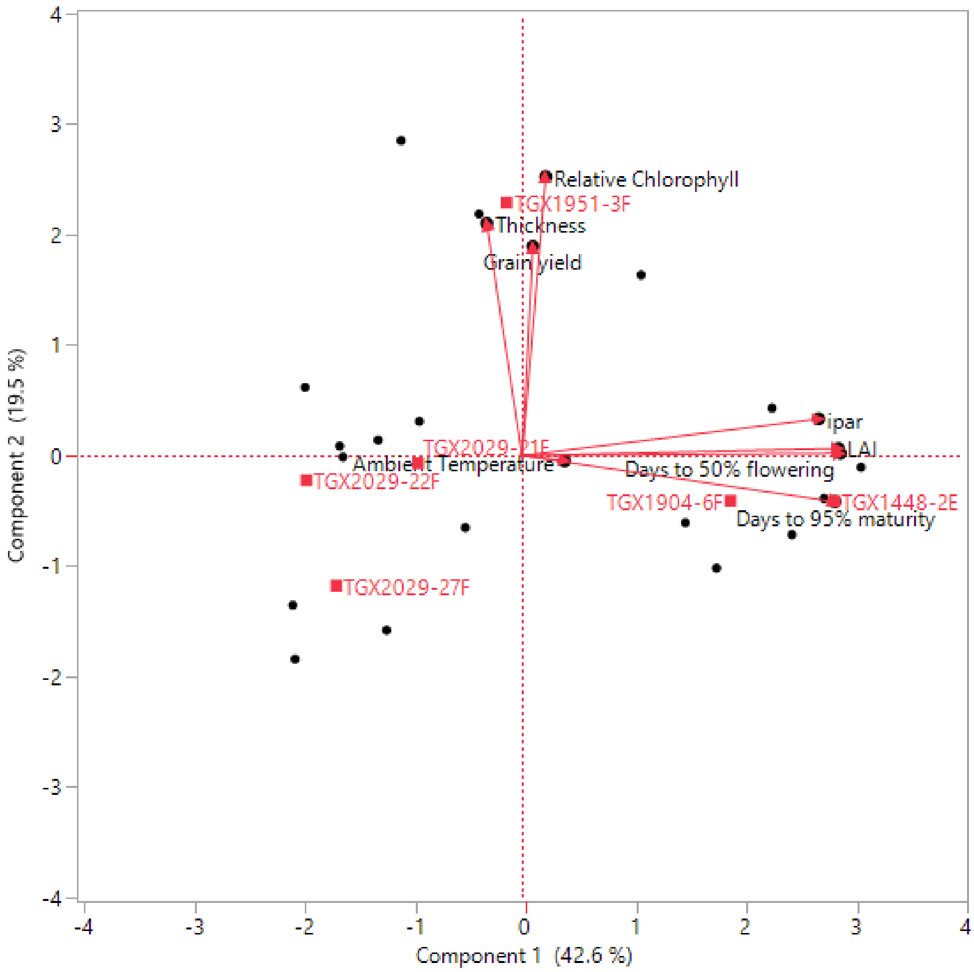

Figure 1: Principal component analysis of the soybean traits

PHENOTYPIC EVALUATION OF SORGHUM (*Sorghum bicolor* L. Moench) GERMPLASMS FOR VARIATION IN PHYTIC ACID CONTENT IN GUINEA AND SUDAN SAVANNAS OF NIGERIA

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ABSTRACT

Field experiments were conducted in 2020 rainy season at the National Institute for Horticultural Research (NIHORT) Bagauda, Kano (latitude 11° 33'N and longitude 8° 23'E) situated in the Sudan Savannah and Institute of Agricultural Research (IAR) Samaru, Zaria (latitude 11° 61'N and longitude 7° 64') situated in the Northern Guinea savannah agro-ecological zone Nigeria to evaluate the phenotypic diversity of Sorghum germplasm and its phytic acid contents. Experimental treatments consisted of 730 genotypes laid out in an alpha lattice design and replicated twice. Results showed that there was highly significant statistical variation ($P \leq 0.05$) among the growth, phenological, yield and quality traits. The traits evaluated includes days to 50% flowering, days to physiological maturity, panicle length, panicle exertion, panicle compaction and shape (form), grain, maturity group, grain yield panicle, grain yield. The result of the mean total grain yields of the germplasms indicated high variation in grain yield from both locations. Result also indicated that out of 500 germplasms subjected to phytic acid analysis, 145 germplasms were screened as having high level of phytic acid while the remaining 355 germplasms are having low phytic acid. It can be concluded that the development of low phytic acid sorghum assumes much-more significance in the context of increasing uses of sorghum as diverse value-added food products. Sorghum is very rich in genetic diversity, the present study showed the possibility to get genotypes with reduced PA, if large-scale screening for reduced phosphate is undertaken.

Key words: Phenotypic evaluation, Germplasms, Phytic acid

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is a major staple and fodder crop in tropical/semi tropical Africa and Asia (Doggett, 1988). It is currently considered the fifth most important cereal in the world, followed by wheat, corn, rice and barley (Luna *et al.*, 2018). In the same year, Africa accounted for 65% of the global area cropped to sorghum (more than 29 million hectares) to produce nearly 29 million metric tons, representing more than 40% of global production, with a mean yield of 999 kg ha^{-1} (FAO, 2016). In Nigeria, there are numerous sorghum accessions that are yet to be characterized. Majority of these accessions are planted by farmers on yearly basis using different parameters for identification (Alade *et al*., 2017). Sorghum and other cereals are rich in minerals but, the bioavailability of these minerals is usually low because of the presence of anti-nutrition factors such as phytic acid (Valencia *et al*., 1999). Phytic acid has been termed as anti-nutrient, due to its ability to bind minerals, protein and starches, either directly or indirectly and thus alter their soluble functionality and absorption (Nelson, 1967). The effect on nutrition due to phytic acid in human and animals is related to the interaction of phytic acid with proteins, vitamins, and several minerals, thereby restricting their bio-extractability (Svanberg and Lorri, 1997). In view of these adverse effects, attempts have been made to reduce the content of PA in crops (Aggarwal *et al.,* 2018; Eltyeb and Ahmed, 2017; Suha and Babiker, 2015; Abdelseed *et al.*, 2011). In sorghum, decortications, milling, and soaking have been employed traditionally to reduce concentration of PA, but these have been implicated in the losses of several other essential nutrients (El Tyeb, 2017). Advances in biotechnology have opened a promising strategy to develop crops with high nutritive values by manipulating the PA bio-synthetic pathway. Before the manipulation, an effective phenotypic evaluation of all existing germplasm especially as it relates to their PA contents is a major step. Also, information on lowering the PA content of sorghum with improved micro-nutrients bio-availability is very limited. Hence, the need for better understanding of the physiological basis of PA bio-synthesis in sorghum, its distribution in grain and how its accumulation is affected by genetic and environmental factors and possible ways to increase micro-nutrient bio-availability by lowering the effects of PA is essential for developing low-PA sorghum.

MATERIALS AND METHODS

Experimental site and description: Field experiment was conducted at the National Horticultural Research Institute (NIHORT) Bagauda, Kano (latitude 11^{o} 33'N and longitude 8^{o} 23'E) situated in the Sudan Savannah while the second location was at Institute of Agricultural Research (IAR) Samaru, Zaria. (Latitude 11^{o} 61'N and longitude 7^{o} 64') situated in the Northern Guinea Savanna of Nigeria. Before sowing, soil samples were taken from the experimental site in both study seasons for estimating the physical and chemical analyses.

Experimental design and layout: The experimental entries for both locations comprised of 700 genotypes laid out in an alpha lattice design and replicated two times. The crop was sown manually by hand in one-row plots (5m long) at the rate of 2seeds/hill with an inter and intra row spacing of 75cm and 30cm respectively between stands, to produce bulks of selfed grains for nutrient analysis. All other agronomic practices were kept normal and uniform. Sorghum was manually harvested at physiological maturity.

Data collection: Data was taken on plant height, number of days to 50% heading, number of days to 50% flowering, days to physiological maturity, panicle length, panicle exertion, panicle weight, 1000grain weight and grain yield.

Procedure and Method of Phytic Acid Determination: Sample extraction, enzymatic dephosphorylation reaction of phytic acid, Colorimetric determination of phosphorus, and preparation of a phosphorus calibration curve was done using megazyme kit.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) and significant differences were tested. While mean were separated using Student Newman-Keuls test (SNK). Cluster analysis using the K Means clusters was conducted on the grain yield and phytic acid content with a view to grouping the various accessions into clusters.

RESULTS

Table 1 shows the summary statistics of germplasm traits for growth and phenology (Plant height, Days to 50% heading, Days to 50% flowering, Days to maturity) in Bagauda and Zaria. Performance of the germplasm for the trait number of days to 50% heading, depicted considerable variation in both locations. Means for days to 50% heading among the genotype ranged from 55 to 108 days. Germplasm ICSG 1980327 took Minimum 52 days to reach 50% heading, followed by Germplasm ICSG 1981075. Means for days to 50% flowering among the genotype ranged from 56 to 120 days. Same germplasm took Minimum of 56 days to reach 50% flowering. Mean for maturity date at Bagauda ranged from 100 to 183. While mean for maturity date at Zaria range from 97 to 167.

Table 2 shows the summary statistics of germplasm traits for yield and yield components (number of harvested hills, Panicle exertion, Panicle form, Panicle weight/ ha, grain yield/ha, 1000 grain weight). At Bagauda, mean for number of harvested hills ranged from 1 to 16, while at Zaria the mean for number of harvested hills, ranged from 1 to 34. Mean for panicle exertion at both locations ranged from 1 to 4 while mean for panicle form at both locations ranged from 1 to 12. Performance of the genotypes for the trait panicle weight/ ha showed highly significant variation at both locations. At Bagauda, mean for Panicle weight/ ha ranged from 173 to 7640. While Mean for Panicle weight/ ha, at Zaria ranged from 173 to 5664.

At Bagauda, the Mean for 1000 grain weight ranged from 10 to 65 while at Zaria the Mean for 1000grain weight range from 4 to 71. Mean for Grain yield/ha at Bagauda ranged from 80 to 5427 while mean for Grain yield/ha, at Zaria range from 80 to 3936.

Table 3 shows the ANOVA for maturity group for grain yield/ha and 1000 grain weight at both locations. The result evaluated that there was no significant statistical difference in 1000 grain weight at Bagauda and grain yield/ha at Zaria. However, highly significant variation ($P \leq 0.05$) was observed for grain yield/ha at Bagauda where late varieties produce the highest number of grain yield/ha followed by intermediate varieties and the remaining varieties are statistically at par. At Zaria, highly significant variation ($P \leq 0.05$) was observed for 1000grain weight where extra early varieties produced the highest numbers of 1000grain weight followed by early varieties and the late varieties produced the least.

Figure 1 shows summary statistics of germplasms traits of phosphorus and phytic acids. Mean for phosphorus level at Bagauda and Zaria ranged from 0.003 to 2.77, while Mean for Phytic acid at Bagauda and Zaria range from 0.0048 to 9.65. The result also indicated that out of 500 germplasms subjected to Phytic acid analysis, 145 germplasms were screened as having high level of Phytic acid while the remaining 355 germplasms were having low Phytic acid. Varieties such as ICSG 1980456, ICSG 1981395 and ICSG 1980461 are having high level of phytic acid while varieties such as ICSG 1980079, ICSG 1980815 and ICSG 1980847 are having low level of phytic acid.

DISCUSSION

When it comes to the management of germplasm, it is important to consider phenotypic variation or morphological characterization as markers either within or between species, varieties or accessions (Acquaah, 2007). From the results, it was observed that the earliest flowering was 60 days after planting in extra early varieties and the maximum number of days observed after emergence was 143 days in the accessions. Even though the mean was 98 days, the difference is still very wide, which might be due to genetic difference of the genotype in response to flowering and location. This in agreement with the finding of different result (Tekle and Zemach, 2014; Hussain *et al.,* 2011). The tallest plant had a height of 600 cm and the shortest plant had a height of 100 cm. Height plays a major role in harvesting and the plants susceptibility to lodging *(*Lamptey *et al.,* 2014*).* This indicated that the higher the plant, the more the chance of lodging. The result also showed that days to maturity varies within the germplasms due to genetic difference of the germplasms been influenced by the variety. In agreement with the finding of Hussain *et al*.

(2011) different sorghum varieties had different days to maturity; this might be the genotype /variety has different growth degree days.

The analysis of variance for grain yield and yield-related traits of the two locations indicated that genotype and environment are important in governing in the expression of these traits. The result of the mean total grain yields of the germplasms indicated high variation in grain yield from both locations which were influenced by variety. This is in agreement with the finding of (Hussain *et al.*, 2011) different sorghum variety has different grain yield weight than other. Also, in line with the work of (Abush *et al.*, 2001) grain yield was significant difference due to variety, location and the interaction of variety with location. The result also showed the grouping of the germplasms into extra early, early, intermediate and late varieties. Where late varieties produce the highest number of grain yield/h. This result agree with the findings of Baumhard (2005), who reported that late maturity sorghum tend to yield higher than shorter season sorghum hybrids due to the longer grain-filling period and increased vegetative growth.

In the present study, frequency distribution of phytic acid content among the gemplasms showed that there is presence of significant variability for seed phosphorus and phytic acid. A wider range of values were observed for low Phytic acid than high Phytic acid. Low phytate crops have several benefits, as they enhance the bioavailability of 'P' and several important nutritional cations including iron (Warkentin *et al*., 2012). The relative performances of germplasms for quantitative traits such as seed weight, grain yield, and seed phosphorus vary from one environment to another. To develop a variety with high yielding ability and consistency, focus should be placed on the multi-environment testing of genotypes, This result is in agreement with Raboy and Dickinson in which they found significant environmental effects for Phytic acid, which they concluded were due to soil phosphorus availability and hence, soil characteristics should be considered in breeding for low phytic acid.

CONCLUSION

This study revealed significant sufficient genetic diversity in the available sorghum germplasm for different traits. Different genotypes of sorghum displayed potential for selection of the desired characters. The study revealed high level of variation of phytic acid in the germplasm accessions such as 145 germplasms were screened as having high level of phytic acid while the remaining 355 germplasms were having low phytic acid. It can be concluded that the development of low phytic acid sorghum assumes much-more significance in the context of increasing uses of sorghum as diverse value-added food products. Sorghum is very rich in genetic diversity, the present study showed the possibility to get genotypes with reduced PA, if large-scale screening for reduced phosphate is undertaken.

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REFERENCE

Aggarwal, A., Schulz, H., Manhardt, T., Bilban, M., Thakker, R. V. and Kallay, E. (2018). Expression profiling of colorectal cancer cells reveals inhibition of DNA replication licensing by extracellular calcium. *Biochimica et Biophysica Acta (BBA) - Molecular Cell Research*, 1864(6): 987–996.

Alade, O.D., Fayeun, L.S. and Obilana, A.B. (2017). Morphological evaluation of long season sorghum accessions in Akure, south west Nigeria. Proceedings of the 3rd conference of the association of seed scientists of Nigeria (ASSN). Pg 62–69

Doggett, H. (1998). Genetic variability and divergence in sorghum germplasms. *Journal of Agricultural Science*, 43: 824-828.

El Tayeb, O. E. (1991). Effect of Sowing Methods and Fertilization on the Productivity of Fodder Sorghum in a Saline-Sodic Soil, M.Sc. Thesis (Agric.), Faculty of Agriculture, University of Khartoum, Sudan.

FAO (2016). The State of food and Agriculture Climate, Agriculture and Food Security. Food and Agricultural Organization of the United Nations, Rome.

Lamptey, S., Nyarko, G., Falon, A., and Yeboah, S. (2014). Assessing the Performance of Sorghum Varieties in the Guinea Savanna Zone of Ghana. *Asian Journal of Agriculture and Food Science*, Volume 02 – Issue 01, **02**(01), 64–72.

Luna, D.F., Pons, A.B.S., Bustos, D. and Taleinik, E. (2018). Early responses to Fe-deficiency distinguish sorghum bicolor genotypes with contrasting alkalinity tolerance. *Environment and Experiment Botany*, 155: 165-176

Nelson, T. S. (1967). The utilization of phytate –phosphorus by poultry: A review. *Poultry Science*, 46: 862-871.

Svanberg, U. and Lorri, W. (1997). Fermentation and nutrient availability. *Food Control*, 8(5): 319-327.

Valencia, S., Svanberg, U., Sandberg, A. S. and Ruales, J. (1999). Processing of quinoa (*Chenopodium quinoa*, Wild): effects on in vitro iron availability and phytate hydrolysis. *International Journal of Food Science and Nutrition*, 50:203-211.

Weaver, C.M. and Kannan, S. (2002). Phytate and mineral bioavailability. In: Reddy N.R., Sathe S.K. (eds). *Food Phytates*. Pp 211–223.

Table 1: Summary Statistics of Germplasm Traits on Days to 50% Heading, Days to 50% Flowering, Days to Maturity at Bagauda and Zaria.

	SUMMARY STATISTICS			
	MEAN	MIN	MAX	CV
		BAGAUDA		
CHARACTER				
Days to 50% Heading	93.3	55	108	16.2
Days to 50% Flowering	97.5	60	123	15.7
Days to Maturity	138.5	100	183	10.9
		ZARIA		
Days to 50% Heading	105	52	122	9.5
Days to 50% Flowering	107	56	125	9.3
Days to Maturity	150	97	167	27.1

Table 2: Summary Statistics of Germplasm traits on number of harvested hills, Panicle exertion, Panicle form, Panicle weight/ha, Grain yield/ha, 1000grain weight at Bagauda and Zaria.

	SUMMARY STATISTICS			
	MEAN	MIN	MAX	CV
		BAGAUDA		
CHARACTER				
Harvested hill	10.8	1	16	23.1
Panicle exertion	1.9	1	4	37.2
Panicle form	5.2	1	12	55.2
Panicle weight/ha	2204.2	173.9	7640.6	56.1
1000grain weight	39.3	10.6	5.9	15.2
Grain yield/ha	1249.7	80.4	5427.9	65.4
		ZARIA		
Harvested hill	12.6	1	34	38.3
Panicle exertion	1.9	1	4	37.2
Panicle form	4.8	1	12	16.4
Panicle weight/ha	1940	173.9	5664.4	42.3
1000grain weight	42.6	4	71	14.6
Grain yield/ha	1161	780.4	3926.5	51.1

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Student–Newman Keuls Test.

Table 3: Grain yield/ha and 1000grain weight Responses for different Maturity Groups of Sorghum at Bagauda and Zaria, 2020

	Bagauda	Zaria

Treatments	Grain yield/ha	1000 grain weight	Grain yield/ha	1000 grain weight
Genotypes (G)				
Extra early	1244.36[ab]	38.98	1319.31	48.89[a]
Early	1209.45[ab]	39.39	1121.36	44.17[b]
Intermediate	1173.92[b]	39.18	1178.79	43.14[ab]
Late	1386.80[a]	39.82	1148.40	41.32[c]
SE $\pm$	72.51	0.24	668.22	0.705
Probability level	0.0452	0.79	0.89	0.025

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Student–Newman Keuls Test.

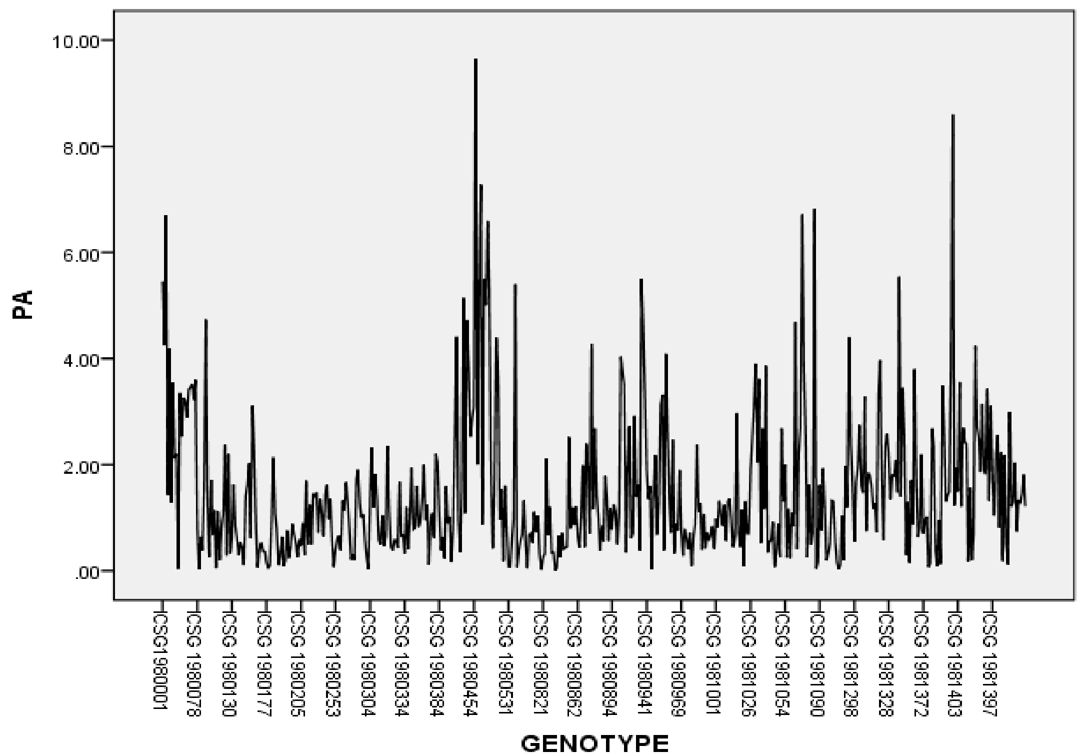

Fig 1: Chart distribution of Phytic acid contents of the germplasm accessions

PERFORMANCE OF SOYBEAN (*Glycine max* (L.) Merrill) BASED ON SEED PHENOTYPIC CHARACTERS

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ABSTRACT

Field experiment was conducted at the Training and Research Farm of CDA Bayero University, Kano during 2021 rainy season to determine the seed quality performance of soybean accessions. Treatment consisted of 30 soybean genotypes; laid out in a Randomized Complete Block Design. Data were collected on growth and seed phenotypic characteristics. Results indicated significant difference among the soybean genotypes for all the characters measured. TGm-1035 produced the highest plant height at the vegetative stage while TGm-1061 had the highest plant height at maturity. TGm-1051 had the highest chlorophyll content at vegetative stage while TGm-1066 had the highest chlorophyll content at maturity. TGx-1448-2E recorded the highest days to first flowering, 50% flowering, first podding, 50% podding, and maturity, TGm-1048 recorded the highest one hundred seed weight. Phenotypically, all the genotypes had yellow coat color except for TGm-1051, TGm-1152 and TGm-1061were green and TGm-1032, TGm-1031 and TGm-1010 were black. All the genotypes had smoothed textured coat and spherical in shape except TGm-1 and TGm-1037 which were elongated. The yellow groups recorded the highest plant height at vegetative stage, days to maturity, flowering, podding and one hundred seed weight. The green group however recorded the highest plant height at maturity and chlorophyll content at vegetative stage. The yellow groups had the highest performance among the soybean genotypes used.
Key words: Soybean, phenotypic, characteristics, growth, yield

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a leading important oil crop grown worldwide due to its diverse uses of oil and protein for human and livestock. It considered as an important commercial crop and contained approximately 40 to 45 % protein, 20 to 22 % oil, and 20 to 26 % carbohydrate, greater quantity of Ca, P, and vitamins (Adu - Dapaah *et al*., 2004; MoFA and CSIR, 2005). The oil accounts for 60.85% of the world's oil seed production (Ahmed *et al*., 2019). The world experienced shortage of oil seeds immediately after the World War II which accelerated the drive for increased Soybean production in Nigeria (Dugje *et al*., 2006)). Soybean cultivation in Nigeria has expanded as a result of its nutritive, economic and diverse domestic usage. The crop can be grown successfully in many states of Nigeria by the use of low agricultural inputs (Idrisa, 2009); with the development of improved varieties, commercial production of soybean has expanded beyond its "traditional home" (Benue, Kaduna, Niger and Plateau) states. It is now produced in other states, such as Bauchi, Borno, Jigawa, Kano, Kebbi, Kwara, Lagos, Nasarawa, Oyo, Sokoto, Taraba, Zamfara and Federal Capital Territory. Soybean is consumed as food (milk), used for production of edible oil, animal feeds, edible protein and for industrial purposes as biofuel (Abdullahi, 2004; Hill *et al*., 2006). Despite the importance of this crop, many soybean users make choice of soybean varieties without prior knowledge on the physical characteristics features of the seed such as color, texture, weight, size and shape and how these features can influence selection for yield potential and usage.

This research work associated with the objectives as to determine the phenotypic features of some soybean genotypes and to determine the effect of phenotypic characteristics on the performance of soybean genotypes.

MATERIALS AND METHODS

The experiment was conducted at the Training and Research farm of the Centre for Dryland Agriculture, Bayero University, Kano located in the Sudan Savannah zone of Nigeria situated at latitude 11.980430^{0}N and longitude 8.4012347^{0}E with annual rainfall of 834.5mm, mean minimum temperature of 19.4^{0}C and mean maximum temperature of 35.1^{O}C at altitude 427.98m above sea level.

The treatment consisted of 30 soybean genotypes originated from China, Indonesia, Taiwan, USA, Burkina Faso, and Nigeria sourced from the gene bank of International Institute for Tropical Agriculture (IITA); and laid in a Randomized Complete Block Design (RCBD) with three replications. The field was ploughed, harrowed and ridged using a tractor drawn implements, the plot size was 1.5m by 3m. Two seeds were sown per hole at 10cm by 75cm inter and intra row spacing at the depth of 3cm. Compound fertilizer was applied immediately at 20:40:20 using drilling method. One hoe weeding was carried out to keep the plots weed free. The soybeans were harvested when fully matured by hand picking.

Plant height was measured from the base of the plant to the highest tip of the apical meristem using a 100cm meter rule. Leaf chlorophyll content was recorded at vegetative and reproductive stage using SPAD-502 PLUS by taking the average reading from three tagged plants in each plot. Number of days to first flower was recorded when first flower appeared on the plot. Number of days to 50% flowering was recorded when half of the plants in a plot produced flowers. Number of days to first podding was recorded when first pod appeared on the plot. Number of days to 50% podding was recorded when half of the plants in a plot produced pods. Number of days maturity taken when the plant attained physiological and turns brownish in color. Seed color determination was carried out by visual observation of the seeds. Seed texture was done by rubbing the seeds in between the palm to determine for roughness or smoothness. One hundred seed weight was recorded using a weighing scale PEC MEDICAL USA (TH-1000). Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 16th edition and means were separated using Student-Newman-Keuls (SNK) at 5% probability level.

RESULTS

Results showed significant difference at (p<= 0.05) among the soybean genotypes for plant height, chlorophyll content and number of days to maturity as presented in Table 1. TGm-1035 recorded the highest plant height: mean value (38.00cm) followed by TGx-1448-2E (35.67cm) and TGm-1039 (35.97cm), while TGm-1061 and TGm-1051 had the lowest mean value (20.67). For plant height at maturity, TGm-1061 recorded the highest mean value (92.00cm), followed by TGm-1023 (85.33cm), and TGm-1006 (76.33cm), while TGm-1072 had the lowest mean value (21.00cm).

For chlorophyll content at 4WAS, TGm-1051 recorded the highest with a mean value (39.47) followed by TGm-1019 (38.20) and TGm-1 (37.77) while TGm-1010 had the lowest mean value (34.07). For chlorophyll content at maturity, TGm-1066 recorded the highest mean value (30.09), followed by TGm-1024 (28.50) and TGm-1035 (27.23), while TGm-1020 had the lowest mean value (17.13) Table 1.

For days to maturity, TGm-1035 had had the shortest days to maturity with a mean value (79.00) followed by TGm-1061 and TGx-1835-10E with mean values (101.33) and (104.83) respectively, while TGx-1448-2E had the longest days to maturity with a mean value (108.75) as presented in Table 1. Table 2 shows the mean performance of the soybean accessions for days to flowering, days to podding and one hundred seed weight. For days to first flowering, TGx-1448-2E, recorded the highest with a mean value (54.25), followed by TGm-1051 and TGm-1061 with mean values (53.00) and (51.67), respectively while TGm-1072 had the lowest mean value (35.67). For days to 50% flowering, the highest was recorded by TGx-1448-2E with a mean value (61.75), followed by TGm-1051 and TGm-1061 with mean values (58.67) and (57.67) respectively, while TGm-1047 had the lowest mean value (38.00).

For days to first podding, the highest was recorded in TGx-1448-2E, with a mean value (69.00), followed by TGm-1061 and TGx-1835-10E with mean values (62.67) and (62.33) respectively, while the lowest was recorded in TGm-1035 with mean value (45.67). For days to 50% podding, the highest was recorded in TGx-1448-2E with a mean value (76.08), followed by TGm-1061 and TGx-1835-10E with mean values (67.67) and (66.50) respectively, while the lowest was recorded in TGm-1035 with a mean value (50.00) as presented in Table 2.

Result for one hundred seed weight is presented in Table 2. The mean value for one hundred seed weight ranged from 7.33g-17.43g. TGm-1048 recorded the highest with a mean value (17.43) followed by TGm-1037 and TGm-1 with mean values (15.91) and (15.20) respectively, while the lowest was recorded in TGm-1032 with a mean value of (7.33) as presented in table 2.

Physical characteristics of the seed are presented in Table3. Results indicated that all the genotypes had yellow coat color except for genotypes TGm-1051, TGm-1152 and TGm-1061 are green while TGm-1032, TGm-1031 and TGm-1010 were black. Results showed all the genotypes had smooth texture Table 3.

The yellow groups recorded the highest mean for plant height at 4WAS and for days to maturity as in TGm-1035. The yellow group had the highest days to first flowering; 50% flowering; first podding and 50% podding as in TGx-1448-2E. However, the green group recorded the highest mean value for plant height at maturity as in TGm-1061 Table 3. For chlorophyll content at 4WAS, the green group recorded the highest mean as in TGm-1051, while the yellow group recorded the highest mean value for chlorophyll content at maturity as in TGm-1066, while the black group had the lowest mean for chlorophyll content at maturity as in TGm-1010. Similarly, the black group recorded the lowest mean value for one hundred seed weight as in TGm-1032, while the yellow group recorded the highest mean value for one hundred seed weight in TGm-1048 Table 3.

DISCUSSION

Characterizations of soybean accession based on variations in phenotypic characters are useful for identification and avoid duplication of genotypes (Ramteke and Murlidharan, 2012). Visually observed traits as seed coat color can be used to classify accessions into broad groups (Arun-Kumar *et al*., 2018). The observed differences for plant height at maturity among the soybean accessions falls within the range reported by Pushpa and Ketoswara (2013), with mean value of 38.35cm. This might be due to variation in genetic makeup of some of the soybean as well as variation in Agro-ecological zones where experiment was performed.

Many studies have been conducted to evaluate the chlorophyll content in soybean accessions. The results obtained in this experiment for chlorophyll content is in agreement with the study conducted by Zhang *et al.* (2015), and falls within the range of the observed chlorophyll content among the soybean germplasms. The results indicated variation in chlorophyll content ranging from 30.50-77.90. This may be due to variations in edaphic factors, climatic factors or different Agro-ecological zones where the experiment was conducted. Days to flowering mark the end of the vegetative phase and the early part of the reproductive stage. The observed differences for days to flowering is in contrary to the findings and report of Kuswantoro (2017a) and Kuswantoro (2017b) who recorded a range of 37-38 days. This variation could be attributed to different in anthesis time, to photoperiod, sensitivity of the plant, its response to the environmental condition and genetic nature of the seed.

The observed range for days to podding falls within the range (10.67-86.67) reported by Parameshwar (2006), with a mean value of 61.46. However, this is in contrary to the results obtained by Chandrawat *et al*. (2017); 95.00-111.50 with a mean value of 102.60. The observed differences could be attributed to variation in environmental factors of the site and genetic make-up of the plants.For seed coat color, about 83% of the genotypes had a yellow coat color while the remaining 17% had green and black coat color. The dominance in terms of yellow coat color observed in the study could be attributed to its abundance in the collection site, the predominant yellow seed color was earlier observed by (Ramteke and Murlidharan, 2012) and that the yellow group fetches higher prices more than the green and black group as observed in Manchurian classification. The observed textural classes of the soybean accessions are in agreement with the work of Ahiwe (2021) who reported a similar result for smoothness for all the soybean genotypes.

REFERENCES

Abbey, T. K., Ameyibor, K., Alhassan, A., Essiah, J. W., Fometu, E. and Wiredu, M. B. (2001). Integrated science for senior secondary schools. GAST. Ministry of Education.75-78.

Abdullahi, A. (2004). Soybean Production, Maiden edition, Raw Materials Research and Development (crumil, RMRDC), Nigeria, pp.17.

Adeniyan, O. N. and Ayoola, O. T. (2006). Growth and yield performance of some improved soybean varieties as influenced by intercropping with maize and cassava in two contrasting locations in South-west Nigeria. *Journal of Biotechnology*, 5(20), 82-89.

Adu-Dapaah, H. K., Asafo-Adjei, B., Owusu-Akyaw, M. and Amoah, S. (2004). Sustainable Soybean Production in Ghana. Paper presented at a Radio program on soybean in Ghana, 6 pages.

Ahiwe A. Uloma. (2021). Thesis on Genetic variability of some Nigeria Soybean Accessions.

Ahmed M. Abdelghany, S. Zhang, M. Azam, A.S Shaibu. (2018). Soystats a reference Guide to important Soybean facts and figures. American Soybean Association. Available online: http://soystats.com/.

Ani, A. O. and Undiandeye, U. C. (2001). Assessment of farmer's adoption of improved agricultural technologies in soya bean production in Michika Local Government Area of Adamawa state. *Nigeria Journal of Arid Agriculture*,1,107-11.

Arun-kumar, M. B., Varier, A., Sherry, R. J., Aruna, K. K., Sign, S. P. & Pathy, T. L. (2018). Characterization of pearl millet (*Pennisetum glaucum* L. R.Br.) genotypes by seedling anthocyanin pigmentation and seed characters. *Seed Science and Technology*, 33, 21

Asafo-Adjei, B., Ansah, I. O. O., Asuboah, R. A., Dapaah, H., Harruna, M. and OtiBoateng, C. (2005). CSIR (CRI and SARI) and MOFA. Soybean Production Guide. Food Crops Development Project, Ghana. 1 - 39.

Chandrawat, K. S., Baig, K. S., Hashmi, S., Sarang, D. H., Kumar, A. and Dumai, P. K. (2017). Study on Genetic Variability, Heritability and Genetic Advance in Soybean. International *Journal of Pure and Applied Bioscience*, 5, 57-63.

Dugje, I. Y. L. O., Omoigui, F., Ekeleme, R., Bandyopadhyay, P., Lava, K. and Kamara, A. Y. (2009). Farmers' guide to soybean production in Northern Nigeria. International institute of tropical agriculture, Ibadan, Nigeria. 21.

Dugje, I. Y., Omoigui, L. O., Ekeleme, F., Brandyopadhyay, R., Kumar, P. R. &Kamara, A. Y. (2006). Farmers guide to soya bean production in Northern Nigeria, International Institute of Tropical Agriculture, Ibadan, Nigeria, pp. 1-16E: R.P. Benz and Sotranko (Eds) Improving Agricultural Extension: A Reference Manual, pp. 165-167.

FAO. (2007). Food and Agriculture Organization of the United Nations: world soybean production by region and world total.

FAO. (2010). FAOSTAT. Food and Agriculture Organization of the United Nations

Hill, A., Kurki, A. and Morris, M. (2006). Biodiesel: The sustainability dimensions, ATTRA publication, Buttee M.T, National Centre for Appropriate Technology. Pp.4-5

Idrisa, Y. L. (2009) Analysis of determinants of soybean production technology adoption by farmers in Southern Borno, Nigeria. Unpublished PhD Thesis Submitted to the Department of Agricultural Economics and extension services, University of Maiduguri, Nigeria. Pp1-4.

IITA, (2008). Thirty years R4D in soybean: What's next?.

IITA, (2009). Soybean overview. Summary. 5. IITA Ibadan.

MoFA and CSIR (2005). Soybean production guide. Food crops development project.Ghana’s Ministry of Food and Agriculture. 38pp.

MoFA, (2012). Strategy for soybean production and marketing in Kenya. Unpublished, 1-20.

Parameshwar, M. (2006). Genetic investigation in Soybean (*Glycine max* (L) Merrill). M.Sc. (Agri.) Thesis, University of Agricultural Science, Dharward, USA.

Pushpa, R. & Ketoswara R. (2013). Genetic Variability in soybean. International Journal for Plant, Animal and Environmental Science, pp. 35

Ramteke, R. and Murliharan, P. (2012). Characterization of Soybean (*Glycine max* (L.) Merrill) varieties as per DUS guidelines. International Journal of Agricultural Science, 82(7), 572-577

USDA. (2011). U.S. Soybean inspection. Available from http://www.usda.gov/oce/commodity/wasde/latest.pdf. Date accessed 17th/06/216.

Zhang, L. X., Kyei- Boahen, S., Zhang, J., Zhang, N. H., Freeland, T. B., Watson, C. E., & Liu, X. (2007). Modification of optimum adaptation zones of soybean maturity groups in USA. Crop Management, 6(1), 1-11.

Table 1: Mean performance of soybean accessions for plant height, chlorophyll content and days to maturity during 2021 rainy season.

Accessions	Plant Height (cm)		Chlorophyll Content (SPAD)		Maturity
	4WAS	PHTMT	4 WAS	SPAD MT	DMT
TGm-1051	20.67^{c}	59.00^{cdef}	39.47^{a}	26.97^{abc}	99.33^{bc}
TGm-1019	25.00^{abc}	75.00^{abc}	38.20^{ab}	18.93^{bcd}	91.67^{defg}
TGm-1152	22.00^{bc}	46.33^{def}	38.03^{ab}	23.23^{abcd}	92.67^{def}
TGm-1	30.33^{abc}	72.00^{abc}	37.77^{abc}	16.90^{d}	94.33^{cd}
TGm-1017	32.67^{abc}	51.67^{cdef}	37.70^{abc}	23.97^{abcd}	91.00d^{efgh}
TGm-1047	30.67^{abc}	40.33^{fg}	37.57^{abc}	25.17^{abcd}	81.33^{jkl}
TGm-1046	26.27^{abc}	64.97^{bcde}	37.53^{abc}	22.29^{abcd}	92.26^{def}
TGm-1075	29.67^{abc}	68.33^{abcd}	37.00^{abc}	27.13^{abc}	89.00^{defghi}
TGm-1060	34.00^{abc}	47.00d^{ef}	36.97^{abc}	23.30^{abcd}	88.33^{defghi}
TGm-1020	32.33^{abc}	72.00^{abc}	36.90^{abc}	17.13^{d}	91.33^{defg}
TGm-1066	29.06^{abc}	40.77^{efg}	36.84^{abc}	30.09^{a}	86.22^{efghijk}
TGm-1011	28.87^{abc}	52.33^{cdef}	36.80^{abc}	27.40^{ab}	93.33^{cde}
TGm-1006	31.67^{abc}	76.33^{abc}	36.70^{abc}	27.47^{ab}	86.33^{efghijk}
TGm-1061	20.67^{c}	92.00^{a}	36.63^{abc}	23.80^{abcd}	101.33^{b}
TGm-1035	38.00^{a}	59.67^{cdef}	36.57^{abc}	27.23^{abc}	79.00^{l}
TGm-1024	29.00^{abc}	74.00^{abc}	36.53^{abc}	28.50^{ab}	87.00^{efghij}
TGm-1037	31.33^{abc}	36.33^{fg}	36.53^{abc}	17.47^{cd}	91.33^{defg}
TGx-1448-2E	35.67^{ab}	69.17^{abcd}	36.53^{abc}	20.98^{abcd}	108.75^{a}
TGm-1013	27.67^{abc}	59.67^{cdef}	36.50^{abc}	23.83^{abcd}	86.00^{fghijk}
TGm-1048	1.67^{abc}	68.00^{abcd}	36.50^{abc}	27.50^{ab}	94.33^{cd}
TGm-1039	35.67^{ab}	66.67^{bcd}	36.47^{abc}	27.03^{abc}	85.00^{ghijkl}
TGm-1023	33.33^{abc}	85.33^{ab}	36.17^{abc}	17.17^{d}	90.00^{defghi}
TGx-1835-10E	30.25^{abc}	54.92^{cdef}	36.14^{abc}	21.19^{abcd}	104.83^{ab}
TGm-1034	30.67^{abc}	37.33^{fg}	35.80^{abc}	22.77^{abcd}	84.00^{hijk}l
TGm-1032	24.00^{abc}	53.33^{cdef}	35.77^{bc}	21.17^{abcd}	83.00^{ijkl}
TGm-1031	27.00^{abc}	39.67^{fg}	35.23^{bc}	22.23^{abcd}	88.00^{defghij}
TGm-1000	30.62^{abc}	74.97^{abc}	34.93^{bc}	24.45^{abcd}	94.26^{cd}
TGm-1072	22.02^{bc}	21.00^{g}	34.83^{bc}	23.10^{abcd}	79.67^{kl}
TGm-1059	25.33^{abc}	65.33^{bcd}	34.67^{bc}	22.13^{abcd}	89.00^{defghi}
TGm-1010	25.67^{abc}	53.67^{cdef}	34.07^{c}	19.33^{bcd}	92.00^{defg}
SE±	10.14	10.14	3.978	5.786	2.943
cv%	4.300	3.900	2.700	4.500	0.600

Means followed by the different letters in a column are statistically significant at $p \leq 0.05$, while means

Key: WAS=weeks after sowing, PHTMT= Plant height at maturity, SPADMT= Chlorophyll content at maturity, DMT= Days to maturity

Table 2: The mean performance for days to flowering, days to podding and seed weight during 2021 rainy season.

Accessions	Days to flowering		Days to podding		Seed Weight
	First flowering	50% Flowering	First podding	50% podding	100SDW
TGm-1051	53.00^{ab}	58.67^{ab}	61.33^{bcd}	65.00^{bcd}	8.97^{p}
TGm-1019	50.00^{abcde}	51.67^{bcde}	56.00^{cdef}	60.67^{bcde}	11.23^{n}
TGm-1152	45.33^{cdefg}	48.00d^{efghi}	53.67^{efgh}	58.33d^{efg}	13.97^{e}
TGm-1	46.67^{bcdefg}	50.67^{cdef}	56.33^{bcdef}	61.33^{bcde}	15.20^{c}
TGm-1017	41.67^{fghi}	46.00^{efghi}	53.67^{efgh}	58.33de^{fg}	12.17^{jkl}
TGm-1047	41.33^{fghi}	38.00^{j}	47.33^{hij}	52.67^{fgh}	12.50^{hij}
TGm-1046	47.46^{bcdef}	50.52^{cdefg}	57.76^{bcdef}	62.16^{bcde}	14.45^{d}
TGm-1075	40.67^{fghi}	43.67^{fghij}	52.33^{efghi}	56.67^{efgh}	12.33^{hij}
TGm-1060	44.00^{defgh}	47.33^{efghi}	55.00^{defg}	59.33^{cdef}	12.40^{hij}
TGm-1020	50.33^{abcd}	55.33^{abcd}	58.00^{bcde}	62.00^{bcde}	9.63^{o}
TGm-1066	37.12^{hi}	41.75^{hij}	47.51^{hij}	57.21^{efg}	12.30^{hijk}
TGm-1011	47.00^{bcdefg}	52.67^{bcde}	57.33^{bcdef}	61.67^{bcde}	12.90^{fg}
TGm-1006	40.00^{ghi}	43.00^{ghij}	51.00^{fghij}	55.33^{efgh}	13.10^{f}
TGm-1061	51.67^{abc}	57.67^{abc}	62.67^{b}	67.67^{b}	8.33^{q}
TGm-1035	40.00^{ghi}	46.33^{efghi}	45.67^{j}	50.00^{h}	13.69^{e}
TGm-1024	43.00^{efgh}	46.33^{efghi}	53.33^{efghi}	57.67^{defg}	12.57^{ghi}
TGm-1037	40.00^{ghi}	42.00^{hij}	49.00^{ghij}	56.33^{efgh}	15.91^{b}
TGx-1448-2E	54.25^{a}	61.75^{a}	69.00^{a}	76.08^{a}	11.06^{n}
TGm-1013	43.33d^{efgh}	42.00^{hij}	51.00f^{ghij}	56.00^{efgh}	12.63^{gh}
TGm-1048	40.00^{ghi}	42.00^{hij}	53.67^{efgh}	57.67^{defg}	17.43^{a}
TGm-1039	41.00f^{ghi}	45.33^{efghij}	46.67^{ij}	53.00^{fgh}	11.97^{klm}
TGm-1023	47.00^{bcdefg}	52.67^{bcde}	56.33^{bcdef}	60.67^{bcde}	9.87^{o}
TGx-1835-10E	52.83^{ab}	58.92^{ab}	62.33^{bc}	66.50^{bc}	11.21^{n}
TGm-1034	44.00^{defgh}	48.67^{defgh}	53.00^{efghi}	57.67^{defg}	12.27^{ijk}
TGm-1032	47.67^{abcdef}	50.33^{cdefg}	54.00^{efgh}	58.33^{defg}	7.33^{s}
TGm-1031	47.33^{abcdef}	52.67^{bcde}	56.00^{bcdef}	59.67^{cdef}	11.23^{n}
TGm-1000	44.96^{cdefg}	48.52^{defgh}	53.26^{efghi}	57.66^{defg}	11.80^{m}
TGm-1072	35.67^{i}	40.67^{ij}	47.33^{hij}	51.33^{gh}	14.67^{d}
TGm-1059	43.67^{defgh}	49.00^{defgh}	55.33^{defg}	59.67^{cdef}	11.90^{lm}
TGm-1010	47.33^{abcdef}	50.33^{cdefg}	57.00^{bcdef}	61.00^{bcde}	7.93^{r}
S.E±	2.984	2.824	2.824	3.033	0.1585
cv%	1.800	5.600	5.600	4.900	1.000

Means followed by the different letters in a column are statistically significant at $p \leq 0.05$, while means

Table 3: Phenotypic characteristics of soybean seeds

Genotype	**Seed Color**	**Seed Texture**	**Seed Shape**
TGm-1051	Green	Smooth	Spherical
TGm-1019	Yellow	Smooth	Spherical
TGm-1152	Green	Smooth	Spherical
TGm-1	Yellow	Smooth	Elongated
TGm-1017	Yellow	Smooth	Spherical
TGm-1047	Yellow	Smooth	Spherical
TGm-1046	Yellow	Smooth	Spherical
TGm-1075	Yellow	Smooth	Spherical
TGm-1060	Yellow	Smooth	Spherical
TGm-1020	Yellow	Smooth	Spherical
TGm-1066	Yellow	Smooth	Spherical
TGm-1011	Yellow	Smooth	Spherical
TGm-1006	Yellow	Smooth	Spherical
TGm-1061	Green	Smooth	Spherical
TGm-1035	Yellow	Smooth	Spherical
TGm-1024	Yellow	Smooth	Spherical
TGm-1037	Yellow	Smooth	Elongated
TGx-1448-2E	Yellow	Smooth	Spherical
TGm-1013	Yellow	Smooth	Spherical
TGm-1048	Yellow	Smooth	Spherical
TGm-1039	Yellow	Smooth	Spherical
TGm-1023	Yellow	Smooth	Spherical
TGx-1835-10E	Yellow	Smooth	Spherical
TGm-1034	Yellow	Smooth	Spherical
TGm-1032	Black	Smooth	Spherical
TGm-1031	Black	Smooth	Spherical
TGm-1000	Yellow	Smooth	Spherical
TGm-1072	Yellow	Smooth	Spherical
TGm-1059	Yellow	Smooth	Spherical
TGm-1010	Black	Smooth	Spherical

REACTION OF SOME COWPEA (*Vigna unguiculata* (L.) WALP) GENOTYPES TO *STRIGA* (*Striga gesnerioides* (Willd.) Vatke)) IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

The field experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University Kano (Latitude 11.9753° N, Longitude 8.4306° E) to study the reaction of some newly developed cowpea genotypes to *Striga gesnerioides*. The treatments used were seven (7) different cowpea genotypes (IT98K-388-2, IT99K-573-1-1, IT07K-297-13, IT08K-150-12, IT13K-1308-5, TVX-3236, and B301) which were laid out in Randomized Complete Block Design (RCBD) and replicated three times. Data were collected on growth characters, *Striga* count, yield, and yield parameters. The generated data were subjected to analysis of variance (ANOVA) using a general linear model in GenStat. Treatment means were separated using Student-Newman-Keuls (SNK) at a 5% probability level. The result revealed highly significant differences among the growth and yield characters measured except for, plant height at 6WAS, number of leaves at 3,6 and 9WAS, number of branches at 3 and 6WAS, seed yield, and 100 seed weight. Also, the cowpea genotype TVX-3236 recorded the highest number of *Striga*. The result obtained shows that all the cowpea genotypes are resistant to *Striga gesnerioides* except for TVX-3236 which was the only one to have a *Striga* count in the field. Therefore, it can be concluded that all the cowpea genotypes used were resistant to *Striga gesnerioides* except TVx-3236 which supported *Striga* indicating susceptibility to the parasite.

Keyword: Cowpea genotype, *Striga gesnerioides* resistant

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] indigenous to Africa is an important grain legume grown in tropical and subtropical regions of the world primarily in sub-Saharan Africa (Singh 2005; Timko *et al*., 2007a; Close *et al*., 2015). It is an extremely resilient crop and is cultivated under some of the most extreme agricultural conditions in the world where other food legumes do not perform well (Muoneke *et al*., 2012; Asare *et al.,* 2013). Global production of dried cowpea stands at 5.6 million tons from about 12.5 million hectares out of which Africa accounts for approximately 5.4 million tons from about 12.3 million hectares (FAO, 2015). Nigeria is the largest producer and consumer of cowpea producing about 2.1 million tons from 3.7 million hectares (FAO, 2015). However, the annual consumption of cowpeas in Nigeria is over 3.0 million tons. The expected shortfall in supply requires technologies that would enhance the productivity of the crop for high-yielding varieties with resistance to biotic (*Striga*, insect pests and diseases) and abiotic (drought, heat, low soil fertility) stresses as well as improved integrated crop management. The crop has the potential of multiple contributions to household food production and nutritional security (protein) but also as cash crops (grain and fodder) and soil enhancement (Diouf, 2011; Oyelade and Anwanane, 2013). Despite the importance of cowpeas, the average yield in West and Central Africa (WCA) is generally very low resulting from a variety of biotic and abiotic stresses. Among the major biotic constraints of cowpea production is the parasitic weed; *Striga gesnerioides* of the Orobanchaceae family which parasitizes cowpea causing substantial yield loss in the dry savannas of West and Central Africa (Olmstead *et al.*, 2001). The parasite causes severe chlorosis, wilting, and stunting in susceptible hosts (Ejeta 2007; Spallek *et al*., 2013): leading to loss in millions of tons annually, and the prevalence of *Striga* soils is steadily increasing (Cardwell and Lane, 1995; Kamara *et al*., 2008; Omoigui *et al.* 2012a).

Farmers have reported losses between 80 and 100 % and are eventually forced to abandon highly infested farmland due to the menace of *S. gesnerioides* (Singh and Emechebe, 1997). Control of *S. gesnerioides* is difficult to achieve due to the number of seeds of the parasite which can remain viable in the soil for over 20 years (Ouedraogo *et al*., 2012). Several methods have been proposed for the control of *S. gesnerioides* in cowpeas among the options, the use of host plant resistance is considered the most practical, sustainable, effective, and economic method to control the parasite (Omoigui *et al*., 2007). However, the lack of cowpea varieties with broad or horizontal resistance is one of the biggest problems when trying to develop resistant cultivars to *S. gesnerioides* races (Omoigui *et al*., 2012). Despite the acute demand for cowpeas as a less cost and reliable source of protein in many staple diets among many families in Africa. There is a need to study the physiological response of cowpea to *Striga generioides*, limiting yield quantity and quality and retarding farmer's income. Based on the challenges faced by cowpea, this research is intended to critically determine the reaction of some cowpea genotypes to *Striga gesnerioides* to identify cowpea genotypes that are resistant to *the parasite* for cultivation and incorporation in cowpea breeding improvement programs.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and research farm of the Faculty of Agriculture, Bayero University Kano. (Latitude 11.9753° N, Longitude 8.4306° E) in the Sudan Savannah ecological zone of Nigeria. Treatments consisted of seven cowpea genotypes (IT98K-388-2, IT99K-573-1-1, IT07K-297-13, IT08K-150-12, IT13K-1308-5, TVX-3236 and B301). The experiment was laid out in randomized complete block design (RCBD) and replicated three times. The field was cleared, harrowed, and ridged before planting. Each plot size was measured 1.5m by 1.5m making (2.25m^2). The cowpea seeds were sown at two seeds per hole at 0.75 by 0.25m inter- and intra-row spacing, respectively. Compound fertilizer (NPK, 15:15:15) was applied by side dressing method two weeks after sowing. Weeding was done at 3 and 6 weeks after sowing (WAS) while taking proper care not to alter with the emerged *Striga*. Data were collected on plant height (cm), number of leaves, number of branches, *Striga* count pod weight (g), number of seeds per pod, 100-grain weight (g), and grain yield (g). Data collected on growth, yield, and *Striga* were subjected to Analysis of Variance (ANOVA) as described by Snedecor and Cochran (1994) using a general linear model in GenStat. Significant treatment means were separated using the Student Newman-Keul Test (SNK) at a 5% level of probability.

RESULTS

Mean performance of cowpea genotypes for plant height and number of leaves plant^{-1}

Results show that at 3 weeks after sowing (WAS), cowpea genotype IT07K-297-13 recorded the highest plant height (12.11cm) followed by IT08K-150-12 (12.00 cm) which was statistically similar to IT13K-1308-5 (11.78cm). While IT98K-388-2 had the lowest (8.33 cm). At 9WAS, B301 recorded the highest plant height (29.75 cm) followed by TVX-3236 (29.45 cm) which was statistically similar to IT13K-1308-5 (28.89 cm). while IT08K-150-12.had the lowest (21.26 cm). At 6 WAS IT13K-1308 produced the tallest plant (27.78 cm) while IT08K-150-12 had the lowest (21.26cm, no significant difference was observed among the cowpea genotypes for the number of leaves at 3,6 and 9WAS.

Mean performance of cowpea genotypes for the number of branches Plant^{-1} and *Striga* count

Table 2 shows the mean performance of the cowpea genotypes on the number of branches per plant and *Striga* counts at 3, 6, and 9 WAS. A significant difference was observed in the number of branches per plant at 9WAS only where B301 recorded the highest number of branches (8.00) and IT99K-573-1-1 (8.00) which was statistically similar to IT13K-1308-5 (7.667) while TVx-3236.had the lowest (5.667)**.** For *Striga* count, a highly significant difference was observed at 7, 8, and 9WAS where the cowpea genotype TVx-3236 supported *Striga* emergence throughout the recording periods while the remaining had no *Striga* emergence.

Mean performance of cowpea genotypes on yield characters

Table 3 shows the mean performance of the cowpea genotypes on the yield characters (pod weight, number of seeds per pod, seed yield, and 100 seed weight) of cowpea genotypes. For pod weight, the cowpea genotype IT99K-573-1-1 recorded the highest pod weight (203.9g) followed by B301 (176.0) while TVx-3236 lowest pod weight (60.0g). For the number of seeds per pod, no significant difference was observed for all the cowpea genotypes, however for seed yield, c IT99K-573-1-1 recorded the highest (145.1g) while TVX-3236 (43.0g). had the lowest seed yield. For 100 seed weight, no significant difference was observed among all the cowpea genotypes.

DISCUSSION

The result obtained from this study showed that all the cowpea genotypes used were resistant to *Striga gesnerioides* except for TVx-3236 which remains susceptible to the parasite. This conforms with the findings of Joseph *et al*. (2010) who reported that the cowpea genotype IT99K-573-1-1 is among the varieties that are resistant to *S. gesnerioides* in a field trial conducted in Northern Cameroon. The result was also in line with the work of Kamara *et al*. (2024) who reported that the cowpea genotype IT99K-573-1-1 was an improved cultivar that carries the B301 *Striga* resistance gene. The genotype IT99K-573-1-1 also had the highest pod weight and seed weight which resulted in the highest yield. This result is in agreement with the findings of (Kamara *et al.*, 2016) who reported that IT99K-573-1-1 produced more pods per m^2 than other cowpea genotypes used in their research. The genotype B301 also had the second-highest pod weight and seed yield which could be also due to genetics. In the research of (Singh and Emechebe, 1990) they also affirmed the complete resistance of the cowpea genotype B301 to *Striga* by stating that B301 has shown complete resistance to *Striga gesnerioides* in many countries. This is also in conformity with the work of (Singh, Emechebe, and Atokple, 1993) who reported that the cowpea genotype B301 is a landrace from Botswana, and is resistant to both parasite and genetic studies have revealed a single dominant gene for *Striga* resistance.

Cowpea genotypes IT07K-297-13 and IT08K-150-12 are resistant to *Striga gesnerioides* which is also in agreement with the findings of Togola *et al*., (2023) who reported complete resistance of the cowpea genotypes IT07K-297-13 and IT08K-150-12 to *Striga gesnerioides.* Cowpea genotype TVx-3236 having the lowest pod weight and seed yield due to *Striga* infestation is confirmed to be susceptible to *Striga gesnerioides* the results are in agreement with the research of (Kamara *et al.*, 2008) who reported high susceptibility of the cowpea genotype TVx3236 under natural *Striga* infestation. The cowpea genotype IT98K-388-2 having the second to the lowest pod weight and seed weight in this research agrees with the findings of (Singh *et al*., (2017) which revealed significant genetic variations among cowpea genotypes for plant height, branching pattern, and number of seed per pod where they reported the genotype having a low yield may be due to the inherent nature of the genotype.

CONCLUSION

From the findings of this research, it can be concluded that all the cowpea genotypes used are resistant to *Striga gesnerioides* while cowpea genotypes TVx-3236 supported *Striga* indicating susceptibility to the parasite. There is a need for farmers to adopt the use of resistant variety seeds and have a piece of knowledge on different cowpea genotypes to avoid the planting of *Striga* susceptible varieties in areas that have a history of *Striga* infestation. Cowpea breeders should also cross cowpea genotypes that are resistant to *Striga* like IT99K-573-1-1 and IT07K-297-13 with other genotypes that have other improved qualities to tackle the nagging problem of *Striga* across the Agro-ecological zones in Nigeria.

REFERENCES

Asare, A.T., Galyuon, I.K., Padi, F.K., Otwe, E.P. and Takrama, J.F. (2013). Responses of recombinant inbred lines of cowpea [(*Vigna unguiculata* (L.) Walp] to *Striga gesnerioides* infestation in Ghana. *European Scientific Journal*, 9(21).

Atokple, I.D.K., Singh, B.B and Emechebe, A.M. (1993). Independent inheritance of *Striga* and *Alectra* resistance in cowpea genotype B301. *Crop Science* 33,714-715.

Cardwell, K.F. and Lane, J.A. (1995). Effect of soils, cropping system, and host phenotype on incidence and severity of *Striga gesnerioides* on cowpea in West Africa. *Agricultural Ecosystem Environment*., 53, 53 262.

Close, T.J., Lucas, M.R., Amatriain, M.M., Mirebrahim, H., Wanamaker, S., Barkley, N.A., Clai, S.S., Guo, Y.N., Lo, S., Huynh, B.L., Ndeve, A.D., Santos J.R.P., Joseph, B.T.B., Tignegre, J.B., Drabo, I. Kusi, F., Atokpole, I., Boukar, O., Fatokun, C., Cisse, N., Xu, P., Roberts P.A. and Lonardi, S. (2015). A New SNP - Genotyping Resource for Cowpea and Its Deployment for Breeding. In *Plant and Animal Genome XXIII Conference*. Plant and Animal Genome, *4*, 18159.

Diouf, D. (2011). Recent advances in cowpea [*Vigna unguiculata* (L.) Walp.] "omics" research for genetic improvement. *Africa Journal of Biotechnology,10*, 2803-2810.

Dres, M. and Mallet, J. (2002). Host races in plant-feeding insects and their importance in sympatric speciation. Philosophical Transactions of Royal Society of London**.** *Biological Sciences*, *357*, 471–92.

Ejeta, G. (2007). The *Striga* scourge in Africa: a growing pandemic. In: Integrating New Technologies for *Striga* Control: Towards Ending the Witch-hunt (eds G. Ejeta, and J. Gressel), 3–16. World Scientific Publishing Co. Pte Ltd.

FAO, (2015). Food and Agriculture Organization of the United. FAOSTAT database, http: / /www.FAO.ORG.

Hall, A. E. (2004). Comparative ecophysiology of cowpea, common bean, and peanut. In Nguyen, H. T. *et al.* (eds). Physiology and Biotechnology Integration for Plant Breeding. Marcel Dekker, pp. 271–325.

Joseph, M.B., Jean, B.N.T, Sirina, G.B. and Sodea G. (2010). Varietal response of cowpea (*Vigna unguiculata* [L.] Walp.) to *Striga gesnerioides* (Willd.) Vatke race SG5 infestation. *Notulae Botanicae Horti Agro-botanici Cliy-Napoca*, 38(2),33-41.

Kamara, A.Y., Chikoye D., Ekeleme F., Omoigui L.O. and Dugje I.Y. (2008). Field performance of improved cowpea varieties under conditions of natural infestation by parasitic weed *Striga gesnerioides. International Journal of Pest Management*, 54(3),189-195.

Kamara, A.Y., Omoigui, L.O., Shaibu, A.S., Iyorkaa, A., Ugbaa, M.S., Olufayo, O.O., Lolarmen, T. and Timko, M.P. (2024). Registration of 'UAM14-122-17-7 and UAM14-123-18-3 cowpea cultivars with high yield, resistance to *Striga*, and large seeds with brown color. *Genetic resources and crop Evolution* 71(1), 455-469.

Lane, J.A., Buttler, R.C. and Bailey, J.A. (1993). Resitance of cowpea [*Vigna unguiculata* (L.) Walp.] to *Striga gesnerioides* (Willd.) Vatke, a parasitic angiosperm. *New Phytology*, *125*, 405–412.

Lane, J.A., Child, D.V., Reiss, G.C., Entcheva, V., Bailey, J.A. (1997). Crop resistance to parasitic plants. In: Crute, IR, Holub EB, Burdon JJ (eds) The gene-for-gene relationship in plant-parasite interactions, CAB Int, Wallingford, Oxon, UK. pp. 81-97.

Lane, J.A., Moore, T.H.M., Child, D.V. and Cardwell, K.F. (1996). Characterization of virulence and geographic distribution of *Striga gesnerioides* in cowpea in West Africa. *Plant Disease 80*, 299–301.

Lane, J.A., Moore, T.H.M., Child, D.V., Cardwell, K.F., Singh, B.B. and Bailey, J.A. (1994). Virulence characteristics of a new race of the parasitic angiosperm, *Striga gesnerioides*, from southern Benin on cowpea (*Vigna unguiculata*). *Euphytica*, 72, 183–188.

Li, J. and Timko, M.P. (2009). Gene-for gene resistance in *Striga*-cowpea associations. *Science* 325(5944),1094.

Li, J., Lis, K.E. and Timko, M.P. (2009). Molecular genetics of race-specific resistance to *Striga gesnerioides* (Willd.). Pest Management Science 65(5):520-525.

Muoneke, C.O., Ndukwe, O.M., Umana, P.E., Okpara, D.A. and Asawalam, D.O. (2012). Productivity of vegetable cowpea (*Vigna unguiculata* L. Walp) and maize (*Zea mays* L.) intercropping system as influenced by component density in a tropical zone of southeastern Nigeria *International Journal of Agricultural Research and Development,* 15 (1), 835-847.

Obi, I.U. (1986).Statistical methods of detecting differences between treatment means. SNAAP Press pp. 13-17.

Olmstead, R.G., De Pamphilis., C.W. and Wolfe, A. (2001). Disintegration of the Scrophulariaceae. *American Journal of Botany* 88, 348–361.

Omoigui LO, Kamara AY, Alunyo GI (2017). Identification of new sources of *Striga gesnerioides* in cowpea *Vigna unguiculata* accessions. *Genetic Resources and Crop Evolution* 64(5):901-911.

Omoigui, 1.O., Timko, M.P., Ishiyaku, F.S., Ousmane, B., Muranaka,B.S. Kamara, A.Y. and Yeye, M.Y. (2009). Molecular characterization of cowpea breeding line for *Striga* using FTA (Flinders Technology Associations) technology. African Crop Science Conference, Uganda 9:527-530.

Omoigui, L. O., Kamara, A. Y., Ishiyaku, M. F. and Boukar, O. (2012). Comparative responses of cowpea breeding lines to *Striga* and *Alectra* in the dry savanna of northeast Nigeria. *African Journal of Agricultural Research* Volume 7(5), pp. 747-754.

Omoigui, L.O., Kamara, A.Y., Ajeigbe, H.A., Akinwale, R.O., Timko, M.P., Oyekunle, M. and Bello, L.L. (2017). Performance of cowpea varieties under *Striga gesnerioides* (Willd.) Vatke infestation using biplot analysis. Euphytica 213:244

Omoigui, L.O., Kamara, A.Y., Massawe, F.S., Ishiyaku, M.F., Boukar, O., Alabi, S.O., and Ekeleme, F. (2007). Evaluation of cowpea genotypes for their reactions to *Striga gesnerioides* in the dry savanna of the northeast (what?). In: Ahmed KZ, Mohamoud A ,Abdel-Hakim M, Shalabi, SI, El-Morsi.H, Ismael AM. Editors. *Proceedings of the 8th African Crop Science Society Conference*: 2007 (El-Minia) Egypt, pp. 273-278.

Omoigui, L.O., Timko, M.P., Ishiyaku, F.S., Ousmane, B., Muranaka, B.S., Kamara, A.Y. and Yeye, M.Y. (2009). Molecular characterization of cowpea breeding line for *Striga* resistance using FTA technology. *African Crop Science Conference,* Uganda 9:527-530.

Omoigui, L.O., Yeye, M., Ousmane, B., Gowda, B.S. and Timko, M.P. (2012a). Molecular Characterization of Cowpea Breeding Lines for *Striga* Resistance Using SCAR Markers. *Journal of Agricultural Science and Technology* Volume (2) 362-367.

Ouedraogo, J.T. (2012). Development of sequence-characterized amplified region (SCAR) markers linked to race-specific resistance to *Striga gesnerioides* in cowpea (*Vigna unguiculata* L.). *African Journal of Biotechnology*, *11*(62), 12555–12562.

Ouédraogo, J.T., Maheshwari, V., Berner, D.K., St-Pierre, C.A., Belzile, F., and Timko, M.P (2001). Identification of AFLP markers linked to resistance of cowpea (*Vigna unguiculata*

L.) to parasitism by *Striga gesnerioides*. *Theoretical and Applied Genetics, 102*(6-7), 1029-1036.

Oyelade, O.A. and Anwanane, N.B. (2013).Ensuring Food Security in Nigeria. *Journal of Advances in Agriculture, Sciences and Engineering Research*, 3, 8, 10621076.

Rao, P.S. (1965). In vitro induction of embryonal proliferation in *Striga asiatica* Phytomorphology, 15, pp 175.

Singh, B.B and Emechebe, A.M. (1990). Inheritance of *Striga* resistance in cowpea genotype B301. *Crop science 30*:879-881.

Singh, B.B. (2005). Cowpea [*Vigna unguiculata* (L.) Walp]. In: Singh R.J., Jauhar, P.P. (eds) Genetic Resources, Chromosome Engineering and Crop Improvement. Volume 1, CRC Press, Boca Raton, FL, USA. pp. 117-162.

Singh, B.B. and Emechebe, A. M. (1991). Breeding for resistance to *Striga* and *Alectra* in cowpea. *Proceedings of the 5th International Symposium of parasitic weeds*, Nairobi, Kenya, 24-30 June 1991 [edited by Ransom, J.K.; Musselman, L.J.; Worsham, A.D.; Parker, C.] Nairobi, Kenya; CIMMYT (International Maize and Wheat Improvement Center), 303-305.

Singh, B.B. and Emechebe, A.M. (1997). Advances in research on cowpea *Striga* and *Alectra*. In: Singh, B. B., Mohan Raj D. R., Dashiel K. E., Jackai L. E. N, eds. Advances in Cowpea Research. Ibadan, Nigeria: IITA, 215-224.

Singh, B.B. and Tarawali, S.A. (1997). Cowpea and its improvement: key to sustainable mixed crop/livestock farming systems in West Africa. In: C. Regard (ed.) Crop Residues in Sustainable Mixed Crop Livestock Farming Systems. CAB in Association with ICRISAT and ILRI, Wallingford, UK, pp 79-100.

Singh, B.B., Ajeigbe, H.A., Tarawali, S.A., Rivera, S.F and Abubakar, M. (2003). Improving the production and utilization of cowpeas as food and fodder. *Field Crop Research* 84(1-2), 169-177.

Singh, B.B., and Emechebe, A.M. (1990). Inheritance of *Striga* resistance in cowpea genotype B301. *Crop Science* 30(4), 879-881

Singh, B.B., Emechebe, A.M. and Atokple, I.D.K. (1993). Independent inheritance of *Striga* and Alectra resistance in cowpea genotype B301. *Crop Science* 33(4), 714-715.

Spallek, T., Mutuku, M., and Shirasu, K. (2013). The genus *Striga*: A witch profile. *Molecular Plant Pathology, 14*(9), 861–869.

Timko, M., Gowda, B., Ouedraogo, J., and Ousmane, B. (2007). Molecular markers for analysis of resistance to *Striga gesnerioides* in cowpea. Pages 115–128 in G. Ejeta and J. Gressel, eds. Integrating New Technologies for *Striga* Control: Towards Ending the Witch-Hunt. Singapore: World Scientific.

Timko, M.P, Ehlers J.D. and Roberts P.A. (2007a). Cowpea. In: Genome mapping and molecular breeding in plants, Volume 3, Pulses, sugar, and tuber crops. Kole, C, (Ed.). *Springer* Verlag, Berlin and Heidelberg, Germany. pp. 49-67.

Timko, M.P., Ehlers, J.D. and Roberts P.A. (2007). Cowpea. In: C Kole (eds.) Pulses, Sugar and Tuber Crops, Genome Mapping and Molecular Breeding in Plants. Vol.3 Berlin/Heidelberg: *Springer*-Verlag, pp, 49-67.

Togola, A., Ongom, P.A, Fatokun, C., Mohammed, S.B., and Jackson D. (2023). Exploiting the genetic potential of cowpea in an inter cropping complex. *Agronomy* 13(6) 1594.

Table 1. Mean performance of cowpea genotypes for plant height (cm) and number of leaves per plant at 3, 6, and 9 WAS at BUK during the 2023 rainy season

Genotype	Plant height (cm)			Number of leaves		
	3WAS	6WAS	9WAS	3WAS	6WAS	9WAS
IT98K-388-2	8.33^{c}	25.22	25.22^{ab}	15.89	77.78	56.89
IT99K-573-1-1	9.56^{ac}	21.56	22.78^{b}	18.67	78.33	52.00
IT07K-297-13	12.11^{a}	22.78	22.78^{b}	18.33	71.67	51.67
IT08K-150-12	12.00^{a}	21.26	21.26^{b}	15.44	74.78	53.22
IT13K-1308-5	11.78^{ab}	27.78	28.89^{a}	18.78	75.22	54.22
TVx-3236	10.50^{abc}	24.00	29.45^{a}	12.50	30.50	38.00
B301	8.80^{c}	22.30	29.75^{a}	15.50	53.50	71.00
Mean	10.44	23.56	25.73	16.44	66.00	53.90
P Value	0.002	0.07	0.001	0.297	0.156	0.692
SE±	0.828	2.007	1.800	2.763	17.020	18.120

Means followed by different letter(s) in a column are significantly different at a 5% probability level.

Table 2. Mean performance of cowpea genotypes for number of branches *Striga* count of cowpea genotypes at BUK during 2023 rainy season

Genotype	Number of branches			*Striga* count		
	3WAS	6WAS	9WAS	7WAS	8WAS	9WAS
IT98K-388-2	3.667	4.667	5.667^{ac}	0.000^{b}	0.000^{b}	0.000^{b}
IT99K-573-1-1	4.000	5.333	8.000^{ab}	0.000^{b}	0.000^{b}	0.000^{b}
IT07K-297-13	3.333	4.333	6.000^{a}	0.000^{b}	0.000^{b}	0.000^{b}
IT08K-150-12	3.333	4.667	6.000^{abc}	0.000^{b}	0.000^{b}	0.000^{b}
IT13K-1308-5	3.667	4.667	7.667^{abc}	0.000^{b}	0.000^{b}	0.000^{b}
TVx-3236	4.000	5.000	5.667^{abc}	17.667^{a}	28.000^{a}	37.333^{a}
B301	4.500	5.667	8.000^{a}	0.000^{b}	0.000^{b}	0.000^{b}
Mean	3.79	4.90	6.71	2.52	4.00	5.33
P Value	0.344	0.153	0.010	<0.001	<0.001	<0.001
SE±	0.525	0.466	0.713	0.642	0.617	1.458

Means followed by different letter(s) in a column are significantly different at a 5% probability level.

Table 3. Mean performance of cowpea for yield characters

Genotype	Pod weight(g)	No. of see/pod	Seed yield(g)	100 seed weight(g)
IT98K-388-2	101.4^{bc}	11.27	78.7^{ab}	20.33
IT99K-573-1-1	203.9^{a}	10.50	145.1^{a}	22.60
IT07K-297-13	162.3^{ab}	9.60	121.9^{a}	23.60
IT08K-150-12	139.1^{ab}	10.47	98.9^{a}	21.90
IT13K-1308-5	160.1^{ab}	9.60	121.8^{a}	21.47
TVX-3236	60.0^{c}	11.50	43.0^{b}	14.50
B301	176.0^{ab}	12.50	128.5^{a}	14.25
Mean	143.20	10.78	105.4	19.81
P value	0.002	0.08	0.005	0.066
SE±	25.43	0.936	20.62	3.298

Means followed by different letter (s) in a column are significantly different at a 5% probability level.

GENETIC VARIABILITY STUDIES FOR AGRONOMIC AND HAULM YIELD OF GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES IN GAYA SUDAN SAVANNAH NIGERIA

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Abstract

In the present study, 10 genotypes of groundnut were grown under field condition at Aliko Dangote University of Science and Technology Teaching and Research Farm Gaya Sudan savannah of Nigeria during 2023 rainy seasons. The experiment was laid in Randomized Complete Block Design with three replications in order assess the extent of genetic diversity in groundnut through Principal Component Analysis (PCA) and to determine the relationship between growth performance, haulm yield and its related traits of groundnut genotypes Results reveals that Out of 9 PCA's, only 3 principal components (PCA's) exhibited greater than 1.00 Eigen value, and explained 79.56% cumulative variability among the traits studied. The PC1 displayed 44.78% while, PC2 and PC3 exhibited 23.45% and 11.33% variability respectively among the genotypes for the traits under study. It could be concluded that first principal component Analysis (PCA1) scores explained 44.78% of the total variation, mainly associated to genotypes growth performance and haulm yield and its related traits. This study will be helpful in identifying the variability contributing parameters and selection of suitable genotypes for breeding and utilization in groundnut improvement for growth and haulm yield attributing traits.

KEYWORDS: GENETIC, GROUNDNUT, GENOTYPES, VARIABILITY

INTRODUCTION

Peanut (*Arachis hypogea* L.) is major a legume crop grown principally for its edible seeds (Li *et al*., 2018). It is widely cultivated due to its high oil content as an oil crop and is considered one of the cash crops (Popoola *et al.,* 2022). It is greatly nutritious due to containing 25% protein and 50% edible oil (Javanmardi *et al.,* 2022). It is utilized in the form of edible oil, shelled nuts, or distinct processing forms such as peanut butter, flour, sauce, or confectionery items (Yin *et al.*, 2022). Global annual production of shelled peanuts was 53.6 million ton produced from 31.5 million hectare in 2020 (FAOSTAT, 2022). Peanut is an annual summer crop in Egypt with acreage area about 64 thousand hectare in the 2020 with a total production of about 213.8 thousand ton with an average productivity of 3.34 ton/ha. Seed viability and seedling vigour are crucial factors for the successful growth of peanut (Prasad *et al*., 2020). Rapid germination, vigorous seedlings, uniform emergence, and strong early growth reflect a high potential for crop stand establishment and a successful cropping system (Damalas *et al*., 2019). Improving stand establishment is a vital prerequisite for high growth and productivity (Sagvand *et al.*, 2022). Genotypes exhibited contrasting performances under different agricultural practices (Khorami *et al*., 2018). Peanut cultivars differed in chemical composition, germination, vigour, fungi infection, and storability (Bera *et al*., 2019. The crop is a native to Central America and has never been found uncultivated (Vabi *et al.*, 2019). The World production figure of groundnut in 2019 was 48.8 million tonnes from 29.6 million hectares with average production of 1647 kg ha-1 (FAO, 2021). The production of groundnut is concentrated in Asia and Africa, where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs. Nigeria is the third largest producer of groundnut in 2019 with annual production of 4.4 million tonnes after China 17.1 million tonnes and India 6.7 million tonnes (FAO, 2021). It is estimated that 3.9 million hectares were planted in 2019 with groundnut in Nigeria (FAO, 2021). The main agro-ecological zones for groundnut production in Nigeria are Sahel, Sudan, northern guinea and most of the southern guinea and derived savannah (Vabi *et al*., 2019). However The need to improve groundnut productivity has also necessitated the breeding of varieties that can take the advantage of factors such as high yielding early maturing crop, resistance to pests and diseases, tolerant to drought and escape to end of season drought due to extra early maturity (Vabi *et al*., 2019).

Under utilisation of vast potential of groundnut landraces has led to low genetic variability among varieties available to farmers. This low genetic variability remains one of the main challenges to groundnut improvement (Pasupuleti *et al*., 2013). According to Tulole *et al*. (2008), cultivation of low yielding varieties and poor seed supply are among the major constraints to increasing groundnut production. In Nigeria, attention has not been given to collection and evaluation of available groundnut landraces and information on the qualitative and quantitative properties of groundnut cultivars grown in Nigeria has not been adequately evaluated. In addition, Hassan and Ahmed, (2012) also noticed that the major focus of the breeding program by the groundnut breeders has not been on the improvement in yield and yield related traits. However, quantity and quality of oil in term of fatty acid has rarely been studied. Pollen production, viability and germinability test of the groundnut genotypes have not been used to determine genetic variability among the accessions of groundnut grown in Nigeria. There is therefore a need to develop better genotype (s) of the crop in order to encourage its cultivation for increased production of yield as well as enhancing its improvement. Knowledge of the genetic variability in a population and partitioning the variance into the components provides useful information for improvement of desirable traits (Zaman *et al*., 2011)

The objectives of this study were to assess the extent of genetic diversity in groundnut through Principal Component Analysis (PCA) and to determine the relationship between growth parformance, haulm yield and its related traits of groundnut genotypes

MATERIALS AND METHOD

Experimental Site

The experiment was conducted at Aliko Dangote University of Science and Technology, teaching and research farm Gaya. Latitude of 11^0N–12! N and longitude of 70 30! E–8035! E. These coordinates are for Gaya zone which falls in Sudan Savannah region of Nigeria (Kano State Station of IAR, 2008). .

Treatment and Experimental Design

The treatments comprises ten groundnuts genotypes to which nine are improved varieties i.e.(SAMNUT 21,SAMNUT 22,SAMNUT 23, SAMNUT 24, SAMNUT 25, SAMNUT 26, SAMNUT 27, SAMNUT 28,SAMNUT 29) and a local check (MAI BARGO). The nine varieties was obtained from the Institute for Agricultural Research (IAR), Samaru, Zaria Kaduna State and a Local check from Wudil Community, The experiment was laid out in a Randomized complete block design (RCBD) with three replications and Each entry was planted in two-rows per plot of 4 meter long. Two seed was planted at 20cm intra-row and 75cm inter-row spacing

The trial plot was 4m×0.75m wide ($7.5m^2$) in three replication and 0.75 path between adjoining plot to which each replication consist of 20 rows of 4m wide with border row of 1m (between the replication). Two (2) seeds were sown per hole at the depth of 2-3cm by dibbling method at inter and intra-row spacing of 75cm×20cm respectively. Supplying was done on the missing stands at 3WAS, which gives total number of 44,444.40 plant population per/ha. First weeding was carried out manually by hand hoeing at three weeks after sowing (3WAS) and the second weeding was at eight weeks after sowing (3WAS). This was carried out in order to control weed while regular visits were made to the experimental field to assess the occurrence of pest and disease and take the appropriate measure to control them. Inorganic fertilizer was applied to groundnut i.e. single super phosphate (SSP) is the recommended fertilizer for peanut while mixed with NPK. The application was done at 3 WAS. In the absent of SSP, N.P.K. can be used as substitute.100kg NPK 15:15:15/ha and 150kg SSP/ha was applied.

The data collected was subjected to the analysis of variance (ANOVA) using Genstat (2014) statistical package and separation of treatment mean effect was done using Student Newmans Kuels (SNK) at 5% levels of significant.

RESULTS AND DISCUSSION

The principal component analysis result for the 9 traits of groundnut in Gaya, presented in (Table 1) were the Eigen values, % variance, % cumulative variance and factor loading of different traits are given. In canonical variant analysis, the number of variable is produce to linear function called canonical vector which account for most of the variation produce by these characters. The 9 vectors accounted for 99.99% to the total variability produced by all groundnut genotypes for haulm yield this is in agreement with the results presented by species (Majiand Saibu, 2012) and (Rama Krishnan *et al*., 2016). The results indicated that all the traits showed positive and negatives loading on PC1 which contributed 44.78% of the total variation, having an Eigen value of 4.03 with the highest loadings coming from Canopy spread at 9WAS. Components with eigen values greater than one are meaningful and theoretically have more information than any single variable alone (Iezzoni and Pritts, 1991) reported similar results. Plant height at 9WAS, Canopy spread at 3 WAS with their corresponding values of 0.42, 3.9 and 0.37, respectively. The least contribution came from Days to 50% flowering with highest negatives value of -0.39. The PC2 which contributed 23.45% of the total variability with Eigen value of 2.11 showed maximum positive loadings on Stand count at 3WAS, Stand count at 9WAS, Days to 95% flowering were 0.66, 0.61 and 0.30 respectively while Plant height at 3WAS (-0.11) and haulm weight (-0.24) had the highest negative values. The PC3 which contributed 11.33% of total variability with an Eigen value of 1.02, which showed maximum positive loadings on Canopy spread at 3WAS, days to 50 %flowering and Canopy spread at 9WAS, with the corresponding values of 0.584, 0.455 and 0.450, respectively with the highest negative values on Plant height (-0.22) and Stand count at harvest (-0.27). The PC4 which contributed 9.65% of the total variability with an Eigen value of 0.8686 and it shows maximum positive loadings on haulm weight (0.57), plant height at 3WAS (0.54) and Days to 50% flowering (0.41) with the least highest negatives value of -0.21 canopy spread at 3WAS. The **PC 5** which contributed 5.69% of the total variability with an Eigen value of 0.5124, it showed maximum positive loadings on Plant height at 9WAS, Plant height at 3WAS and Days to 50% flowering with loading factors of 0.59, 0.33 and 0.315 respectively, with the least values of -0. 16 came from Stand count at harvest. The results indicated that all the traits showed both negatives and positive loading on PC6 which contributed 3.53% of the total variation having an Eigen value of 0.032 with the highest loadings coming from Plant height 3WAS, Plant height at 9WAS, haulm weight with values of 0.65, 0.64 and 0.33, respectively. The least contribution came from Canopy spread at 3WAS, with highest negatives value of -0.17. The PC7 which contributed 0.78% of total variability with an Eigen value of0.0701, it showed maximum positive loadings on Canopy spread at 3WAS (0.66) and Canopy spread at 9WAS, with the corresponding highest negative values of -0.74. PC8 which contributed 0.64% of the total variability with an Eigen value of 0.0579and showed maximum positive loadings on Days to 95% flowering (0.696), while Days to 50% flowering (-0.605) had higher negative values. PC 9 accounted 0.14% of the total variabilitywith an Eigen value of 0.01 showed maximum positive loadings on Stand count (0.66) and Stand count at harvest (-0.70) had maximum negative contribution towards genetic diversity. Similar results were reported in groundnut by (Makinde and Ariyo, 2010) and (Aondover et al., 2013; El-Hashash, 2016) in soybean genotypes.

CONCLUSION

Three principal components (PCs) exhibited more than 1.00 Eigen value, and showed about 79.56 % cumulative variability among the traits studied. The PC1 showed 44.78% while, PC2 and PC3 exhibited 23.45% and 11.33% variability respectively among the genotypes for the traits under study. The scree plot exhibited high variability among the genotypes and between the parameters. In this regard, the study will be helpful in identifying the variability.

REFERENCES

Bucheyeki, T. L., Shenkalwa, M. E, Mapunda, T., &Matata, W. L. (2010). The groundnut client oriented research in Tabora, Tanzania. African Journal of Agricultural Research, 5(5), 356-362.

Damalas, C.A., S.D. Koutroubas and S. Fotiadis (2019). Hydro-priming effects on seed germination and field performance of faba bean in spring sowing. Agric., 9: 201.

FAO (2021).Faostat. Retrieved May 13, 2021 from http://www.fao.org/faostat/en/#data/QC

FAOSTAT (2022).Food and Agriculture Organization of the United Nations.Statistical Database. Available online: http:// www.fao.org/faostat/en/#data (accessed on 30 October 2022).

FAOSTAT(2019).FoodandAgricultureOrganizationoftheUnitedNations.Rome: FAOSTATStatisticalDatabase.

Javanmardi, F., D. Khodaei, Z. Sheidaei, M. Bashiry, K. Nayebzadeh, Y. Vasseghian and A.M. Khaneghah (2022). Decontamination of aflatoxins in edible oils: A comprehensive review. Food Rev. Int., 38: 1410-1426.

Li, Y., R. Zhang, X. Qin, Y. Liao and K.H. Siddique (2018).Changes in the protein and fat contents of peanut (Arachis hypogaea L.) cultivars released in China in the last 60 years. Plant Breed., 137: 746-756.

Popoola, J.O., O.S. Aworunse, O.B. Ojuederie, B.D. Adewale, O.C. Ajani, O.A. Oyatomi, D.I. Eruemulor, T.T. Adegboyega and O.O. Obembe (2022). The exploitation of orphan legumes for food, income, and nutrition security in Sub-Saharan Africa. Front. Plant Sci., 13: 782140.

Prasad, R., K. Chandrika and V. Godbole (2020). A novel chitosan biopolymer based Trichoderma delivery system: Storage stability, persistence and bio efficacy against seed and soil borne diseases of oilseed crops. Microbiol. Res., 237: 126487

Sagvand, M., M.N. Esfahani and F. Hadi (2022). Pre-sowing enrichment of Echinacea angustifolia seeds with macronutrients improved germination performance and early seedling growth via stimulating the metabolism of reserves. Ind. Crops Prod., 188: 115614.

USDA-NASS (2021).U.S. Department of Agriculture. 2020. Washington, DC: National Government Printing Office.

Upadhyaya H, Nigam S (1994). Inheritance of two components of early maturity in groundnut (Arachis hypogaea L.). Euphytica 78(1): 5967.

Vabi BM, Mohammed SG, Echekwu CA, Mukhtar AA, Ahmed B, Ajeigbe HA, EcheCO (2019). Best choices for enhancing

Yin, H., Y.T. Li, W. Tsai, H. Dai and H. Wen (2022). An immunochromatographic assay utilizing magnetic nanoparticles to detect major peanut allergen Ara h 1 in processed foods. Food Chem., 375: 131844

Yada, B., Tukamuhabwa, P., Alajo, A. and Mwanga.R.O.M. (2010).Morphological characterization of Ugandan sweet potato germplasm. Crop Sci. 50:2364-2371

Makinde, S. C. O., & Ariyo, O. J. (2010).Multivariate analysis of genetic divergence in twenty two genotypes of groundnut (Arachis hypogaea L.). Journal of Plant Breeding Crop Science, 2(7), 192–204. http://www. academicjournals.org/jpbcs.

Aondover, S., Lekan., B. L., & Terkimbi, V. (2013). Correlation, path coefficient and principal component analysis of seed yield in soybean genotypes. International Journal of Advance Research, 1(7), 1–5. http://www.journalijar. com/uploads/2013-10-03_105313_753.pdf.

Iezzoni, A. F., & Pritts, M. P. (1991).Applications of principal component analysis to horticultural research. HortScience, 26(4), 334–338. https://doi.org/10. 21273/HORTSCI.26.4.334

Table 1: Eigen value, contribution of variability and Eigen vectors for the principal component axis of Groundnut.

Eigen component	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9
Standard Deviation	2.01	1.45	1.01	0.932	0.72	0.56	0.27	0.24	0.11
Proportion of variance	0.45	0.24	0.11	0.09	0.06	.035	0.01	0.01	0.01
Cumulative proportion	0.45	0.68	0.79	0.89	0.95	0.98	0.99	0.99	1.00
Eigen value	4.03	2.11	1.02	0.87	0.51	0.03	0.07	0.06	0.01

Principal component (PV) variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Stand count 3WAS	0.12	0.66	-0.11	0.08	-0.14	0.01	-0.08	-0.28	0.66
Canopy spread 3WAS	0.37	0.06	0.58	-0.21	-0.09	-0.17	0.66	-0.03	0.05
Plant height 3WAS	0.35	-0.11	-0.22	0.54	0.33	0.65	0.05	0.003	0.03
Stand count at harvest	0.18	0.61	-0.27	-0.04	-0.16	-0.06	0.09	-0.01	-0.70
Canopy spread 9was	0.419	0.06	0.45	-0.19	-0.01	-0.17	-0.74	0.07	-0.09
Plant height 9WAS	0.399	0.11	0.01	0.16	0.59	0.64	0.07	0.19	0.01
Days to 50% flowering	-0.38	0.14	0.46	0.32	0.32	0.03	-0.05	-0.61	-0.24
Days to 95% flowering	0.36	0.30	0.34	0.41	-0.09	-0.06	-0.002	0.69	0.04
Haulm weight (kg)	0.99	-0.24	0.07	0.57	-0.62	0.33	0.03	-0.16	-0.08

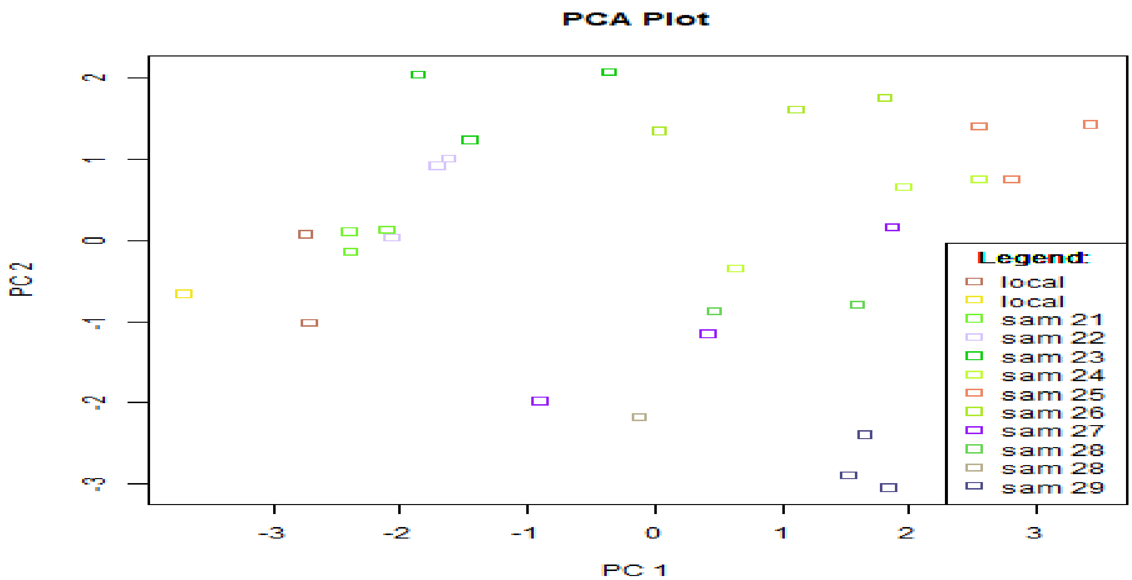

Fig 1: Biplot distribution of groundnut genotypes for the first two principal components

AGRONOMIC AND HERITABILITY STUDIES AMONG SOME OKRA GENOTYPES AND ASSOCIATED HYBRIDS FOR IMPROVED ADAPTATION AND YIELD IN AN AGRO-ECOLOGY

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ABSTRACT

Parental lines, F_1 generation of domesticated Okra and Okra landraces were evaluated at the Research farm of the Department of Crop Science, University of Nigeria, Nsukka for improvement in their quantitative traits. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were collected on agronomic, yield and yield component traits. Better parent heterosis (BPH), genetic variances, heritability, and gene effects of the traits were estimated for the hybrids generated. From the result, most of the crosses involving the wild genotypes as one of the parents, recorded high average fruit weight, fruit girth and number of fruits per plant. Similarly, it was also observed that the wild parent, 'Ele Uhie' alongside the cross, 'Ele Uhie' x 'LD88' produced higher agronomic and yield traits. In same vein, the cross, 'Ele Ogwu' x 'LD88' recorded the highest positive BPH value (161.26%) for total fruit yield. It also recorded higher positive BPH values for average fruit weight and number of fruits per plant. Most of the hybrids exhibited negative BPH for plant height at maturity, 100 seed weight and number of seeds per pod. Hybrids with the landraces as one of the parents as, 'Ele Ogwu' x 'LD88', 'Ele Uhie' x 'Agwu early', and 'Ele Uhie' x 'LD88' had the highest narrow sense heritability in total fruit yield. Hybridization was controlled by a high level of epistasis in expressing quantitative traits; thus, would prove effective in developing new okra genotypes with positive heterotic effects in yield.

Keywords: gene action, genetic variability, heritability, heterosis, hybridization, landraces

INTRODUCTION

Okra (*Abelmoschus* spp.), belonging to the family *Malvaceae* and order *Malvales* is one of the most utilized species among the Mallows (Jemal *et al.*, 2022; Kenaw *et al.*, 2023). It is mainly grown for its immature pods which are mostly consumed as fresh or cooked vegetables, and often used in soups, salads and stews as additives and thickeners (Sorapong, 2012). Due to its rich nutritional, economical and industrial values, production of high yielding potential genotypes with appreciable morphological characteristics is the basis of successful okra production and is crucial for increasing productivity (Ashraf *et al.*, 2020). Thus, good knowledge of genetic resources helps in identifying desirable cultivars for sustainable commercial production aimed towards achieving food security. In same vein, Kenaw *et al.* (2023) stressed that improvement of the crop requires continuous evaluation, hybridization and selection of genotypes for fruit quality, yield, and other morpho-agronomic traits by comparing the potentials of indigenous with introduced varieties to identify and release varieties for early maturity, stress tolerance and resilience to climate change.

Appreciable traits for cultivation and consumption are conferred upon by domestication and improvement of crops through hybridization, which has been highly effective in introducing and concentrating allelic variations in crops (Reddy *et al.*, 2012b). According to Allard (1960) the major goal of hybridization in breeding self-pollinated crops is to combine in a single genotype, genes that are present in two or more different genotypes. Hybridizing domesticated okra species with wild relatives or landraces is essential to broaden the primary gene pool (Sandeep *et al.*, 2022). Thus, the ability to use a particular wild relative depends heavily on the recovery of progeny from initial and subsequent crosses of okra with the wild relative. Although all species can be hybridized with okra, the ease of attaining success varies greatly (Sandeep *et al*., 2022).

Okra hybrids usually produce higher yield. The appreciably increased yield of hybrids could be attributed to the high yielding prowess of the better parents selected for hybridization. They generally mature earlier and exhibit more uniform fruit productivity compared to their conventional, domesticated parents (Udengwu, 2008; Venkatesh *et al.*, 2023). Hybrid plants combine the traits of parent plants as a result of being heavy producers. As such, the genetic distance (variability) between the parental lines has a strong correlation with the occurrence of heterosis in okra hybrids (Kumar and Reddy, 2016). Better disease resistance and improved fruit quality are also associated with hybrid plants. More so, these hybrids which are often referred to as “resistant genotypes” also possess other desirable economic traits that makes them appreciably desired at commercial levels (Kumar *et al.*, 2009).

Bowley and Taylor (2022) as well as Kumar *et al.* (2010) opined that knowledge of the magnitude of heterosis for various traits is essential in identifying better combinations to exploit them through hybridization; thus its effective utilization in okra production. Amaefula *et al.* (2014) further stressed that heterosis can be expressed when the parents of a hybrid have different alleles at a locus and there is seemingly some level of dominance or epistasis among the alleles. Acquaah (2007) observed that the beneficial effect of crosses appear immediately in the F_1 generation, thus exhibiting heterosis. Sandeep *et al.* (2022) reported that heterosis for agronomically and yield essential traits must be manifested prior to obtaining productive hybrids. The yields of the hybrids will be, with fewer exceptions substantially greater than those of the better parents, when parents differ consistently in type and form (Bhatt *et al*., 2016). Fruit yield being the major point of interest in okra production, is a multiplicative trait that integrates variation from several other traits and is therefore expected that the trait would exhibit higher level of heterosis (Jindal *et al*., 2009). However, Kumar and Reddy (2016) buttressed the fact that fruit weight and number of fruits per plant have been consistently identified as very important components of fruit yield and seed yield in okra.

Therefore, the need to develop okra genotypes that will replace suitably the existing conventional and landrace types that are either not favourably adaptable or poor in quality and productivity necessitated this study. Thus, the major objective of this study was to develop new okra genotypes expressing heterosis in fruit yield and fruit quality and investigate the genetic effect of the main quantitative traits controlling fruit yield in okra. The information will be essential in the development of new cultivars with improved fruit quality and yield as well as being tolerant to major biotic and abiotic stress factors.

MATERIALS AND METHODS

The experimental materials used for the research study were five parental lines, comprising three conventional, domesticated okra (*Abelmoschus esculentus* L.) namely: 'Agwu early', 'Clemson spineless' and 'LD88', obtained from National Institute for Horticultural Research and Training (NIHORT), Ibadan, Nigeria and two West African wild landrace parents (*Abelmoschus caillei* L.) namely: 'Ele Ogwu' and 'Ele Uhie', obtained from Obukpa community in Nsukka Local Government Area of Enugu State, Nigeria. A 5 x 5 diallel analysis using Griffings (1956) model 1 method 2, (half-sib diallel reciprocal crossing) was employed to produce 10 F_1 hybrids. The parental lines and the F_1 hybrids generated were evaluated at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. The experiment was laid out in a randomized complete block design (RCBD) and replicated three times. Field measurement of 18 x 20 m developed into 30 plots was adopted. The field was further split into three replications. Each replication consisting 10 plots with dimensions, 1.5 x 1.8 m was separated by a 1 m pathway.

Well cured poultry manure was uniformly incorporated into the soil at the rate of 10 tonnes/ha, then developed into beds. After manure incorporation, the soil was allowed to rest for a week before seed sowing to allow for proper decomposition. NPK 20:10:10 inorganic fertilizer at the rate of 40 kg/ha was applied in two separate doses; three weeks after seed sowing and at the onset of flower initiation. Weeding and all other necessary cultural practices were carried out as at when due. Cypermethrin EC insecticide at the rate of 2.5 ml of water was applied at three weeks interval, especially at the peak of rainfall, to control insect attack. The parental lines with their associated hybrids were evaluated on the following traits; Plant height at maturity (PHM), Stem girth (SG), number of branches per plant (NB/PL), fruit length (FL), fruit girth (FG), Average fruit weight (Av.FW), 100 seed weight (100SW), number of seeds per pod (NS/P), number of fruits per plant (NF/PL) and total fruit yield (TFY).

Heterosis was estimated as Better parent heterosis (BPH) as proposed by Allard (1960) as follows;

$$BPH = \frac{F_1 - \overline{BP}}{\overline{BP}} \times \frac{100}{1}$$

Where $\bar{F}_1$ is the mean of the hybrid, $\overline{BP}$ is the mean of the better parent.

Test of significance was carried out as described by Darshini and Gangaprasad (2022);

$$\text{CD for better parent heterosis} = \sqrt{\frac{2me}{r}} \times t$$

Where CD = critical difference, me = error mean square, r = number of replications, t = t tabulated at 5% level of probability, 2 = a constant.

Estimates of the genetic variances of quantitative traits were determined using the variance estimate method as described by Uguru (2005) and Acquaah (2007)

$$m = \bar{F}_2$$

$$V_e = \frac{P_1 + P_2 + F_1}{3}$$

$$V_a = 2F_2 - (BC_1 + BC_2)$$

$$V_d = \frac{[\langle BC_1 + BC_2 - F_2 - (P_1 + P_2 + F_1\rangle]}{3}$$

$$V_p = V_e + V_a + V_d$$

$$H_b = \frac{V_g}{V_p} \times \frac{100}{1}$$

$$H_{ns} = \frac{V_a}{V_p} \times \frac{100}{1}$$

Where,

m = mean effect;

$\bar{F}_2$ = mean of F_2 filial generation;

V_e = Environmental variance;

V_a = Additive variance;

V_d = Dominance variance;

V_p = Phenotypic variance;

V_g = Genotypic variance;

H_b = Broad sense heritability;

H_{ns} = Narrow sense heritability.

The additive variance, dominance variance, genotypic variance, phenotypic variance, environmental variance, narrow sense heritability and broad sense heritability were determined using the variances of the parental lines, F_1, F_2 and backcrosses, i.e BC_1 and BC_2 populations.

STATISTICAL ANALYSIS

Data obtained were subjected to analysis of variance using Genstat Release Discovery 12.0 Edition software. Treatment means were separated using Fishers' Least Significant difference (F-LSD) at 5% level of probability as outlined by Obi (2002). Graphpad prism 10.2.3 was used to depict graphical illustrations of F-LSD of the treatment means.

RESULTS AND DISCUSSION

Plant height at maturity (cm)

The result shows that the parents and their associated hybrids varied significantly ($p < 0.05$) with respect to plant height at maturity. The undomesticated wild parent, 'Ele Uhie' recorded significantly higher mean value for plant height at maturity (241.02 cm) than others. It was closely followed by the cross, 'Ele Ogwu' x 'Ele Uhie', while the domesticated parent, 'Agwu early' had the least performance for plant height at maturity (42.03 cm) compared to all the genotypes studied. The wild undomesticated parents with higher values for plant height at maturity expressed higher propensity for enhanced plant growth, which influenced the expression of such trait when used as a parent in generating hybrids as revealed in the results. According to Osawaru *et al.* (2013) and Kumar *et al.* (2021), landraces or wild species typically exhibit higher genetic diversity compared to modern domesticated varieties that retain alleles which influence such traits as plant height.

Stem girth (cm)

From the result, the undomesticated parental line, 'Ele Uhie' recorded significantly ($p < 0.05$) higher stem girth (16.10 cm) than all the genotypes studied. It was statistically similar to 'Ele Ogwu', then closely followed by the cross, 'Ele Uhie' x 'LD88'. In contrast, 'Clemson spineless' expressed lower stem girth (3.46 cm). It was closely followed by 'Agwu early'. As such, hybrids generated using 'Ele Uhie' parental line expressed larger stem girth. Sandeep *et al.* (2022) as well as Eshiet and Brisibe (2015) opined that wild relatives of okra possess wider genetic diversity than domesticated conventional varieties which contribute to the broader stem girth observed in most hybrids they are used as one of the parents, thereby providing a basis for improved selection. Similarly, Kishor *et al.* (2016) attributed this development to the genetic makeup and partial dominance of the wild relatives over their conventional counterparts in expressing the trait.

Number of branches per plant

Significant difference was observed in the treatment effect of selected parental lines and their associated hybrids on number of branches per plant. The hybrid, 'Ele Uhie' x 'LD88' produced significantly ($p < 0.05$) higher number of branches per plant (7 branches) than all the genotypes studied while the domesticated parent, 'Clemson spineless' produced the lowest number of branches. From the result, it could be deduced that hybrids generated using the undomesticated genotypes as one of the parents expressed higher number of branches per plant. This agrees with the report of Shaikh *et al.* (2013).

Fruit length and fruit girth (cm)

The selected parental lines of okra and their associated hybrids exhibited significant ($p < 0.05$) difference for fruit length and fruit girth. The highest mean fruit length of 13.57 cm was obtained for the cross, 'Ele Uhie' x 'Clemson spineless' in comparison to other genotypes. It was closely followed by the wild parent 'Ele Uhie' with mean fruit length value of 12.43 cm. Similarly, 'Ele Uhie' wild parent expressed significantly higher result for fruit girth (11.33 cm). In contrast, 'Ele Ogwu' wild parent gave the least performing result of 4.73 cm for fruit length while 'Clemson spineless' recorded the lowest result for fruit girth (5.65 cm). Reduced fruit girth with increased fruit length are highly desirable traits required for okra improvement as they enhance acceptability, marketability, exportation and efficient processing as observed in most genotypes associated with 'Clemson spineless'. Udengwu (2015) reported similar findings. Similarly, Sugri *et al*. (2015) opined that, slender long varieties have higher demand and sales rate because of ease of processing when used in preparing soup delicacies.

Average Fruit weight (g)

From the result obtained, it was observed that significant ($p < 0.05$) difference exist among the parental lines and their associated hybrids in expression of average fruit weight (Figure 6). It further revealed that the hybrid, 'Ele Uhie' x 'LD88' recorded the best result for average fruit weight (30.56 g) compared to other genotypes. It was statistically similar to the result obtained for the undomesticated parent, 'Ele Uhie'. On the other hand, the domesticated parent, 'Agwu early' expressed the lowest result for the trait (20.27 g). Hybrids generated using the wild undomesticated genotypes as one of the parents exhibited higher average fruit weight, thus showing incomplete dominance of the wild parents in expressing the trait. Kumar *et al.* (2021) reported similar result.

100 seed weight (g)

The result revealed that the wild parent, 'Ele Uhie' had significantly ($p < 0.05$) higher 100 seed weight (5.29 g) than other genotypes studied. It was statistically similar to the result obtained for the cross, 'Ele Uhie' x 'LD88' (4.66 g). On the other hand, the wild parent, 'Ele Ogwu' had the least performance for 100 seed weight (3.22 g). From the result, most of the hybrids expressed higher result for the trait in comparison to their wild and conventional parents. This could be attributed to their improved genetic diversity and superior heterotic potentials which would have influenced the hybrids to inherit beneficial traits from one of the parents and complement or compensate for the deficiencies in the other parent in expressing the trait. This agrees with the findings of Suma *et al.* (2023) in their findings on genetic enhancement of okra germplasm through wide hybridization.

Number of seeds per pod

From the result obtained, the wild parent, 'Ele Uhie' produced significantly ($p < 0.05$) higher number of seeds per pod (105.42 seeds). It was closely followed by the result obtained for the hybrid, 'Ele Uhie' x 'LD88', then 'Ele Uhie' x 'Clemson spineless'. On the other hand, the wild parent, 'Ele Ogwu' produced lower number of seeds per pod compared to all the genotypes studied with mean value of 54.22 seeds per pod. It was closely followed by 'Agwu early' (68.74 seeds per pod). The high number of seeds per pod from 'Ele Uhie' and all associated hybrids generated from it could be attributed to its incomplete dominance in expressing the trait (Suma *et al.,* 2023).

Number of fruits per plant and total fruit yield (t/ha)

Results for number of fruits per plants and total fruit yield showed that they significantly ($p < 0.05$) differed in their expression with respect to varietal responses (Figures 9 and 10). The hybrid, 'Ele Uhie' x 'LD88' produced significantly ($p < 0.05$) higher number of fruits per plant and total fruit yield with mean values of 25.63 fruits and 12.72 t/ha, respectively. It was closely followed by the hybrid, 'Ele Ogwu' x 'LD88' most especially in expression of number of fruits per plant. However, the wild parent, 'Ele Uhie' recorded statistically similar result for these traits. On the other hand, the conventional parent, 'Clemson spineless' produced lower number of fruits per plant (2.40 fruits) and total fruit yield (1.78 t/ha). Higher performance of 'Ele Uhie' x 'LD88' and 'Ele Ogwu' x 'LD88' over both their domesticated and wild parents could be due to better heterotic performance of the hybrids over their better parents. In same vein, the progenies inherited a combination of alleles from both parents of which the alleles from one parent might have complemented or enhanced the alleles from the other parent; thus, resulting in improved performance in their fruiting and yield prowess (Reddy *et al.,* 2013).

Estimation of Better Parent Heterosis (BPH)

The magnitude of heterosis depends on the accumulation of favourable dominant alleles in the F_1 population (Labroo *et al*., 2021). According to Wagaw and Tadesse (2020), both positive and negative heterosis is useful in crop improvement, depending on the breeding objectives. As such, Better parent heterosis (BPH) is preferably used to express the performance of hybrids over their parents. From the result, estimates of better parent heterosis (BPH) of the agronomic, yield and yield component traits showed that negative BPH was recorded in plant height at maturity for all the crosses involving the wild parents. However, crosses involving only the domesticated, conventional parents showed positive BPH. The result further revealed that the cross, 'Ele Ogwu' x 'Agwu early' gave the highest negative value of -67.54% while the cross, 'Agwu early' x 'Clemson spineless' had the highest positive BPH heterotic value of 11.05% (Figure 2). The negative BPH exhibited by most of the hybrids involving the wild parents could be as a result of the long distance in the traits between the wild undomesticated parents and the conventional parents of which the wild parents were favoured in this regard. The result is in conformity with the report of Kerure *et al.* (2019) who observed that most crosses between local okra and dwarf-natured okra displayed negative standard heterosis for plant height. In the same vein, Eshiet and Brisibe (2015) opined that negative heterosis is desirable for plant height as it aids in the development of short-natured plants which helps in controlling lodging as well as ensuring ease in harvesting.

For stem girth, most of the hybrids generated using the wild genotypes as one of the parents exhibited positive BPH. It further revealed that the hybrid, 'Ele Ogwu' x 'LD88' had the highest BPH value of 91.52%. In contrast, the hybrid, 'Agwu early' x 'Clemson spineless' gave the highest negative BPH value of -65.04% for the trait. The positive heterosis in stem girth exhibited by most of the crosses could be as a result of incomplete dominating effect of the much broader wild parents over the slender domesticated ones. This conforms to the report of Thirupathi *et al.* (2012) who reported positive heterosis for such traits as branch length, stem circumference and plant height.

In relation to number of branches per plant, most of the hybrids generated using the wild parents as one of the parents recorded positive BPH. ‘Ele Uhie’ x ‘LD88’ had the highest positive BPH with percentage value of 59.41%, while ‘Clemson spineless’ x ‘LD88’ had the highest negative BPH value (-58.66%) for the trait. Positive heterosis for number of branches per plant indicates that an improvement in the trait could positively influence higher accommodation of number of nodes and fruit-bearing surface of the plant, which is considered an important growth attribute necessary for improved yield. This agrees with the findings of Kerure and Pitchaimuthu (2018).

Most of the hybrids generated had positive heterosis for average fruit weight; of which the highest positive heterotic value of 128.69% was recorded for the cross, ‘Ele Ogwu’ x ‘LD88’, while ‘Agwu early’ x ‘Clemson spineless’ had the highest negative BPH value (-74.70%). This could be as a result of the hybrid vigour of ‘Ele Ogwu’ x ‘LD88’ over the parents. It further revealed that the wild parent, ‘Ele Ogwu’ had partial dominance in masking the recessive alleles of smaller fruit weight possessed by the domesticated parent, ‘LD88’. According to Koli *et al.* (2020), enhanced fruit weight has been consistently observed as an important component of fruit yield in crops. This also agrees with the findings of Bhatt *et al.* (2016).

Significantly positive ($p < 0.05$) heterosis was observed for fruit length for all the F_1 hybrids generated using the wild genotypes as one of the parents. It further showed that the hybrid, ‘Ele Uhie’ x ‘Clemson spineless’ recorded higher positive value for fruit length (96.43%) than all the crosses studied while the cross, ‘Clemson spineless’ x ‘LD88’ had the lowest heterotic mean value of -69.86%. Hybrids generated using domesticated conventional genotypes as both parents as well as interspecific crosses exhibited negative heterosis. However, ‘Clemson spineless’ expressed partial dominance as it was favoured in expressing the trait across most of the hybrids it was involved in. Koli *et al.* (2020) reported similar result.

For fruit girth, the cross, ‘Ele Uhie’ x ‘Clemson spineless’ had the highest negative mean value of -92.75% for the trait. In contrast, the cross, ‘Ele Ogwu’ x ‘LD88’ produced the highest positive heterotic value of 83.09%. Most of the hybrids generated using ‘Clemson spineless’ expressed slender fruits, thus showing its partial dominance in expressing the trait across hybrids. This trend could prove crucial in okra production due to the appreciably high demand for long, slender, glabrous fruits with high drawability across okra consumers in preparing African soup delicacies (Umeri *et al*. 2023). The result also agrees with the findings of Udengwu (2015) who reported that reduced fruit girth with increased fruit length are highly desirable traits required for okra improvement as they enhance acceptability, marketability, transportation and efficient processing.

The hybrid, 'Ele Uhie' x 'LD88' gave the highest positive BPH result of 51.37%, for 100 seed weight. In contrast, the hybrid, 'Agwu early' x 'Clemson spineless' gave the highest negative (-46.25%) value for the trait. Most of the hybrids generated involving the wild genotypes as one of the parents, with the exception of, 'Ele Uhie' x 'Clemson spineless' exhibited positive BPH for 100 seed weight. The positive BPH for 100 seed weight could indicate an increase in number of seeds produced by the fruit pods which could have a resultant increase in fruit yield. The result is in agreement with the findings of Kumar *et al.* (2023) and Akhtar *et al.* (2010) who observed positive heterosis for 100 seed weight in okra in their studies.

Estimates of BPH for number of seeds per pod showed that number of seeds per pod recorded negative heterosis for all the hybrids generated with the exception of 'Agwu early' x 'Clemson spineless' and 'Ele Ogwu' x 'Agwu early' of which the cross, 'Ele Ogwu' x 'Ele Uhie' recorded the highest negative value of -25.66% while the cross, 'Ele Ogwu' x 'LD88' gave the lowest BPH negative value of -1.13%. The cross, 'Ele Ogwu' x 'Agwu early' recorded the highest BPH value of 3.24%. This could imply that number of seeds per pod did not make significant positive contribution to the yield of most hybrids generated. This assertion agrees with the findings of Patel *et al.* (2015) who reported that 14 out of 24 F_1 hybrids showed significant negative heterosis over the standard check used for their study. Similar findings were also reported by Solankey *et al.* (2013), Nagesh *et al.* (2014), Jethava (2014) and Kumar (2014).

Number of fruits per plant and total fruit yield recorded significantly ($p < 0.05$) positive heterosis for all the crosses involving the wild parents with the exception of 'Ele Ogwu' x 'Clemson spineless' and 'Ele Uhie' x 'Clemson spineless'. The result further showed that the hybrid, 'Ele Uhie' x 'LD88' gave the highest positive values of 86.82% and 145.03% for number of fruits per plant and total fruit yield, respectively. On the other hand, most of the crosses involving only the domesticated, conventional genotypes as the parents gave negative BPH for number of fruits per plant and total fruit yield. It further showed that the cross, 'Ele Ogwu' x 'Clemson spineless' gave the highest negative BPH values of -77.77% and -46.21% for number of fruits per plant and total fruit yield, respectively. The result revealed that the adoption of 'Clemson spineless' as one of the parents could have contributed negatively to the poor fruiting prowess for hybrids it was involved in; since its involvement in generation of hybrids produced negative heterosis. The obvious high positive heterosis recorded for total fruit yield as observed in the crosses 'Ele Uhie' x 'LD88' and 'Ele Ogwu' x 'LD88' could be due to increase in their appreciably high fruiting prowess; as this is a highly desirable requirement in okra improvement. Kerure *et al.* (2019) reported similar trend in their studies.

Estimates of Variance Components, Broad and Narrow Sense Heritability

Heritability provides an idea of the extent of genetic control for the expression of a particular character and the reliability of the phenotype in predicting its breeding value (Medagam *et al.*, 2012). According to Patel *et al.* (2024), the presence of genetic variability in breeding materials is essential for broadening the gene pool and therefore for the success of plant breeding programs. A decomposition of phenotypic variance into additive, dominant, and heritability components were carried out for different crosses.

From the result obtained, it was observed that additive variance was higher than dominance variance in all crosses involving the wild parents in the expression of plant height at maturity, fruit length, average fruit weight, number of seeds per pod, number of fruits per plant, and total fruit yield. It further revealed that the cross, 'Ele Uhie' x 'Clemson spineless' produced higher additive variance in plant height at maturity (6.37) and fruit length (80.39) compared to other crosses. The cross, 'Ele Uhie' x 'LD88' gave higher additive variance for average fruit weight (85.73), number of seeds per pod (6.58), number of fruits per plant (791.40) and total fruit yield (2918.13). In same vein, the cross, 'Ele Ogwu' x 'LD88' recorded higher additive variance over other crosses generated for stem girth (9.48) and number of branches per plant (57.44). The cross, 'Ele Uhie' x 'LD88' produced higher additive variance for fruit girth (11.13), 100 seed weight (18.35) and number of seeds per pod (6.58). This implies that additive variance contributed to the heritability of these traits and were expressed higher in these hybrids; thus, making it more predictable and reliable for selection purposes for these traits (Mudhalvan and Senthilkumar, 2021). According to Costa *et al.* (2016), the additive genetic expression of traits is the result of the cumulative effect of numerous genes and the rapid additive gene action.

From a different standpoint, dominance variance was higher than the additive variance in stem girth, number of branches per plant, fruit girth and 100 seed weight. The cross, 'Ele Ogwu' x 'LD88' produced higher dominance variance over additive variance for number of branches per plant (58.08) and 100 seed weight (1.42); while the cross, 'Ele Uhie' x 'LD88' gave high dominance variance for stem girth (9.86) and fruit girth (27.48) compared to other crosses studied. Higher dominance variance over additive variance in expression of these traits could imply that the environment played a key role by interacting with the genetic makeup of the hybrids, thus affecting the expression of these traits (Makdoomi *et al.,* 2018). In same vein, 'Agwu early' x 'LD88' gave higher dominance variance for plant height at maturity (4.37) while the 'Ele Uhie' x 'Clemson spineless' gave higher result for fruit length (60.81). The cross, 'Ele Ogwu' x 'LD88' produced higher dominance variance for average fruit weight (21.74) while 'Ele Uhie' x 'LD88' produced higher result for number of fruits per plant (272.01) and total fruit yield (1910.03). The result also showed that the cross, 'Ele Ogwu' x 'Ele Uhie' gave higher dominance variance for number of seeds per pod (4.11). As such, these traits may be controlled by multiple genes which could lead to predominance of dominance variance. This could be because alleles from one parent, most notably 'LD88', 'Ele Uhie' and 'Clemson spineless can mask the alleles from the other parents involved in those crosses, leading to higher expression of these traits in the hybrid lines generated in comparison to other hybrids. Rahman *et al.* (2020) observed similar trend of result.

Phenotypic variance was higher than the genotypic variance in most of the traits for the entire 10 hybrid lines generated for agronomic and yield component traits. 'Ele Uhie' x 'Clemson spineless', 'Ele Uhie' x 'LD88', and 'Ele Ogwu' x 'LD88' hybrid lines recorded higher magnitude of phenotypic variance over genotypic variance compared to other hybrid lines for all the traits studied. The result further revealed that 'Ele Uhie' x 'Clemson spineless' recorded a higher magnitude of phenotypic variance over other hybrid lines generated for plant height at maturity (12.19) and fruit length (163.90). Similarly, the cross, 'Ele Ogwu' x 'LD88' produced a higher magnitude of phenotypic variance for number of branches per plant (113.84). In the same vein, the cross, 'Ele Uhie' x 'LD88' produced higher result for phenotypic variance for the traits; stem girth (22.04), fruit girth (18.37), average fruit weight (164.70), 100 seed weight (11.75), number of seeds per pod (10.62), number of fruits per plant (953.70) and total fruit yield (10128.68). It was closely followed by the cross, 'Ele Ogwu' x 'LD88' (9707.01), then 'Ele Uhie' x 'Agwu early' (8821.35) in relation to total fruit yield. The observed higher phenotypic variance over genotypic variance for most of the traits studied indicates that the observed variance was caused not only by genotypes but also by appropriate environmental effects; thus, masking or amplifying the effects of genetic differences among genotypes. The environmental influence might be attributed to such factors as; soil fertility status, heterogeneity, and other uncontrollable variables. The report is in tandem with the findings of Reddy *et al.* (2022) and Jonah and Kwaga (2019).

Although phenotypic variance was higher than genotypic variance for all the traits studied, however, high magnitude of genotypic variance was observed in the expression of some traits in comparison to the hybrid lines generated and studied. It revealed that the cross, 'Ele Uhie' x 'Clemson spineless' produced high magnitude of genotypic variance for fruit length (158.69) while 'Ele Ogwu' x 'LD88' had higher genotypic variance effect over other crosses in expression of number of branches per plant (113.52). In same vein, the cross, 'Ele Uhie' x 'LD88' expressed high magnitude of genotypic variance in expression of average fruit weight (168.04), number of fruits per plant (883.41) and total fruit yield (8218.16). High magnitude of genotypic variability in these traits as expressed by these crosses is largely attributed to their genetic constitution and high genetic diversity in expression of these traits due to the presence of multiple alleles which offer much scope for improvement by means of selection (Noopur *et al.*, 2023). In contrast, low magnitude of genotypic variance was observed in plant height at maturity, stem girth, fruit girth, 100 seed weight and number of seeds per pod. However, in comparison to other crosses, its effect was higher in 'Agwu early' x 'Clemson spineless' in expression of plant height at maturity (7.87) while 'Ele Ogwu' x 'LD88' produced higher effect for stem girth (19.82). 'Ele Uhie' x 'LD88' expressed higher values for fruit girth (16.61) and 100 seed weight (9.57) while 'Ele Ogwu' x 'Ele Uhie' expressed higher value for number of seeds per pod (7.99). This development could be attributed to narrow genetic base among the crosses generated due to limited genetic diversity (Habtam, 2023) and high environmental stability of these traits (Kumar *et al.*, 2013).

Low environmental variance was observed in most traits among the 10 hybrid lines generated except for number of fruits per plant and total fruit yield. However, the result further showed that the cross, 'Ele Uhie' x 'LD88' produced higher magnitude of environmental variance over other crosses generated in expression of plant height at maturity (5.45), number of branches per plant (2.15), average fruit weight (2.66) and number of seeds per pod (3.00). Similarly, 'Ele Ogwu' x 'LD88' produced higher stem girth (9.33) while 'Ele Uhie' x 'Clemson spineless' gave higher result for fruit length (9.21). For fruit girth, 'Clemson spineless' x 'LD88' gave higher environmental variance (2.08). In contrast, the cross, 'Ele Uhie' x LD88' produced high environmental variance for number of fruits per plant (143.29) and total fruit yield (160.52). It was closely followed by the cross, 'Ele Ogwu' x 'LD88' (122.15), then 'Ele Ogwu' x 'Ele Uhie' (94.96). Number of fruits per plant closely followed the total fruit yield for environmental variance especially among crosses involving the wild undomesticated genotypes as one of the parents. According to Sandeep *et al.* (2022) the low environmental variance observed among interspecific hybrids of okra in expression of agronomic and yield traits suggests that the interspecific hybrids had exhibited hybrid vigour over the parents, resulting in reduction in the variability of traits due to the buffering effect of diverse genetic backgrounds. It also agrees with the findings of Adewuyi and Adewoso (2018).

Schmidt *et al.* (2019) opined that heritability (degree of genetic determination) is an expression of the extent to which the genotype of an individual determines its phenotype. As such, heritability in broad-sense reflects all possible genetic contributions to a population's phenotypic variance, and this includes gene effects due to allelic variation, or their epistatic action. From the result obtained, most of the hybrids with wild genotypes as one of the parents recorded high (>70%) broad sense heritability for most of the traits studied. It further revealed that the cross, 'Ele Ogwu' x 'LD88' expressed the highest broad-sense heritability for stem girth (84.80%), number of branches per plant (99.72%) and fruit girth (94.11%). It also expressed the highest percentage broad-sense heritability for number of fruits per plant (97.68%) and total fruit yield (98.92%). It was closely followed by 'Ele Uhie' x 'LD88' (96.40%) for total fruit yield. Similarly, the cross, 'Ele Uhie' x 'LD88' had the highest broad-sense heritability value of 99.60% for average fruit weight while 'Ele Uhie' x 'Clemson spineless' expressed the highest value of 96.82% for fruit length. With respect to plant height at maturity, the cross, 'Clemson spineless' x 'LD88' gave the highest value of 87.29% while the cross, 'Agwu early' x 'Clemson spineless' gave the highest value for 100 seed weight (85.76%). The cross, 'Ele Ogwu' x 'Ele Uhie' gave the highest broad-sense heritability value of 91.22% for number of seeds per pod. The high broad-sense heritability observed among these interspecific hybrids in the expression of growth and yield traits could be attributed to the significant additive gene actions and the presence of desirable traits from the wild parents used for the crosses (Komolafe *et al.,* 2023; Mohammed *et al.*, 2022). This further show that most of the characters studied with respect to these crosses were less influenced by the environment but by the genetic effect because they have high heritability as this forms the basis for selection. This agrees with the report of Abed *et al.* (2020) in their research on development of okra hybrids selected from selected inbreds under drought stress.

Narrow-sense heritability on the other hand, is the expression of the reliability upon which phenotypic value guides towards attaining a breeding value. Moreover, it represents the portion of phenotypic variation due to its additive effects as it is the breeder's best estimate of breeding value (Taneva *et al.* 2019). From the result, it was observed that in general, the estimates for heritability in broad-sense was higher than the corresponding heritability in narrow-sense in all the traits studied. This agrees with the report of Abed *et al.* (2020) that high estimates of broad-sense heritability over narrow-sense heritability suggests that a large portion of the total variation is under genetic control, thus making selection based on phenotypic levels beneficial for enhancing these traits expressed. However, in comparison to other hybrid lines generated, the cross, 'Ele Ogwu' x 'Clemson spineless' expressed the highest values for narrow-sense heritability with respect to plant height at maturity (58.33%) and fruit girth (54.69%). Similarly, the cross, 'Ele Ogwu' x 'LD88' had the highest heritability values of 65.40%, 58.70%, 58.80%, 59.99% and 60.80% for stem girth, number of branches per plant, 100 seed weight, number of fruits per plant and total fruit yield, respectively. It was closely followed by the cross, 'Ele Uhie' x 'LD88' with respect to number of fruits per plant (57.86%) and total fruit yield (59.28%). In same vein, 'Ele Uhie' x 'LD88' recorded the highest narrow-sense heritability for fruit girth (59.70%). For average fruit weight and number of seeds per pod, the cross, 'Ele Ogwu' x 'Ele Uhie' gave the highest values of 64.87% and 69.43%, respectively. Most of the crosses involving the wild genotypes as one of the parents, recorded high average fruit weight, fruit girth and number of fruits per plant. More so, the high narrow-sense heritability (>50%) observed in these traits as expressed in the hybrid lines showed that they were highly heritable. This could be attributed to expression of additive gene effects, where the additive genetic variance is the predominant source of genetic variation. This agrees with the report of Shwetha *et al.* (2022), that the higher values of narrow sense heritability for a particular character indicated that it was controlled largely by genes acting in an additive fashion. On the other hand, other hybrids involving the domesticated genotypes as both parents had low narrow sense (<50) heritability in most traits studied except for fruit length. Environmental variation can obscure the genetic contribution to phenotypic variance, leading to low narrow-sense heritability (Das *et al.*, 2012).

CONCLUSION

The significant differences that occurred in all the parental accessions and the hybrids for the traits of interest studied showed that appreciable diversity existed in the parents and their related hybrids thereby providing a basis for selection. The wild landrace parent, 'Ele Uhie' and its associated hybrid, 'Ele Uhie' x 'LD88' as well as the hybrid, 'Ele Ogwu' x 'LD88' produced significantly higher result for most agronomic and yield related traits studied. Similarly, the conventional genotype, 'Clemson spineless' and its related hybrid, 'Ele Uhie x 'Clemson spineless' produced the best result for fruit yield compared to all the genotypes studied. Better parent heterosis which is of great importance to farmers was found to be higher in most of the crosses having the local landrace as the pistilate parent for number of fruits per plant and total fruit yield. Hence, the findings of the research showed that the local landrace varieties were good donor of genes for improvement of quantitative traits and yield in okra. More so, high narrow sense heritability was recorded in these hybrids for these traits, most especially the crosses, 'Ele Ogwu' x 'LD88' and 'Ele Uhie' x 'LD88'. High narrow sense heritability and genetic variance observed in some agronomic and yield traits indicated that they are controlled mainly by additive genes that are heritable and thus transferred from one generation to another. Furthermore, the hybrids, 'Ele Ogwu' x 'LD88', 'Ele Uhie' x 'Agwu early' and 'Ele Uhie' x 'LD88' were the best combiners for agronomic traits, with 'Ele Ogwu' x 'LD88' and 'Ele Uhie' x 'LD88'proving to be the best combiners for fruit yield traits compared to the other hybrids generated; thus expressing their effectiveness in developing new okra cultivars with appreciable heterotic effects in fruit yield.

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REFERENCES

Abed MY, Ibrahim EA, El-Shoura AM (2020). Development of Okra (*Abelmoschus esculentus* L. Moench) Hybrids Derived from Selected Inbreds under Drought Stress. *Journal of Plant Production, Mansoura Univ.*, 11 (1): 61 – 69. DOI: 10.21608/jpp.2020.79155

Acquaah G (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing, Oxford.

Adeniji OT, Kehinde OB, Ajala MO, Adebisi MA (2007). Genetic studies on seed yield of West African okra (*Abelmoschus caillei* (*A. chev*.) stevels). *Journal of Tropical Agriculture*, 45: 36-41.

Adewuyi OF, Adeweso SO (2018). Genetic variability and heritability studies in West African okra (Abelmoschus caillei (A. Chev. Stevels). *Journal of Experimental Agriculture International*, 28(5):1-8. https://doi.org/10.9734/JEAI/2018/194

Akhtar M, Singh JN, Shahi JP, Srivastava K (2010). Exploitation of heterosis for yield and its attributing traits in okra (*Abelmoschus esculentus* (L.) Moench). *Journal of Environmental and Ecological Sciences*, 28: 1243-1246.

Allard RW (1960) Principles of Plant Breeding. John Willey and Sons Inc., New York.

Amaefula C, Agbo CU, Nwofia GE (2014). Hybrid vigour and genetic contol of some quantitative traits of tomatoes *(Solanium lycopersicum* L.). *Open Journal of Genetics*, 4, 30-39. http://dx.doi.org/10.4236/ojgen. 2014. 41005.

Ashraf ATMH, Rahman MM, Hossain MM, Sarker U (2020). Study of Correlation and Path Analysis in the Selected Okra Genotypes. *Asian Research Journal of Agriculture* 12(4): 1-11, 2020; Article no. ARJA.55599. ISSN: 2456-561X

Bhatt JP, Patel NA, Acharya RR, Kathiria KB (2016). Heterosis for fruit yield and its components in okra (*Abelmoschus esculentus* L. Moench). *International Journal of Agriculture Sciences*, 8 (18): 1332-1335.ISSN: 0975-3710&E-ISSN: 0975-9107.Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217.

Bowley SR, Taylor NL (2022). Introgressive hybridization. In CRC Handbook of Plant Science in Agriculture; Christie, B.R., Ed.; CRC Press: Boca Raton, FL, USA, 1987; Volume 1, pp. 23–59. Available online: https://www.jstor.org/stable/24084997.

Chemeda D, Amsalu A, Habtamu Z, Adugna W (2015). Generation means analysis for some quantitative traits in Sesame (*Sesamum indicum* l.) crosses from Ethiopia. *Ethiop. J. Sci*., 38 (2):75-84. ISSN: 0379–2897 (Print), 2520–7997 (Online).

Costa EV, Diniz DB, Veroneze R, Resende MDV, Azevedo CF, Guimaraes SEF, Silva FF, Lopes PS (2016). Estimating additive and dominance variances for complex traits in pigs combining genomic and pedigree information. *Genet. Mol. Res.* 14 (2): 6303-6311. DOI http://dx.doi.org/10.4238/2015.

Darshini TK, Gangaprasad S (2022). Estimation of heterosis for yield and yield components in okra [Abelmoschus esculentus (L.) Moench]. *International Journal of Agricultural Sciences*, 18 (1): 383-391. DOI:10.15740/HAS/IJAS/18.1/383-391. www.researchjournal.co.in.

Das S, Chattopadhyay A, Chattopadhyay SB, Dutta S, Hazra P (2012). Genetic parameters and path analysis of yield and its components in okra at different sowing dates in the Gangetic plains of eastern India. *African Journal of Biotechnology*, 11: 16132-16141.

Eshiet AJ, Brisibe EA (2015). Morphological Characterization and Yield Traits Analysis in Some Selected Varieties of Okra (*Abelmoschus Esculentus* L. Moench). *Advanced Crop Science and Technology*, 3: 197. doi:10.4172/2329-8863.1000197.

Habtam S (2023). Genetic Variability Analysis foTraits in Okra (Abelmoschus esculents L. Moench) Genotypes. *International Journal of Food Science and Agriculture*, 7(1), 95-104. DOI: 10.26855/ijfsa.2023.03.01

Hayman BI (1958). The Separation of Epistatic from Additive and Dominance Variation in Generation Means. Heredity, **12**, 371-390. http://dx.doi.org/10.1038/hdy.1958.36

Jemal M, Wassu M, Eleni S (2022). Phenotypic Diversity Assessment of Okra (Abelmoschus Esculentus (L.) Moench) Genotypes in Ethiopia Using Multivariate Analysis. *Hindawi Scientifica* https://doi.org/10.1155/2022/3306793.

Jethava BA (2014). Heterosis and combining ability in okra (*Abelmoschus esculentus* (L.) Moench). M.Sc. Thesis, Navsari Agricultural University, Navsari.

Jindal SK, Arora D, Ghai TR (2009). Heterobeltiosis and combining ability for earliness in okra (*Abelmoschus esculentus* (L.) Moench). *Crop Improvement*. 36 (2): 59-66

Jonah PM, Kwaga YM (2019). Genetic interrelationship among quantitative traits and path analysis of some West African okra (*Abelmoschus caillei*) genotypes. *Agricultural Science & Technology* (1313-8820). 2019 Mar 1;11(1). Available:https://doi.org/10.15547/ast.2019.01.001.

Kenaw W, Mohammed W, Woldetsadik K (2023). Morpho-agronomic variability of okra [Abelmoschus esculentus (L.) Moench] genotypes in Dire Dawa, eastern Ethiopia. *PLoS ONE* 18(7): e0288534. https://doi.org/10.1371/journal. pone.0288534

Kerure P, Pitchaimuthu M (2018). Heterosis Studies in Okra (Abelmoschus esculentus L. Moench). *International Journal of Current Microbiology and Applied Sciences*, 7(9): 1851-1862.

Kerure P, Pitchaimuthu M, Srinivasa V, Venugopalan R (2019). Heterosis for Yield and its Components in Okra (Abelmoschus esculentus L. Moench). *International Journal of Current Microbiology and Applied Sciences,* 8(1): 353-367. https://doi.org/10.20546/ijcmas.2019.801.036.

Kishor DS, Arya K, Yogeesh KJ, Kumar V, Yashoda, Hee-Jong K (2016). Genotypic Variation among Okra (Abelmoschus esculentus (L.) Moench) Germplasms in South India. *Plant Breed. Biotech.* 2016 (May) 4(2):234~241, http://dx.doi.org/10.9787/PBB.2016.4.2.234. Online ISSN: 2287-9366, Print ISSN: 2287-9358

Koli HK, Patel AI, Vshai JM, Chaudhari BN (2020). Study of Heterosis for Fruit Yield and its Component Traits in Okra [Abelmoschus esculentus (L.) Moench]. *International Journal of Current Microbiology and Applied Sciences*, 9(9): 1930-1937.

Komolafe RJ, Ariyo OJ, Alake CO, Oduwaye OA (2023). Genetic variability, heritability, genetic advance, association between fruit yield and yield components of okra (*Abelmoschus esculentus* L. Moench) accessions grown in two different years. *Israel Journal of Plant Sciences.* Pp 1-13. DOI: 10.1163/22238980-bja10080.

Komolafe RJ, Ariyo OJ, Alake CO, Oduwaye OA (2023). Genetic variability, heritability, genetic advance, association between fruit yield and yield components of okra (*Abelmoschus esculentus* L. Moench) accessions grown in two different years. *Israel Journal of Plant Sciences.* Pp 1-13. DOI: 10.1163/22238980-bja10080.

Kumar DS, Eswar DT., Praveen AK, Ashok KK, Srinivasa DBR, Nadendla R (2013). A Review on: Abelmoschus esculentus (Okra). *International Research Journal of Pharmaceutical and Applied* Sciences, 3(4), 129-132.

Kumar N (2014). Heterosis and combining ability for yield and yield attributes in okra (*Abelmoschus esculentus* (L.) Moench). M. Sc., Thesis, Navsari Agricultural University, Navsari.

Kumar R, Pandey MK, Pitha CC, Mehandi S, Chaudhary PL (2023). Analysis of heterotic potential for yield and its attributing traits in okra (Abelmoschus esculentus L. Moench). *Electronic Journal of Plant Breeding* 14(4), 1515–1526. https://doi.org/10.37992/2023.1404.17.

Kumar S, Dagnoko S, Haougui A, Ratnadass A, Pasternak D, Kouame C (2010): Okra (*Abelmoschus spp*.) in West and Central Africa: potential and progress on its improvement. *African Journal of Agricultural Research,* 5: 3590-3598.

Kumar S, Reddy MT (2016). Heterosis potential of single cross hybrids in okra *(Abelmoschus esculentus L.* Moench). *Journal of Global Agriculture and Ecology*, 4 (1): 45-66. International Knowledge Press.

Kumar V, Deo C, Sarma P, Wangchu L, Debnath P, Singh AM, Hazarika BN (2021). Yield and Economics of Okra Seed Production Influenced by Growth Regulators and Micronutrients. *International Journal of Current Microbiology and Applied Sciences*, 10(1): 3280-3286. https://doi.org/10.20546/ijcmas.2021.1001.382

Kumar YKH, Patil SS, Dharmatti PR, Byadagi AS, Kajjidoni ST, Patil RH (2009). Estimation of Heterosis for Topovirius Resistance in Tomato. *Karnataka Journal of Agricultural Sciences*, **22**, 1073-1075.

Labroo MR, Studer AJ and Rutkoski JE (2021). Heterosis and Hybrid Crop Breeding: A Multidisciplinary Review. *Front. Genet.* 12:643761. doi: 10.3389/fgene.2021.643761

Makdoomi MI, Wani KP, Dar ZA, Hussain K, Nabi A, Mushtaq F, Mufti S (2018). Heterosis Studies in Okra (Abelmoschus esculentus L. Moench). *International Journal of Current Microbiology and Applied Sciences*, 7(2): 3297-3304. ISSN: 2319-7706

Maurya BK, Singh DP, Singh MK, Maurya SK, Mishra UK (2022). Diallel Analysis to Investigate the Nature of Gene Action in Okra [Abelmoschus esculentus (L.) Moench]. *International Journal of Plant & Soil Science*, 34(22): 762-768. ISSN: 2320-7035.

Medagam TR, Kadiyala H, Mutyala G, Hameedunnisa B (2012). Heterosis for yield and yield components in okra [Abelmoschus esculentus (L.) Moench]. *Chilean Journal of Agricultural Research*, 72(3), 316-325.

Mohammed J, Mohammed W, Shiferaw E (2022). Performance and Genetic Variability of Okra (Abelmoschus esculentus (L.) Moench) Genotypes in Ethiopia for Agromorphology and Biochemical Traits. *Hindawi Advances in Agriculture* Volume 2022, Article ID 5521151, 8 pages https://doi.org/10.1155/2022/5521151

Mudhalvan S, Senthilkumar N (2021). Combining ability, reciprocal effects and heterosis for fruit yield characters in okra (Abelmoschus esculentus (L.) Moench). *Journal of Pharmacognosy and Phytochemistry* 2021; 10(1): 96-101. E-ISSN: 2278-4136. P-ISSN: 2349-8234.

Nagesh GC, Mulge R, Rathod V, Basavaraj LB, Mahaveer SM (2014). Heterosis and combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and quality parameters. *The Bioscan*. 9 (4): 1717-1723.

Noopur K, Samnotra RK, Kumar S (2023). Influence of okra (Abelmoschus esculentus) genotypes on growth, yield and biochemical traits. *Indian Journal of Agricultural Sciences* 93 (1): 57–61, January 2023/Article https://doi.org/10.56093/ijas.v93i1.122668.

Obi IU (2002). Statistical Methods of Detecting Differences between Treatment Means and Research Methodology Issues in Laboratory and Field Experiments. AP Express Publishers, limited, 3 Obollo Road, Nsukka – Nigeria. pp.117

Osawaru ME, Ogwu MC, Dania-Ogbe FM (2013). Morphological Assessment of the Genetic Variability among 53 Accessions of West African okra [*Abelmoschus caillei* (A. Chev.) Stevels] from South Western Nigeria. *Nigerian Journal of Basic and Applied Science* (September, 2013), 21(3): 227-238 http://dx.doi.org/10.4314/njbas.v21i3.8. Available online at http://www.ajol.info/index.php/njbas/index

Patel DD, Delvadiya IR, Kumar R (2024). Analysis of Heterotic Potential for Earliness, Yield and its Attributing Traits in Okra (Abelmoschus esculentus L. Moench). *International Journal of Bio-resource and Stress Management*, 2024; 15(2), 01-09. HTTPS://DOI.ORG/10.23910/1.2024.5064.

Patel HB, Bhandari DR, Patel AI, Tank RV, Kumar A (2015). Magnitude of heterosis for pod yield and its contributing characters in okra [Abelmoschus esculentus (l.) Moench]. *The Bioscan International Journal of Life Sciences* 10 (2): 939-942.

Rahman M, Islam AFMS, Hasan M, Uddin M (2020). Growth and yield performance of okra genotypes in acidic soil at Sylhet region, Bangladesh. *Archives of Agriculture and Environmental Science* 5(3): 283-291.

Reddy JP, Anbanandan V, Kumar BS (2022). Genotypic, phenotypic variability and evaluation of okra [Abelmoschus esculentus (L.) Moench] genotypes for yield components. *Journal of Applied and Natural Science*, 14(1), 180 - 187. https://doi.org/10.31018/jans.v14i1.3322.

Reddy MT, Haribabu K, Ganesh M, Reddy KC, Begum H, Reddy RVSK, Babu JD (2013). Gene action and combining ability of yield and its components for late Kharif season in okra (*Abelmoschus esculentus* (L.) Moench. *Chilean Journal of Agricultural Research* 73, 9-16.

Reddy MT, Kadiyala H, Mutyala G, Hameedunnisa B (2012b). Heterosis for yield and yield components in okra (Abelmoschus esculentus (L.) Moench. *Chilean Journal of Agricultural Sciences*, 72: 316-325.

Sandeep N, Dushyanthakumar BM, Sridhara S, Dasaiah L, Mahadevappa SK, El-Shehawi AM, M Althaqafi M, Aloufi S, Sharma H, Alaklabi A, Elansary HO (2022). Characterization of Okra Species, their hybrids and crossability relationships among *Abelmoschus* Species of the Western Ghats Region. *Horticulturae* 8, 587. https://doi.org/10.3390/horticulturae8070587

Schmidt P, Hartung J, Bennewitz J, Piepho HP (2019). Heritability in Plant Breeding on a Genotype-Difference Basis. *Genetics.* 2019 Aug;212(4):991-1008. doi: 10.1534/genetics.119.302134. Epub 2019 Jun 27. PMID: 31248886; PMCID: PMC6707473.

Shaikh Md, Soyab Akhil Mohd. Ab, Mazid, Mohrir MN, Jadhav RS (2013). Genetic variability, heritability and genetic advance in okra (Abelmoschus esculentus (L.) moench.) *Electronic Journal of Plant Breeding*. 2013; 4(3):1255-1257

Shwetha A, Basavaraja N, Raghavendra G, Ganiger VM, Jagadeesha RC, Mesta RK, Pitchaimuthu M (2022). Genetic variability studies in okra [Abelmoschus esculentus (L.) Moench] for yield and yield contributing traits. *The Pharma Innovation Journal* 2022; 11(6): 287-290.

Singh RK, Chaudhary BD (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi.

Singh RK, Rai M, Kumar A, Dwivedi SV, Kumar M (2023). Genetic variability and divergence in okra (Abelmoschus esculentus). *Current Horticulture* 11(2): 39–43 DOI: 10.48165/chr.2023.11.2.19.

Solankey SS, Singh AK, Singh RK (2013). Genetic expression of heterosis for yield and quality traits during different growing seasons in okra (*Abelmoschus esculentus*). *Indian J. Agricultural Sciences*. 83(8): 815-819.

Sorapong B (2012). Okra (*Abelmoschus esculentus* (L.) Moench) as a Valuable Vegetable of the World. *Journal of Field and Vegetable Crops Research*, (49) 105-112.

Sugri I, Abdulai MS, Larbi A, Hoeschle-Zeledon I, Kusi F, Agyare RY (2015). Participatory variety selection of okra (Abelmoschus esculentus L.) genotypes for adaptation to the semi-arid agroecology of Northern Ghana. *African Journal of Plant Science*, 9, 466-475.

Suma A, Joseph John K, Bhat KV, Latha M, Lakshmi CJ, Pitchaimuthu M, Nissar VAM, Thirumalaisamy PP, Pandey CD, Pandey S, Kumar A, Gautam RK and Singh GP (2023). Genetic enhancement of okra [*Abelmoschus esculentus* (L.) Moench] germplasm through wide hybridization. *Front. Plant Sci.* 14:1284070.doi: 10.3389/fpls.2023.1284070.

Taneva K, Bozhanova V, Petrova I (2019). Variability, heritability and genetic advance of some grain quality traits and grain yield in durum wheat genotypes. *Bulgarian Journal of Agricultural Science*, 25 (No 2) 2019, 288–295.

Thirupathi RM, Haribabu K, Ganesh M, Begum H (2012). Heterosis for yield and yield components in okra (*Abelmoschus esculentus* (L.) Moench). *Chilean Journal of Agricultural Research,* 72 (3): 316-325.

Udengwu OS (2008). Inheritance of Fruit Colour in Nigerian Local Okra, *Abelmoschus Esculentus* (L.) Moench, Cultivars. *Agro-Science,* 7 (3): 216 – 222.

Udengwu OS (2015). Inheritance and production of multiple small fruits per node in *Abelmoschus* species, to meet consumer's demand in the West African region. *African Journal of Agricultural Research* 10 (14): 1684-1692.

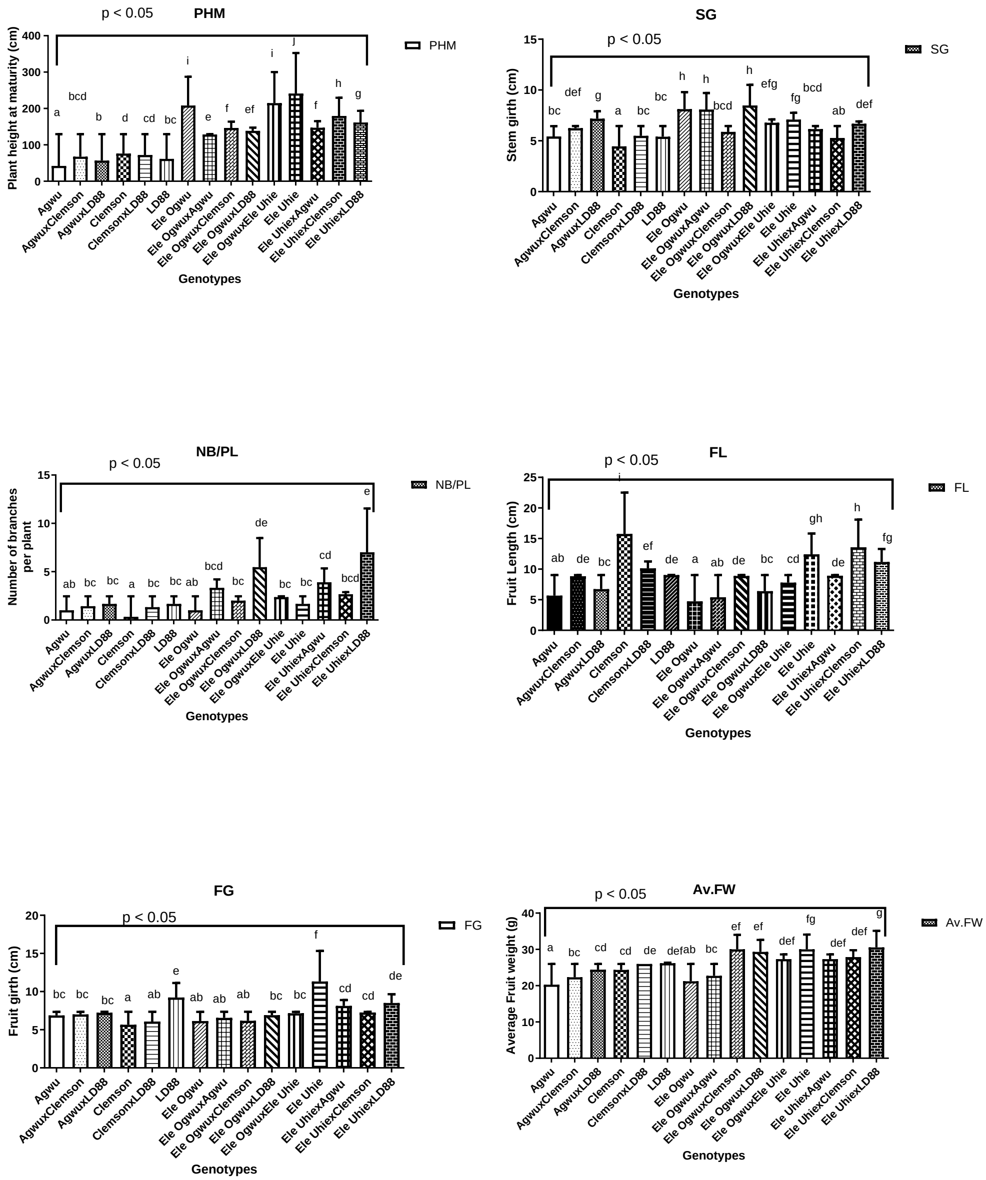
Uguru MI (2005). Crop Genetics and Breeding. 2nd Edition, Ephrata Press, Nsukka.

Umeri C, Nwajei SE, Moseri H, Bamidele MC (2023). Growth and yield of seven varieties of okra (Abelmoschus esculentus (L.) Moench) in Agbor, Delta State, Nigeria. *Journal of Agriculture and Environment*, 19 (1): 135-143. ISSN: 1595-465X (Print) 2695-236X (Online).

Venkatesh D, Srinivas J, Lakshminarayana D, Nagaraju K, Sai Krishna Nikhil B, Sathish G (2023). Evaluation of Hybrids for Growth, Yield and Yield Attributes in Okra (*Abelmoschus esculentus* L. Moench). *Biological Forum – An International Journal* 15(10): 536-543.

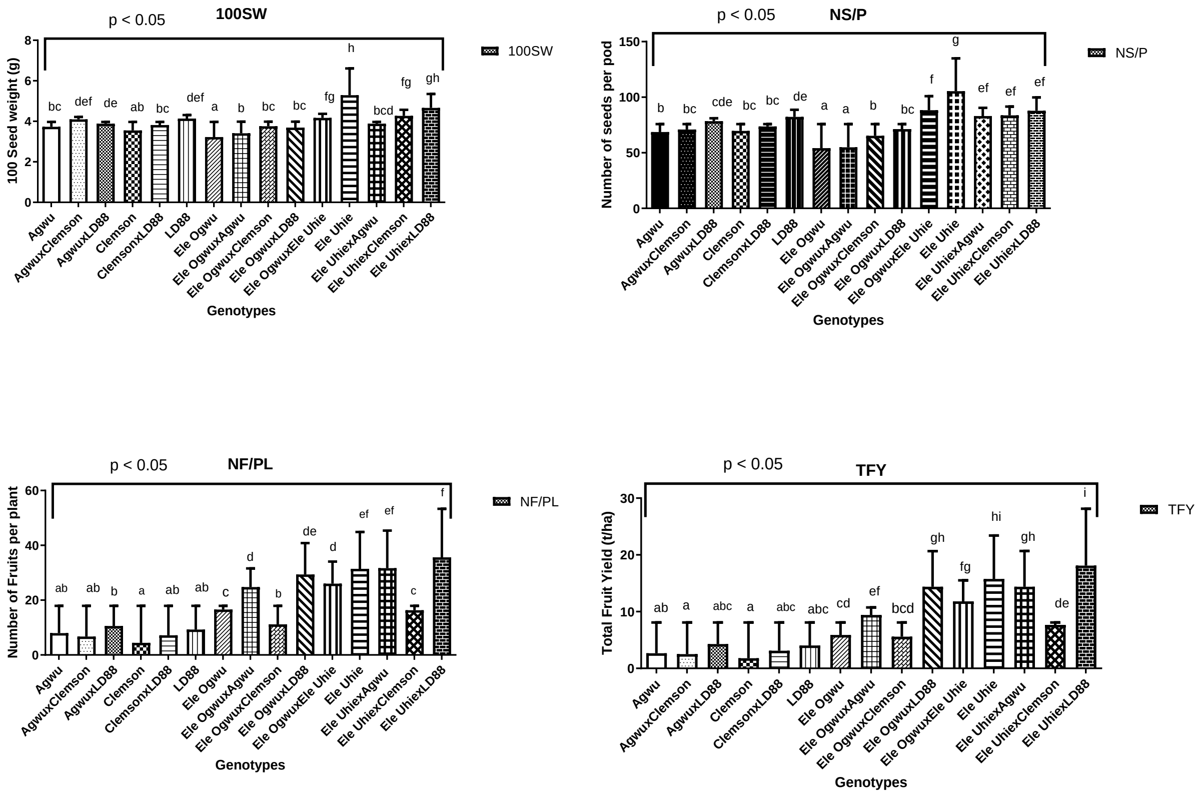
Wagaw K, Tadesse T (2020). Combining Ability and Heterosis of Sorghum (Sorghum bicolor L. Moench) Hybrids for Grain and Biomass Yield. *American Journal of Plant Sciences*, 11, 2155-2171. https://doi.org/10.4236/ajps.2020.1112151

Wakode MM, Bhave SG, Navhale VC, Dalvi VV, Mahadik SG (2015). Genetic analysis of yield and yield contributing traits in okra (Abelmoschus esculentus L. Moench). *Electronic Journal of Plant Breeding,* 6(4): 956-961 ISSN 0975-928X



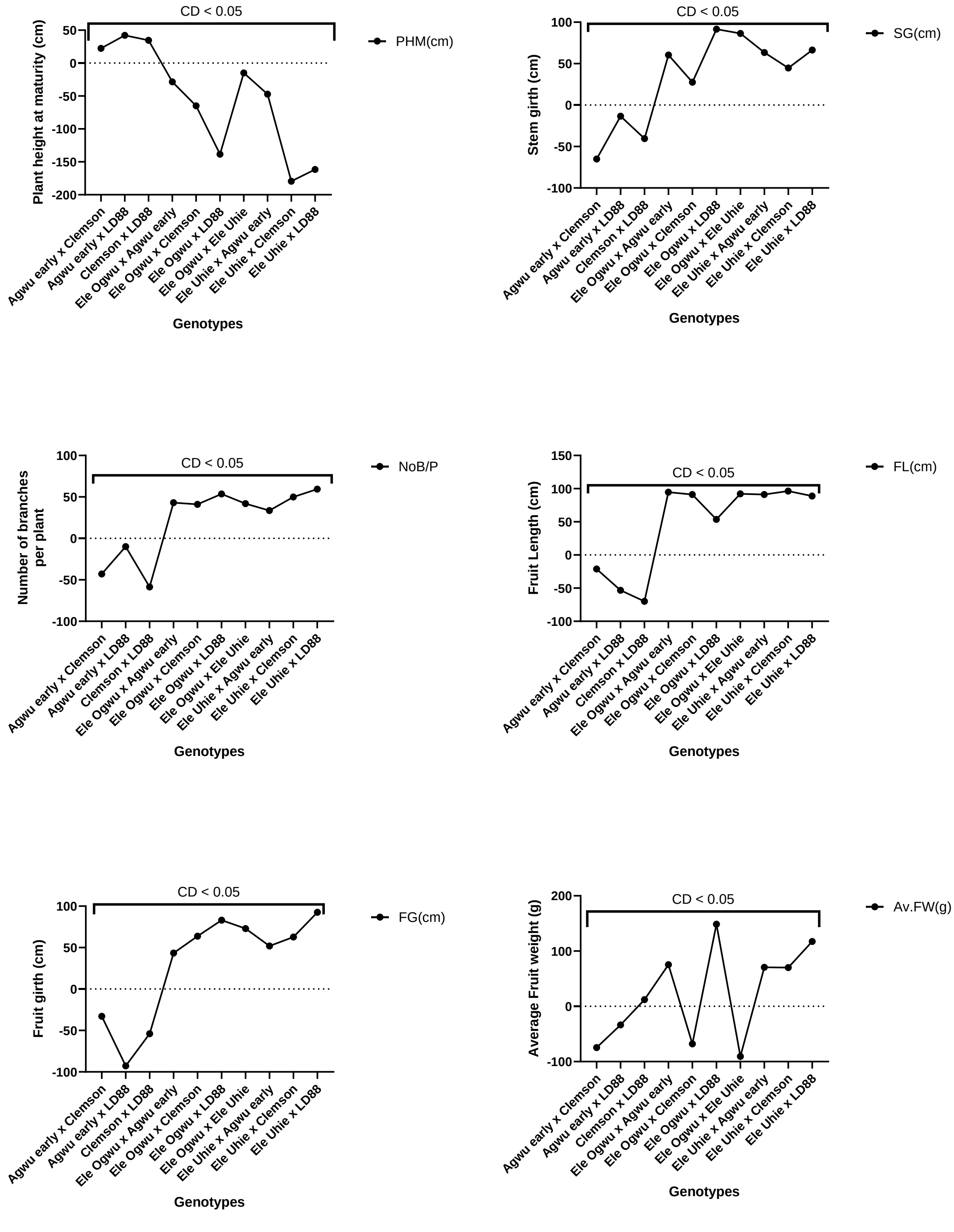
Where PHM = plant height at maturity, SG = stem girth, NoB/PL = number of branches per plant, FL = fruit length, FG = fruit girth, Av.FW = average fruit weight

Figure 1a. Agronomic, yield and yield related responses of selected parental lines of okra and their associated hybrids



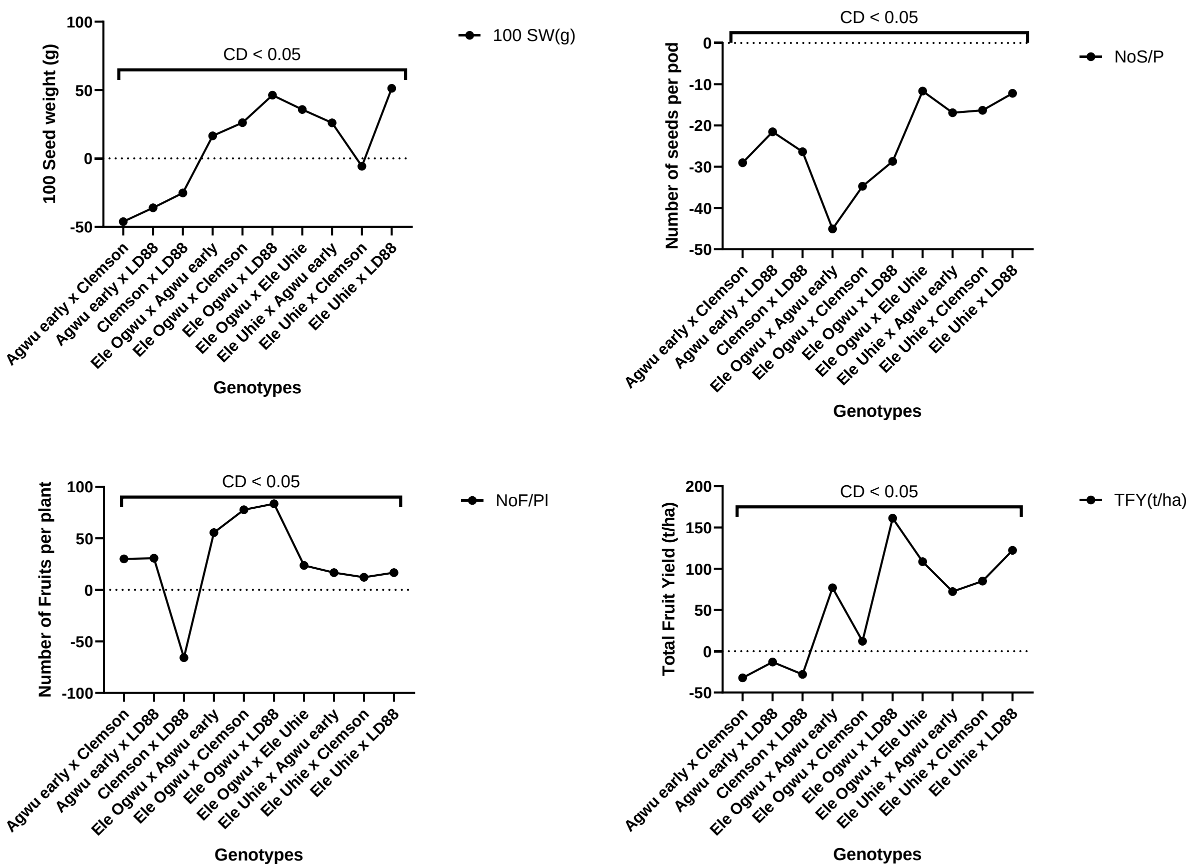
Where 100SW = 100 seed weight, NoS/P = number of seeds per pod, NoF/PL = number of fruits per plant, TFY = total fruit yield.

Figure 1b. Agronomic, yield and yield related responses of selected parental lines of okra and their associated hybrids



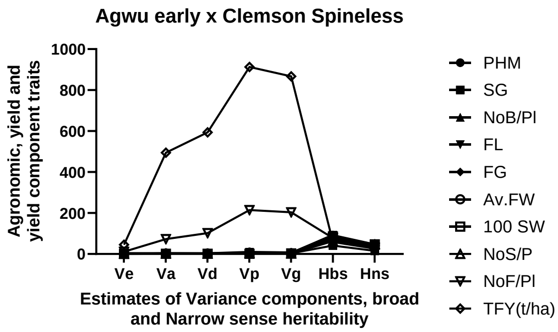
Where PHM = plant height at maturity, SG = stem girth, NoB/PL = number of branches per plant, FL = fruit length, FG = fruit girth, Av.FW = average fruit weight

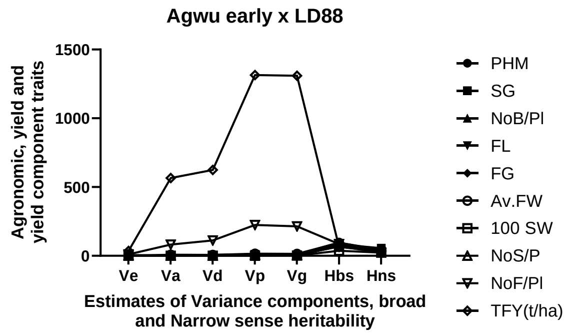
Figure 2a. Graphical representation of estimates of the Better Parent Heterosis (BPH) of the agronomic, yield and yield component traits of the F_1 hybrids of Okra used for the study.

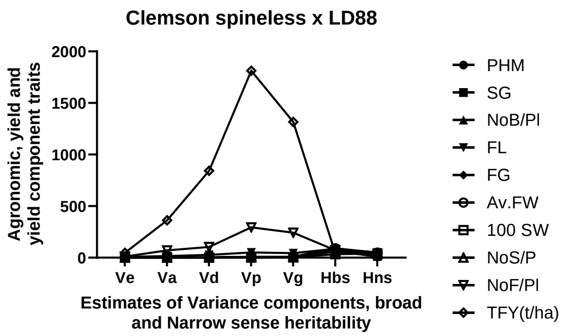


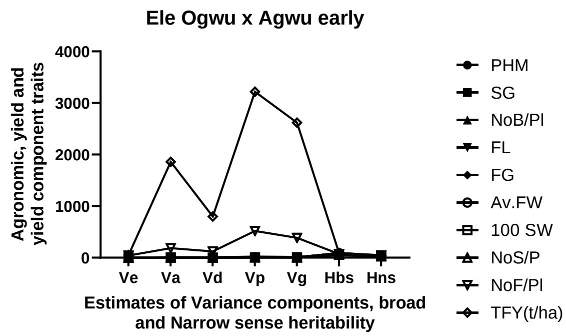
Where 100SW = 100 seed weight, NoS/P = number of seeds per pod, NoF/PL = number of fruits per plant, TFY = total fruit yield

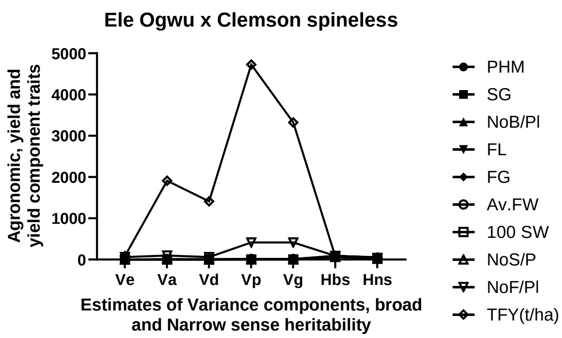
Figure 2b. Graphical representation of estimates of the Better Parent Heterosis (BPH) of the agronomic, yield, and yield component traits of the F_1 hybrids of Okra used for the study.

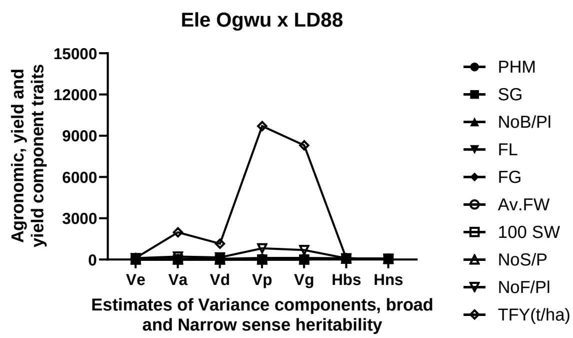






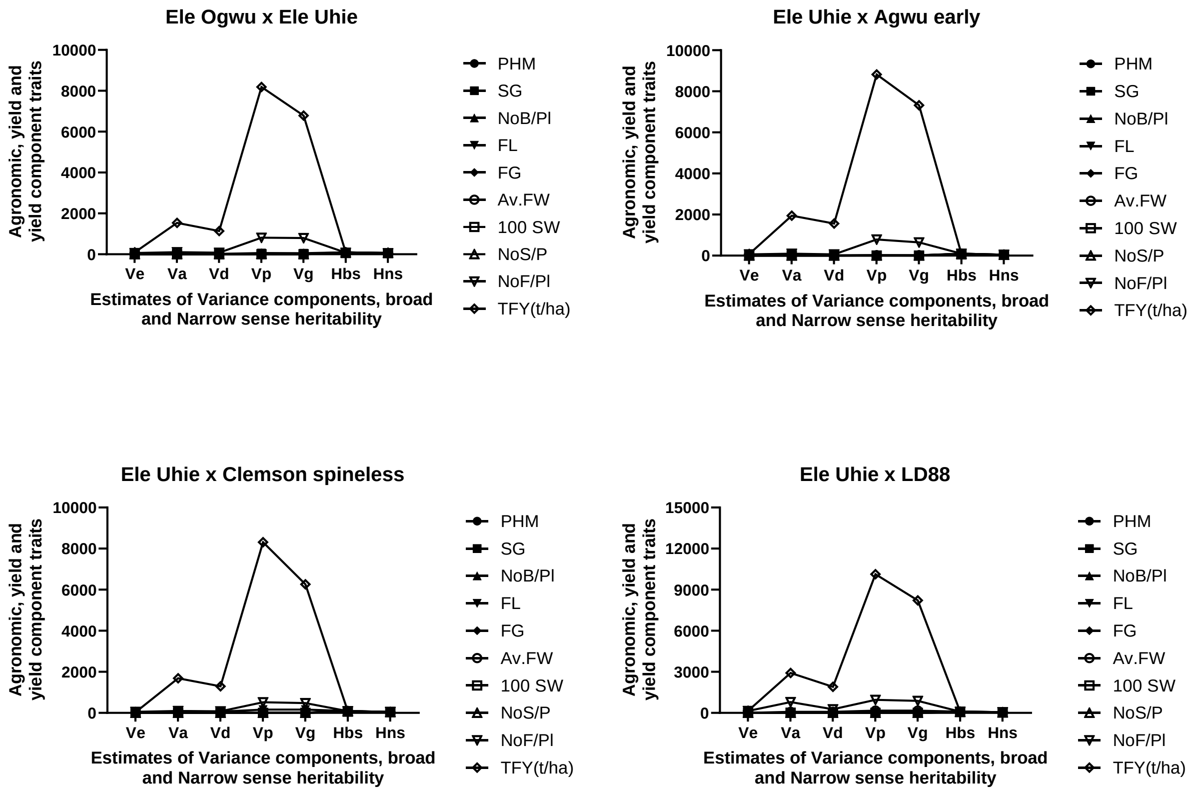






Where PHM = plant height at maturity, SG = stem girth, NoB/PL = number of branches per plant, FL = fruit length, FG = fruit girth, Av.FW = average fruit weight, 100SW = 100 seed weight, NoS/P = number of seeds per pod, NoF/PL = number of fruits per plant, TFY = total fruit yield, Ve = environmental variance, Va= additive variance, Vd = dominance variance, Vp = phenotypic variance, Vg = genotypic variance, Hbs = broad sense heritability, Hns = narrow sense heritability

Figure 3a. Estimates of the variance components, broad and narrow sense heritability among hybrid lines for agronomic, yield and yield component traits



Where PHM = plant height at maturity, SG = stem girth, NoB/PL = number of branches per plant, FL = fruit length, FG = fruit girth, Av.FW = average fruit weight, 100SW = 100 seed weight, NoS/P = number of seeds per pod, NoF/PL = number of fruits per plant, TFY = total fruit yield, Ve = environmental variance, Va= additive variance, Vd = dominance variance, Vp = phenotypic variance, Vg = genotypic variance, Hbs = broad sense heritability, Hns = narrow sense heritability

Figure 3b. Estimates of the variance components, broad and narrow sense heritability among hybrid lines for agronomic, yield and yield component traits.

Table 1. Estimates of the Better Parent Heterosis (BPH) of the agronomic, yield, and yield component traits of the F_1 hybrids of Okra used for the study.

GENOTYPES	PHM(cm)	SG(cm)	NoB/P	FL(cm)	FG(cm)	Av.FW(g)	NoF/Pl	100 SW(g)	NoS/P	TFY(t/ha)
Agwu early x Clemson	22.38	-65.04	-43.00	-21.15	-33.00	-74.70	30.00	-46.25	-29.03	-32.14
Agwu early x LD88	42.12	-13.46	-10.00	-53.27	-92.77	-33.58	30.79	-36.12	-21.54	-13.10
Clemson x LD88	34.68	-40.42	-58.66	-69.86	-53.93	12.02	-65.71	-25.18	-26.37	-28.11
Ele Ogwu x Agwu early	-28.49	60.42	43.00	94.60	43.44	75.27	55.52	16.59	-45.08	76.98
Ele Ogwu x Clemson	-64.85	27.56	41.00	91.11	63.83	-67.99	77.77	26.24	-34.73	12.15
Ele Ogwu x LD88	-138.53	91.52	53.54	53.59	83.09	148.69	83.55	46.31	-28.68	161.26
Ele Ogwu x Ele Uhie	-14.85	86.43	41.92	92.20	72.85	-90.69	23.80	35.83	-11.63	108.70
Ele Uhie x Agwu early	-47.29	63.34	33.53	91.08	51.88	70.70	16.75	26.12	-16.88	72.32
Ele Uhie x Clemson	-179.54	44.72	49.88	96.43	62.75	70.12	12.19	-5.73	-16.31	85.08
Ele Uhie x LD88	-161.47	66.34	59.41	88.83	92.50	117.44	16.82	51.37	-12.18	122.43
SE	2.38	0.22	1.01	0.45	0.12	1.56	1.26	0.10	2.18	2.44
CD5%	7.55	0.47	1.53	0.78	0.82	2.18	2.67	0.22	5.15	3.20

PHM = Plant height at maturity, SG = stem girth, NB/PL = number of branches per plant, FL = fruit length, FG = fruit girth, FW = Fruit weight, NF/PL = number of fruits per plant, 100SW = 100 seed weight, NS/P = number of seeds per pod, TFY = total fruit yield, Agwu early x Clemson = Agwu early x Clemson spineless, Clemson x LD88 = Clemson spineless x LD88, Ele Ogwu x Clemson = Ele Ogwu x Clemson spineless, Ele Uhie x Clemson = Ele Uhie x Clemson spineless, SD = Standard error, CD5% = Critical difference at 5% level of probability

CLIMATE SMART CROP PRODUCTION TECHNOLOGIES FOR FOOD AND NUTRITION SECURITY

AND

CROP MODERNIZATION FOR RESILIENCE AND ADAPTATION TO CLIMATE CHANGE

EFFECT OF INTRA-ROW SPACING FOR HIGHER YIELD OF OKRA (*Abelmoschus esculentus* (L.) Moench) IN JALINGO, TARABA STATE, NIGERIA

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ABSTRACT

This study was conducted at the Teaching and Research Farm, Taraba State University Jalingo in 2020 cropping season to determine the effects of intra-row spacing on yield of okra in Jalingo, Taraba State, Nigeria. The spacings tested were 90×15cm, 90×25cm and 90×35 cm inter and intra row. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on: plant height, leaf length, number of leaves, stem girth, days to 50% flowering, number of flowers, number of fruit, fruit length, fresh weight and yield per hectare. The collected Data were subjected to analysis of variance (ANOVA) and significant means were separated using least significant difference (LSD) using SAS. Results revealed that the spacing of 90×35 cm produced the best result compared to other spacings in terms of fruit weight per hectare, fresh fruit, fruit length etc. In recommendation farmers in the study area should adopt spacing of 90×35 cm to cultivate okra for high yield.
Keywords: Abelmoschus esculentus and intra-row spacing

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is an important vegetable crop grown in the wet season and to a little extent in the dry season (Alegbajo and Ogunlana, 2006). The world's greatest producer of okra is India, producing up to 70% of the total world's production estimated to be 6 million tons per year (FAOSTAT, 2012), followed by Nigeria and Sudan (Varmudy, 2011). Nigeria ranks third in okra production in terms of consumption and production area following tomato and pepper (Odeleye *et al.*, 2005). In Nigeria, the limiting factors in okra production, among others, are sub-optimal planting density, weed management, tillage practices and low yielding varieties (Adeyemi *et al.*, 2008). Chadha, (2002) reported that optimum plant density is the key element for higher yields of okra, as plant growth and yield are affected by inter-and intra-row spacings. Siemonsma, (2008) reported increases in crop productivity as density increased up to 10 plants m^{-2}. Whitehead and Singh (2011) also reported a continuous increase in fruit yield from the lowest (2.4 plants m^{-2}) to the highest density (14 plants m-^{2}). However, Hermann and Singh **(**2003) revealed no difference in okra yield at spacing of 4, 8, or 16 plants m^{-2}. They noted that the yield potential, in terms of the number of generative nodes per unit area, was higher in plots with closer spacing (16 plants per square meter). However, due to flower abscission, densely spaced plants failed to realize their yield potential. Similarly, Okunowo (2012) observed no significant difference in yield of okra planted at spacing of 100 cm x 25 cm, 90 cm x 30 cm, 60 cm x 40 cm and 50 cm x 50 cm. On the other hand, Albregts and Howard (2002) observed increases in yield up to 64 plants m^{-2}. Increased yields at higher population densities have also been reported in other vegetable crops such as pepper, tomato and eggplant (Nasto *et al*., 2009). Many researchers have worked on the effect of spacing on the productivity of okra. However, different spacing's have been recommended for higher okra yield in different agro-ecological conditions (Vikash *et al.*, 2016; Paththinige *et al.*, 2008). The improper plant spacing may cause either too dense or too sparse population resulting in the reduction of okra yield. But optimum plant density ensures the plants to grow uniformly and properly through efficient utilization of moisture, nutrients, light and thus causes to produce maximum yield of okra. Planting with proper spacing increases yield quality and size of fruit. In Jalingo, the effort on plant spacing to increase yield potential of okra is inadequate or sporadic. Considering this, an experiment was carried out to determine the appropriate intra-row spacing for higher yield of okra in Jalingo, Taraba State, Nigeria.

MATERIALS AND METHODS

Experimental site

The Experiment was carried out at the Teaching and Research Farm Taraba State University Jalingo that is located between latitudes $11^0\ 52^1$- $11^0\ 57^1$N and longitudes $11^0\ 19^1$ - $11^0\ 26^1$E. The region is characterized by double rainfall maxima pattern with about four months of dry season, the relative humidity is generally over 80% in the morning and fall to between 50 and 79% in the afternoon (Iloeje, 1981). The dry and wet seasons are controlled by annual migration of the inter-tropical zone of convergence (ITZC). The dry season is characterized by the dry dust laden harmattan winds coming across the Sahara desert and occurring between November and February. The wet season set in by April lasts till October; it has a mean annual rainfall ranging between 1000-1200mm, rainfall between July and August. The mean annual temperature is about 34^0C but the mean monthly value vary between 28.4^0C in the coolest month of December and 37^0C in the hottest month of March (NIMET 2009).

Treatment and experimental Design

The experiment was consisted of three levels of spacing's (90×15cm, 90×25cm and 90×35cm) wish was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total land area for the experimental field was 10m × 14m, each plot was 2.5m×4m which was separated by 0.5 m between the plots and 1 m between the replicates.

Cultural practices

The land was ploughed and harrowed after which the beds were prepared and the different levels of spacing was used. The seeds were sown in rows and covered thinly with soil and mulched with straws and watered daily until germination after which the straws were removed. Manual hoe weeding was done at 4, 6 and 8 weeks after planting to ensure a weed-free growth environment and avoid any competition between the crop and the weeds for nutrients, space, sunlight and other factors. Young pods were harvested 60-180 days from sowing, about 5-10 days after flowering.

Data collection

Plant height (cm): the height of plant was measured with ruler in centimeter.

Leaf length (cm): the length of leaves was measured with ruler in centimeter.

Number of leaves: the number of leaves at 3, 6 and 9 weeks after planting (WAP) was counted and recorded.

Stem girth (cm): the length of the girth was measured using ruler in centimeter

Days to 50% flowering: this is the number of days from planting to 50% flowered.

Number of flowers: the number of flowers per plant was counted and recorded.

Days to fruit formation: this is the number of days from planting to the appearance of the first fruit.

Number of fruits per plant: the number of fruit per plant was counted and recorded.

Weight of fresh fruit (kg): the weight of a fresh fruit was taken using electric weighing balance in kilogram (kg).

Fruit length (cm): the length of fruit was measured using meter rule in centimeter.

Yield per hectare (kg/ha): the yield per hectare was obtained after harvest by converting the yield/plot.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS) and the mean was separated by LSD at 5% probability.

RESULT AND DISCUSSION

Effect of spacing on growth parameter

The Effect of spacing on growth parameter is presented in Table 1; result revealed that there was significant difference among the spacing's used. Plant height at 2, 4 and 6 weeks after sowing; spacing 90×35 cm produced the tallest plant with a mean average of (10.3 cm, 19.68cm and 26.23cm) while spacing 90×15 cm produced the shortest plant with a mean average of (6.3 cm, 12.76cm and 19.33cm). Leaf length at 2, 4 and 6 weeks after sowing; was longer at a pacing of 90×35 cm (2.68 cm, 3.87cm and 13.25cm) while the shortest leaf was observed at a spacing 90×25 cm at 2 and 6WAS with a mean value of (2.60 and 11.27cm). On the same train the wider spacing of 90×25 cm recorded more number of leaves at 2 and 6 weeks with a mean of 2.53 and 12.93, while spacing 90×15 cm recorded the least number of leaves at 2 and 6 WAS (2.400 and 12.40). This result is in line with Gupta and Shukla, (2000) who reported number of leaves per plant is an important parameter considering the highest performance of okra yield. This study was also supported by Iremiren and Okiy (1999) who reported significant differences in the number of okra leaves among different spacing; the highest number of leaves per plant obtained at the intermediate and wider spacing. Gebre (2006) also stated that from wider inter-and intra-row spacing significantly increased the number of leaves during observation in sesame crop; probably this could be most likely due to the availability of growth factors and better penetration of light at the wider spaced plants.

The Stem girth at 2, 4 and 6 WAS is shown in Table 1. Statistically revealed that the wider stem was observed in okra sown at a spacing of 90×25 cm at 2 and 4 WAS with a mean value of 1.52 cm and 3.24 cm while the spacing of 90×35 cm recorded the narrow stem (1.45 cm, 2.56 cm and 3.32cm). Days to 50% flowering; okra planted at a spacing of 90×35 cm flowered earlier with 50 days compared to those planted at the remaining spacing, this signifies that if okra was planted at a wider space can flower earlier and set pods earlier. On the contrary, Singh (1996) and Abdul (1999) reported that plant spacing had non-significant effect on number of days to flower in okra. Likewise, increased plant density in faba bean did not affect the days to flowering but hastened uniformity in maturity (Amato *et al*., 1992). The number of flowers was significantly higher on okra planted at a spacing of 90×25 cm with 23.00 and had a least on those planted at 90×15 cm (22.67).

Effect of spacing on yield parameters

The Effect of spacing on yield parameters is presented in Table 2. Result revealed that there were significant differences among the spacing; the number of fruits at 6, 8 and 10 weeks after sowing was observed to have more fruit at a spacing 90×35 cm (3.33cm, 6.00 cm and 8.00cm) while the least was recorded at a spacing of 90×15 cm (2.73cm, 4.73cm and 6.67cm). This result was supported by Palanisamy *et al.* (1986) who reported that wider spacing slightly increased number fruits/plant. The fruits were significantly longer at a spacing of 90×35 cm with mean of 9.37cm while the remaining spacings recorded the least (8.36cm). This result is contrary with that of Palanisamy *et al*. (1986). They found that fruit length increased with decreasing of plant density. The heaviest fresh weight was recorded at 90×35 cm (374.39 g) while the least weighed was recorded at 90×15 cm (283.07g). Weight of fruit per hectare was also better at 90×35 cm which recorded 3.1 kg while 90×15 cm recorded least (2.4). This result is in contra with Khan and Jaisal (1988) who reported higher yield of okra per hectare at closer spacing.

CONCLUSION AND RECOMMENDATIONS

Based on the finding of this study, the following is recommended; Farmers in the study area should adopt spacing of 90×35 cm to cultivate okra for high yield. Multi-location trials may also be conducted to ascertain the validity of the result obtained in this study.

REFERENCES

Abdul, K. S. (1999). Effects of plant spacing and fertilizer levels on the growth and yield of okra. *Iraqi J. Agri. Sci*., 4:77-89.

Adeyeymi, O.R., Smith, M.A.K., & Ojeniyi, S.O. (2008). Effect of land Preperation Techniques on Weed Control Effectiveness in Okra (*Abelmoshus esculentus* (L) Moench). *Nigeria Journal of Weed Science, 21*, 72-83.

Albregts, D. A. and G. O. Howard (2002). Effect of spacing on the growth, yield and quality of okra in Southern Nigeria. *J. Agri. Sci.*, U. K. 106 (1): 12–26.

Alegbejo, M.D., & Ogulana, M.O. (2006). Survey for Incidence of Okra Mosaic Virus (OKMV) at Samaru and its Evironment in Gombe State University, Gombe, Nigeria. *Journal of Agricultural Research, 6* (3), 408-411.

Amato, G., R. Cibella, D. Giambalvo and L. Gristina (1992). Observations of the reproductive development in faba bean (*Vicia faba* L. var. *equina*) in relation to plant density. In:

Proceedings of the 1st European Conference on Grain Legumes. 1–3 June, Angers, France. 245–246.

Chadha (2002). Response of tomato cultivars differing in growth habit to nitrogen and phosphorus fertilizers and spacing on vertisol in Ethiopia. *Acta agriculture Slovenica*. Department of Plant Sciences, Ambo University College, Ethiopia. www.degruyter.com/view/j/acas. Accessed on February 9, 2013.

FAOSTAT (2012). Food and Agriculture Organization of the United Nations. On Line and Multilingual Database http//faostat.fao.org.

Gebre Hadgu (2006). Effect of Planting Methods and Spacing on Yield and Yield Attributes of Sesame (*Sesamum indicum* L.) in the Lowland Plain of Humera, Western Tigray, Ethiopia. An MSc. Thesis presented to the School of Graduate Studies of Alemaya University.

Gupta, A. and V. Shukla (2000). Response of okra (*Abelmoschus esculentus* L.) to plant spacing, nitrogen and phosphorus fertilization. *Indian J. Hort. Sci*., 38:218-222.

Hermann, B.P. and H.T. Singh. 2003. Densely planted okra for destructive harvest: Effects on yield. Department of Horticulture and Landscape Architecture, Oklahama State University, Stillwater, OK 74078.

Iloeje, N.P (1981). A new geography of Nigeria. New Revised Edition, Longman. Nig. Ltd. Ikeja.

Iremiren, G.O.and D.A. Okiy (1999.) Effect of spacing on the growth, yield and quality of okra in Southern Nigeria. *J. Agri. Sci.*, U.K. 106 (1): 12-26.

Khan, A. R. and Jaisal, R. C. (1988). Effect of nitrogen, spacing and green fruit pickings on the seed production of okra (*Abelmoschus esculentus* L. Moench). *Vegetable Science*, 15(1) : 8-14.

Nasto, T.H., A. Balliu and N. Zeka. (2009). The influence of planting density on growth characteristics and fruit yield of peppers (*Capsicum annuum* L.). *Acta Horticulture*, 830: 609-912.

NIMET, (2009). Weather Report: Nigeria Meteorological Agency, Yola International Air Port.

Odeleye, F.O., Adeleye, O.M.O, Dada, O.A., & Olaleye, O.A. (2005). The Response of Okra to Varying Levels of Poultry Manure and Plant Population Density Under Sole Cropping. *Journal of Food, Agriculture and Environment, 3* (4), 68-74.

Okunowo, B. (2012). Effects of Spacing on Growth and Yield of Nhae47-4 Okra Variety (*Abelmoscus esculentus* [L] Moench). Federal University of Agriculture, Abeokuta.

Palanisamy, V., K. Vanangamudi, T. Joyaroj and T. V. Karivarattaraju. (1986). Influence of data of sowing and spacing on seed quality in bhindi. *South Indian Hort*., 34(1) : 23-25.

Paththinige, S.S., Upashanthal, P.S.G., Ranaweera, Banda, R.M., & Fonseka, R.M. (2008). Effect of Plant Spacing on Yield and Fruit characteristic of Okra (*Abelmoschus esculentus*). *Tropical Agricultural Research*, *20,* 336-342.

Siemonsma, C.O. (2008). Response of okra [*Abelmoschus esculentus* (L.) Monech] to plant density and pattern of plant arrangement in Nigeria. *Indian J. Agri. Sci*., 61:726–730.

Singh, B.P.(1996). Effect of row and plant spacing on yield ad yield components of okra. *Indian J. Agronomy*., 35: 439-441.

Singh, B.P.(211). Effect of row and plant spacing on yield ad yield components of okra. *Indian J. Agron*., 35: 439-441.

Varmudy, V. (2011). Marketing Survey Needed to Boost Okra Exports. Department of Economics, Virekananda College, Puttur, Kamatato, India.

Vikash, Dhankhar, S.K., Chandanshive, A.V., & Neha, Y. (2016). Effects of Spacing on growth and yield of two varieties of Okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Farm Sciences, 6* (1), 163-168.

Table 1; Effect of spacing on growth parameter of okra at Taraba State University Jalingo in 2020 cropping season

Spacing	PH at 2WAS	PH at 4WAS	PH at 6WAS	LL at 2WAS	LL at 4WAS	LL at 6WAS	NL at 2WAS	NL at 4WAS	NL at 6WAS	SG at 2WAS	SG at 4WAS	SG at 6WAS	Days to 50% flowering	Number of flowers
90×15 cm	6.3	12.76	19.33	2.64	3.55	11.49	2.40	6.00	12.40	1.46	3.13	4.21	52.00	22.67
90×25 cm	6.4	15.13	21.56	2.60	3.78	11.27	2.53	5.87	12.93	1.52	3.24	4.29	52.00	23.00
90×35 cm	10.3	19.68	26.23	2.68	3.87	13.25	2.46	5.67	12.87	1.45	2.56	3.22	50.67	22.93
Mean	7.7	15.86	22.54	2.64	3.73	12.00	2.46	5.84	12.73	1.48	2.98	3.94	51.56	22.87
LSD	7.88	6.70	2.47	0.181	0.43	1.46	0.261	1.264	1.52	0.307	1.043	1.11	0.75	2.77

PH; plant height, LL; Leaf length, NL; Number of leaves, SG; Stem girth,

Table 2; Effect of spacing on yield parameter of okra at Taraba State University Jalingo in 2020 cropping season

Spacing	**Number of fruits at 6 WAS**	**Number of fruits at 8 WAS**	**Number of fruits at 10 WAS**	**Fruit length (cm)**	**Fresh weight (g)**	**Weight of fruit per hectare**
90×15 cm	2.73	4.73	6.67	8.36	283.07	2.4E
90×25 cm	3.00	5.20	7.20	8.36	326.74	2.7E
90×35 cm	3.33	6.00	8.00	9.37	374.39	3.1E
Mean	3.02	5.31	7.29	8.70	328.06	273387.04
LSD	0.841	0.821	0.778	1.592	104.22	86853.77

OPTIMIZING HYDROPRIMING DURATION FOR IMPROVED GERMINATION, EMERGENCE AND SEEDLING GROWTH IN SCENT LEAF (*Ocimum gratissimum* L.) A PATHWAY TO SUSTAINABLE PRODUCTION

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ABSTRACT

Scent leaf (*Ocimum gratissimum*) is a valuable crop with culinary, medicinal, and ornamental significance. However, its cultivation is constrained by low germination and seedling vigor due to the inhibitory effect of unesterified galacturonic acid in the mucilaginous layer of the seed coat. To address this, an experiment was conducted to determine the optimal hydro-priming duration for improved seed germination, emergence, and early seedling growth. Treatments included 0, 6, 12, 18, and 24 hours of hydro-priming, with three replications in a Completely Randomized Design. Data on germination percentage, emergence percentage, seedling height, number of leaves, and days to 50% germination and emergence were collected and analyzed using ANOVA. Results showed that hydro-priming significantly increased germination and emergence percentages, seedling height, and number of leaves, with 18 hours being the optimal duration. Hydro-priming also significantly decreased days to 50 % germination and days to 50 % emergence with 18 hours being the optimal duration. Therefore, seed hydropriming for 18 hours is recommended to enhance scent leaf cultivation and promote sustainable production.
Keywords*:* Emergence, Germination, Hydropriming, Scent Leaf, Seedling growth

INTRODUCTION

Scent leaf (*Ocimum gratissimum* L.) is a valuable horticultural crop esteemed globally for its culinary, medicinal and ornamental significance. It is herbaceous plant that belongs to the Labiatae family. Native to tropical regions, it is widely cultivated in Nigeria, where it is known by various names in different languages, such as Ahuji or nchanwu in Igbo, Efinrin in Yoruba, and Doddoya in Hausa (Effaraim *et al*., 2003). Scent leaf is a prized ingredient in traditional cuisine in Nigeria, particularly in the southeast region, where it is used to prepare delicacies like pepper soup and ofe akwu (banga soup). The leaves contain useful nutrients necessary for human and livestock growth including antioxidants (Zitte *et al*., 2023; Anjili *et al.*, 2019; Nwankwo *et al.,* 2014). It has been used in traditional medicine to treat various ailments, including epilepsy, fever, diarrhea, mental illness, and fungal infections (Busari *et al*., 2021; Akinmoladun *et al*., 2007; Kabir *et al*., 2005).

Despite its benefits, commercial cultivation of scent leaf in Nigeria is limited, especially in the southeast region due to poor seed germination among other factors. In Southeast Nigeria, local farmers typically grow it as a perennial crop in small quantities, mainly at the back of their compounds and along land boundaries, leading to high market prices (approximately N3000 per kg presently). It has been reported that small seeds horticultural crops of the *Ocimum* genus are characterized with mucilaginous layer that contains high concentration of unesterified galacturonic acid with a large capacity for hydration, blocking the absorption of oxygen while the seeds absorb water, thereby inhibiting germination (Thongtip *et al*., 2022; Yang *et al*., 2010; Baleroni *et al*., 2000). According to Kareem (2021), there exists common acceptance that propagating scent leaf from seed is challenging, resulting in reliance on the stands that fortunately got established through dispersal. As a warm-season crop, optimal seed germination, emergence, and early seedling growth are crucial for successful cultivation.

Seed priming is a technique used to enhance seed germination and crop establishment (Farooq *et al.*, 2006). By controlling seed hydration, priming activates pre-germinative physiological and chemical changes that prepare seeds for rapid and uniform emergence (Khalid *et al*., 2019). During priming, seeds are soaked in different solutions with high osmotic potential so that pre-germinative metabolic activities proceed, while radical protrusion is prevented, and then seeds are dried back to the original moisture level (Adinde *et al.*, 2020). This approach has been shown to improve seedling performance and stress tolerance (Khalid *et al*., 2019). Seed priming approaches include hormopriming (GA3 and IAA), halopriming ($MgSO_4$ and KNO_3), osmopriming (H_2O_2) and hydropriming (H_2O) (Bojović *et al*., 2022). Among these priming approaches, hydropriming is the easiest and cheapest (McDonald, 2000); making it an easy-to-adopt approach by small-scale farmers who are the major horticultural crop producers in Nigeria. Hydro-priming has been reported to improve germination and emergence of some small seeded horticultural crops (Adinde *et al.*, 2020; Caseiro *et al*., 2004). However, the duration of hydropriming significantly impacts its effectiveness (Caseiro *et al*., 2004). Thus, this study aimed to investigate the impact of hydropriming duration on germination, emergence and early seedling growth of scent leaf seeds, with the goal of providing valuable insights for optimizing hydropriming protocols to improved yields and sustainable production of this important horticultural crop.

MATERIALS AND METHODS

The experiment was carried out in the laboratory and in the nursery in the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo, Southeast Nigeria. The study area is located within latitude 06^0 $16.834^{'}$ N and longitude 07^0 $16.834^{'}$ E.

Scent leaf (*Ocimum gratissimum*) seeds used for the experiment were sterilized with a 1.0% solution of sodium hypochlorite (NaOCl) to kill micro organisms that might influence the results. For hydropriming, the seeds were soaked in distilled water in Petri dishes for 6, 12, 18 and 24 h at room temperature and dried back to their original state using filter paper. Some seeds were left un-primed to serve as control. Completely Randomized Design (CRD) with three replications was used for the experiment. The treatments were; 0 (control), 6, 12, 18, and 24 h hydropriming.

For the Germination experiment, three Petri dishes containing two layers of filter papers were wetted with 10 ml of distilled water and thirty seeds were plated in each for each treatment. The Petri dishes were observed every 24 hours for 14 days and germinated seeds were counted. Germination was considered to be when the radicles were 2mm long as described by Moghanibashi *et al.* (2012). Data were collected on Days to 50 % germination and Germination percentage. Days to 50 % germination (D50%G) was determined by counting the number of days it took half of the seeds to germinate. Germination percentage (GP) was evaluated by counting the number of germinated seeds at the end of the germination test and applying the formular;

$$GP = \frac{\text{Germinated seeds}}{\text{Total seeds}} \times 100$$

For the Seedlings emergence experiment, three polypots containing 2kg of nursery medium prepared of mixture of soil, well cured poultry manure and sand in the ratio of 3:2:1 respectively were used for the experiment for each of the treatments. The experiment was set up in the nursery and ten seeds from each of the treatments were sown in the nursery medium at a depth of 2.5cm and watered lightly. Subsequently, each polypot was watered with 50 ml of water daily; morning and evening. The polypots were observed daily for 14 days and emerged seedlings were counted and recorded. Seedling emergence was considered when the plumule emerged from the soil. Data were collected on Days to 50 % emergence (D50 % E) and Emergence percentage (EP). Days to 50 % Emergence (D50%E) was determined by counting the number of days it took half of the seedlings to emerge. Emergence percentage (EP) was evaluated by counting the number of emerged seedlings at the end of the emergence test and applying the formular;

$$EP = \frac{\text{Emerged seedlings}}{\text{Total seeds sown}} \times 100$$

For the early seedlings growth experiment, two seedlings from each poly-pot were tagged and used as sample plants for data collection on seedling height and number of leaves per seedling. Data collection was done at 4 weeks after sowing. Seedling height was determined by measuring the seedlings from the base of stand to the apical bud using measuring tape. Direct counting of the leaves per seedling was done to get the number of leaves per seedling.

The data collected from germination, emergence and early seedlings growth experiments were subjected to analysis of variance (ANOVA) for Completely Randomized Design using Genstat Release 10.3DE software (GenStat, 2011). Means that showed significant differences were separated using Least Significant Difference (LSD) at 0.05 probability level as described by Obi (2002).

RESULTS AND DISCUSSION

The results of the statistical analysis as presented in Table 1 showed significant differences ($p < 0.05$) in days to 50% germination, germination percentage, days to 50% emergence, emergence percentage, seedling height and number of leaves per seedling of Scent leaf (*Ocimum gratissimum*) among the treatments (0, 6, 12, 18 and 24 h hydropriming). The shortest days to 50% germination was observed in 18h (3.00 days), followed by 24h and 12h and (4.67 and 4.33 days, respectively which are statistically at par). The 6h treatment recorded 6.67 days while the control treatment had the longest days (8.00). In germination percentage, 18h recorded the highest value (84%) while the lowest value was observed in control (49.67%). Hydropriming significantly ($p < 0.05$) reduced the days to 50% emergence of scent leaf seedlings. The shortest duration (5.67 days) was observed in18h, followed by 12h and 24h (6.33 days and 6.33 days, respectively). The 6h treatment had 7.33 days while the control took the longest days (11.67 days). The highest emergence percentage of scent leaf seedlings was observed in 18h (70.67%), followed by 24h (62.33%), 12h (61.33%), 6h (55.33%) and the lowest was in control (43.67%). Hydropriming above 18h resulted in a decline in emergence percentage. The 18 h treatment had the highest seedling mean height (9.67cm), followed by 12h (7.67 cm), 24h (7.33 cm) and 6h (5.67 cm). All the hydro-primed seeds performed better than control which had (5.33 cm). In number of leaves per seedling, 18h had mean leaf number of (7.67 leaves), followed by 12h (6.67), 6h (5.33) and control (5.00 leaves).

The results of this study were consistence with the results reported by Adinde *et al*. (2020) in sweet basil; and Shukla *et al*. (2018) in mung bean. The findings were also in agreement with the findings of Adhikari *et al* (2021) who attributed the positive effect of hydropriming to enhanced water imbibition leading to enzyme activation, translocation, and utilization of reserved food materials. Pandita *et al*. (2007) reported that hydropriming facilitates water imbibition in seed making seed coat soft enough for enhanced growth of seed embryo. The findings of the experiment was also in agreement with the findings of Harris *et al.* (2002) who reported that short germination period, early emergence, and vigorous seedlings were observed when seeds were hydro-primed. Harris *et al.* (2002) also reported that each crop cultivar has its critical soaking duration which is lower than the safe limit. The optimal soaking duration in this study was 18h beyond which did not have any positive impact. Adhikari *et al.* (2021) emphasized that the knowledge of suitable priming duration is critical for optimum impact. Hydropriming scent leaf for 18h before planting has been shown in this study to improve germination, emergence and seedling growth of scent leaves.

CONCLUSION

The findings from this study showed that hydro-priming enhanced seed germination, emergence and seedling growth of scent leaf (*Ocimum gratissimum*) with 18 h hydro-priming being the optimal duration.

REFERENCES

Adinde, J. O., T. E. Omeje , O. J. Uche and C. J. Agu (2020). Impact of hydropriming duration on seed germination and emergence indices of sweet basil. *Journal of Agricultural Science and Practice* 5(1), 1-7.

Adhikari, B., Dhital, P. R., Ranabhat, S. and Poudel, H. (2021). Effect of seed hydro-priming durations on germination and seedling growth of bitter gourd (*Momordica charantia*). PLoS ONE 16(8). https://doi.org/10.1371/journal. pone.0255258

Akinmoladun, A. C., Ibukun, E. O., Emmanuel, A., Obuotor, E. M. and Farombi (2007). Phytochemical constituent and antioxidant activity of extract from the leaves *O. gratissimum*. *Science Research Essay*, 2: 163-166.

Anjili, E. M., Nuhu, A. A. and Uba, S. (2019). Comparative Study of Nutritional Contents of *Ocimum Basilicum* and *Ocimum Gratissimum* Plant Leaves and Soil Samples from Borno and Enugu States, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 12(1): 40 – 51. http://dx.doi.org/10.4314/bajopas.v12i1.7

Baleroni, C., Ferrarese, M., Souza, N. and Ferrarese-Filho, O. (2000). Lipid accumulation during canola seed germination in response to cinnamic acid derivatives. *Biol. Plant*. 43, 313– 316 (2000).

Bojović , B. M., Kanjevac, M. M., Todorović , M. S., Jakovljević, D. Z. (2022). Evaluation of Seed Priming on Germination and Growth of Basil (*Ocimum basilicum* L. cv. 'Genovese'). *Kragujevac J. Sci*. 44: 189–198. doi: 10.5937/KgJSci2244189B

Busari, A. O., Salau, F. A., Bashir, S., Bolaji, M., Balogun ,M. E., Ibrahim, M., Garuba, W. O., Popoola, N. A., Adunmo, G. O. , Lawal, A. Z., Ogunwale, K. T., Adedokun, K. A., Ogundiran, S. M., Ahmad, M. B., Mohammed, I. Y., Akinola, F. F. and Adeosun, O. G. (2021). Effect of Aqueous Extract of *Ocimum gratissimum* (Scent Leaf) on Renal Profile of Male Wistar Rats. *Al-Hikmah Journal of Health Sciences*, 1(1): 7-13

Caseiro, R., Bennett, M. A. & Marcos-Filho, J. (2004). Comparison of three priming techniques for onion seed lots differing in initial seed quality. *Seed Science and Technology*, 32, 365–375.

Effraim, K. D., Jacks, T. W. and Sodipo, O. A. (2003). Histopathological studies on the toxicity *O. gratissimum* leave extract on some organs of rabbit. *African Journal of Biomedical Research*, 6:21-25.

Farooq, M., Basra, S. M. A. & Hafeez-ur-Rehman (2006). Seed priming enhances emergence, yield and quality of direct-seeded rice. *International Rice Research Notes*, 31, 42-44.

GenStat Release 10.3DE, 2011. Discovery Edition 4 VSN International Ltd. Rothamsted Experimental Station, Howel, Hempstead, UK.

Harris, D., Tripathi, R. S. and Joshi, A. (2002). On-farm seed priming to improve crop establishment and yield in dry direct-seeded rice. *Direct Seeding Res Strateg Oppor*. 2002

Kabir, O. A., Olukayode, O., Chidi, E. O., Christopher, C. I. and Kehinde, A. F. (2005). Screening of crude extracts of six medicinal plants used in South-West Nigerian unorthodox medicine for anti-methicillin resistant *Staphylococcus aureus* activity. *BMC Complementary and Alternative Medicine*, 5: 1-7.

Kareem, I. A. (2021). Evaluation of Seed Propagation and Early Growth Rates of *Ocimum gratissimum* (Shrubby Basil) as Affected by Different Growth Media. *European Journal of Applied Sciences*, *9*(6), 1–9. https://doi.org/10.14738/aivp.96.11128

Khalid, M. F., Hussain, S., Anjum, M. A., Ejaz, S., Ahmad, M., Jan, M., Zafar, S., Zakir, I., Ali, M. A., Ahmad, N., Rao, M. J. & Ahmad, S. (2019). Hydropriming for plant growth and stress tolerance. In: *Hasanuzzaman M., Fotopoulos V. (eds), Priming and pretreatment of seeds and seedlings*. Springer, Singapore. **pp. 373-384**

McDonald, M. B. (2000). Seed Priming. *In: Seed Technology and its Biological Basis*, Black, M. & Bewley, J. D. (eds.). Sheffield Academic Press, Sheffield, UK. Pp. 287-325.

Moghanibashi, M., Karimmojeni, H., Nikneshan, P. & Delavar, B. (2012). Effect of hydropriming on seed germination indices of sunflower (*Helianthus annuus*L.) under salt and drought conditions. *Plant knowledge Journal.* 1(1), 10-15.

Nwankwo, C. S., Ebenezer, I. A., Ikpeama, A. I. and Asuzu, F. O. (2014). The nutritional and anti – nutritional values of two culinary herbs – uziza leaf (*Piper guineense*) and scent leaf (*Ocimum gratissimum*) popularly used in Nigeria. *International Journal of Scientific & Engineering Research,* 5(12):1160-1163

Obi, I. U. (2002). *Statistical methods of detecting differences between treatment means*. Enugu SNAPP Press Ltd. p.38

Pandita, V. K, Anand, A. and Nagarajan, S. (2007). Enhancement of seed germination in hot pepper following presowing treatments. *Seed Sci Technol*. 35:282–290

Shukla, N., Kuntal, H., Shanker, A. & Sharma, S. (2018). Hydro-Priming Methods for Initiation of Metabolic Process and Synchronization of Germination in Mung Bean (*Vigna radiate* L.) Seeds. *Journal of Crop Science and Biotechnology*, 21 (2), 137-146

Thongtip, A., Mosaleeyanon, K., Korinsak, S., Toojinda, T., Darwell, C. T., Chutimanukul, P. and Chutimanuku, P.(2022). Promotion of seed germination and early plant growth by KNO_3 and light spectra in *Ocimum tenuiforum* using a plant factory. *Scientifc Reports* 12:6995. https://doi.org/10.1038/s41598-022-11001-5

Yang, X., Dong, M. and Huang, Z. (2010). Role of mucilage in the germination of *Artemisia sphaerocephala* (Asteraceae) achenes exposed to osmotic stress and salinity. *Plant Physiol. Biochem*. 48, 131–135

Zitte, L. F., and Udoh, M. E. (2023). "Effect of Scent Leaf (*Ocimum gratissimum*) Aqueous Extract on Neuromuscular Functions of Albino Rats (*Rattus norvegicus*)". *Asian Journal of Biology* 17 (4):58-64. https://doi.org/10.9734/ajob/2023/v17i4331.

Table 1: Effect of hydro-priming duration on sometraits of Scent Leaf (*Ocimum gratissimum* L.)

Hydro-priming duration	D50G	G.P	EP	D50E	Seedling height (cm)	Number of leaves per seedling
6h	6.67	55.67	55.33	7.33	5.67	5.33
12h	4.33	72.33	61.33	6.33	7.67	6.67
18h	3.00	84.00	70.67	5.67	9.67	7.67
24h	4.67	69.00	62.33	6.33	7.33	6.33
Control	8.00	49.67	43.67	11.67	5.33	5.00
$LSD_{0.05}$	0.965	6.12	4.58	1.45	1.04	0.73
CV (%)	26.83	26.67	15.00	29.87	23.6	19.84
S.E.	0.37	3.64	3.77	0.565	1.00	0.32
Grand mean	5.334	53.00	56.46	7.33	7.00	6.20

$LSD_{0.05}$ = Least significant difference at 5% probability level; ; CV = Coefficient of variation; S.E. = Standard error; G.P = Germination Percentage; D50G = Days to 50% germination;
D50E = Days to 50% Emergence; E.P = Emergence Percentage.

PERFORMANCE OF BELL PEPPER (*Capsicum annuum* L.) CULTIVARS AS INFLUENCED BY VARYING LEVELS OF POULTRY BIOMASS IN NIGERIAN SAVANNA

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ABSTRACT

Despite the potential production of sweet pepper in the savanna region of Nigeria, the yield obtained by the small-scale farmers are often very low due to various production constraints such as soil fertility, production practices, cost and unavailability of inorganic fertilizer. Field experiments were conducted at two locations; the Teaching and Research Farm of Bayero University Kano (BUK) (latitude $11^0$58 N, longitude $8^0$25 E) and Kadawa Irrigation scheme, Bunkure local government area of Kano state (latitude 11^o42N, longitude 8^o 33E,). The aim of the experiments was to evaluate the performance of cultivars of bell pepper as influenced by varying levels of poultry biomass. The experiment was a 3 x 4 factorial laid out in a randomized complete block design and replicated three times. The treatments consisted of three bell pepper cultivar (Tattasai Dan Damasak, Yolo wonder and Nsukka yellow) and four levels of poultry biomass (0.0. 1.0, 2.0 and 3.0 tons ha^{-1}). The parameters assessed include plant height, number of branches, fruit yield per hectare and capsaicin content. Data collected was subjected to Analysis of variance (ANOVA) using Genstat (17th edition) and Student's New Man's Kuel (SNK) was used to separate the treatment means. Result indicated that the growth, yield and capsaicin parameters were significantly affected in all the three tested sweet pepper cultivars using the varying levels of poultry manure. Dan Damasak proved to be the highest yielding variety at both locations (10063 kg ha^{-1} at Bunkure and 9861 kg ha^{-1} at BUK). The application of 3 tons ha^{-1} resulted in higher sweet pepper yield (15160 kg ha^{-1}). Nsukka yellow produced the highest capsaicin content while the highest capsaicin content (19.833 mg kg^{-1}) was also recorded when 3 tons ha^{-1} of poultry manure was applied. Dan Damasak interacted favourable with 3 tons ha^{-1} of poultry manure to produce the highest fresh fruit yield ha^{-1} (15160 kg) while Nsukka yellow interacted favorably with 3 tons ha^{-1} of poultry manure to produce the highest capsaicin content (22.23 mg kg^{-1}). Therefore 3 tons ha^{-1} could be recommended in the study area.

Keywords: bell paper, capsaicin, poultry manure, growth, yield

INTRODUCTION

Bell pepper (*Capsicum annum* L.) is a genus of flowering plants in the night shade family *Solanaceae* and is native to Mexico with secondary centre of origin at Guatemala and Bulgaria (Aderemi *et al.,* 2019). Peppers are an excellent source of phytochemicals, such as anthocyanins, vitamins, phenolic acids, flavonoids, carotenoids, and capsaicinoids (Mansor, 2019). Physiologically, capsaicinoids are synthesized by the condensation of vanillyl amine produced by the phenylpropanoid pathway and a branched-chain fatty acid produced by the catabolism of amino acids (Mansor, 2019). Capsaicin is a pungent capsaicinoid responsible for the "hot and spicy" taste of chili peppers and pepper extracts (Niccolò *et al.*, 2017).

Nigeria is one of the major producers of pepper in the world accounting for 50% of the total African production (Idowu-Agcida, *et al.*, 2010). The production of peppers in Nigeria increased from 36,000 ton in 1973 to 65,404.97 ton in 2022 (Knoema, 2022).

Organic farming products are becoming very necessary in today's world to manage ecosystem health and to impart related human health benefits, world over there is growing demand for organic products. The organic areas in the whole world reached to 37.5 million hectares (Fibl and Ifoam, 2014). Maintenance of soil fertility has been established as a prerequisite for sustainable crop production and increased yield, while organic manuring has been reported to play a vital role in this regard (Aderemi *et al*, 2019). Poultry manure like other organic manures are known to improve the soil by enhancing both its physical and chemical properties (Emeka, 2023**).** Therefore, this study was carried out with the aim of evaluating the growth, yield and capsaicin content of organically produced bell pepper (*capsicum annuum* L.) cultivars as influenced by varying levels of poultry manure.

MATERIALS AND METHODS

The study was conducted at two locations; Faculty of Agriculture Teaching and Research Farm, Bayero University Kano (11°58'N and longitude of 8° 25'E), and Kadawa Irrigation Scheme (11°42'N and longitude of 8° 33'E), Bunkure Local government area, Kano State. The experiment was a 3 x 4 factorial laid out in a randomized complete block design and replicated three times. The treatments consisted of three bell pepper cultivar (Tattasai Dan Damasak, Yolo wonder and Nsukka yellow) and four levels of poultry biomass (0.0. 1.0, 2.0 and 3.0 tons ha^{-1}).

Total field area used for the trial was 26.5 x 28.5 m (755.25 m^2). The gross plot size was 3 x 4 meters size giving a total area of 12 meter square, with a discard of 0.5 meter between the plots and 1,0 meter between replications, while The net plots were made up of 2 ridges each spaced at 0.75m and 3m long. Soil samples of the experimental sites were collected at a depth of 0-15cm analyzed for routine fertility parameter, and so also the sample poultry manure used for the experiment was collected and analyzed for mineral content before the commencement of the experiment.

The seeds were sown in well prepared nursery beds of 2 m x 1 m. Seeds were drilled in rows, 10 cm apart in three nursery bed for three varieties. Poultry manure was applied at 5 cm depth and 8 cm away from the spots where the seedlings would be transplanted a week before transplanting. After 39 days the seedling was transplanted on prepared ridges with the spacing of 50 cm intra row 75 cm inter row. Neem oil for controlling the pests was sprayed at 2 ml L^{-1} as suggested by Vijayalakshmi (1996).

Data were taken on plant height, number of branches, fruit yield $hectare^{-1}$ and Capsaicin content. The Capsaicin analysis was determined using five grams of dry fruits as collected from each plot and taken to the laboratory for the determination of the total percentage of Phenolic compound using Liquid-Chromatography-electro-spray/time of flight mass Spectrometry according to standard method as described by Graces *et al*. (2006). Data collected was subjected to Analysis of Variance (ANOVA) using Genstat (17th edition. Student's New Man's Kuel (SNK) was used to separate the treatment means at 5% level of probability.

RESULTS AND DISCUSSION

Soil and organic manure results

The physical and chemical properties of the soil at the experimental site f(Table 1) indicates that, the soil at BUK was sandy loam, with a particle size distribution of sand, clay and silt of 73.90, 14.80 and 11.30%, respectively. The soil nutrient status was 0.68% organic carbon, 0.42% total nitrogen, 9.89 mg kg^{-1} of available phosphorus and 0.33 $cmolkg^{-1}$ potassium. The exchangeable bases were 2.27 cmol kg^{-1} Ca, 1.17 cmol kg^{-1} Mg, 0.11 cmol kg^{-1} Na and pH of the soil was 6.22-6.77. While at Bunkure, the soil was also characterized as sandy loam, with a particles size distribution of sand, clay and silt of 77.80, 12.70 and 9.50% respectively. The soil nutrient status was 0.45% organic carbon, 0.34% total nitrogen, 10.17 mg kg^{-1} available phosphorus and 0.20 cmol kg^{-1} potassium. The exchangeable bases were 2.18 cmol kg^{-1} Ca, 1.37 cmol kg^{-1} Mg, 0.12 cmol kg^{-1} Na and pH of the soil was 6.54 - 6.93. The soil has low levels of nitrogen, organic carbon, available phosphorus and the pH was slightly acidic. Hence the application has the capability to enhance the nutrient status of the soil. (Table 2) which showed 4.27% of total nitrogen, 949.21 mg kg^{-1} of total phosphorus and 6919.37 mg kg^{-1} of potassium, with organic carbon of 6.37%. This indicates poultry manure has higher level of basic nutrient element required by the plant. Hence the application has the capability to enhance the nutrient status of the soil.

Growth, yield and capsaicin content

Bell pepper cultivars and poultry manure had significant ($p<0.05$) effect on plant height (Table 3) and number of branches (Table 4) at both locations. Dan Damasak cultivar outgrow the other two cultivars (Yolo wonder and Nsukka yellow) on plant height and number of branches. This might be attributed to it genetic makeup. Shahein *et al*. (2015) reported that the growth differences between two pepper hybrids might be correlated with gene action of the tested hybrid, or might be due to adaptability to agro-ecological condition of the variety to the study area. The application of 3 tons ha^{-1} of poultry manure produced the tallest plant and plant with higher number of branches while the shortest plants were exhibited by the control (0 ton ha^{-1}) at both locations. (Dauda *et al.* (2008) reported that poultry manure promotes vigorous growth. Ansa and Woke (2018), also added that increasing the application rate of poultry manure was also responsible for the variation in plant height. Interactions were found to be significant at 3, 6 and 9 WAT on plant height at BUK and Bunkure, and at 6 and 9 WAT on number of branches at BUK and Bunkure, where significantly tallest plants with higher number of branches were obtained from the combination of 3 t ha^{-1} with Dan Damasak while Nsukka yellow treated with control was found to be the lowest. Iwuagwu *et al*. (2022) reported a significant interaction effect at 4, 6 and 8 WAT, of sweet pepper varieties with increase in the rate of poultry manure.

The highest yield of fresh fruits of sweet pepper was recorded by Dan Damasak at both locations while the least fresh yield was recorded by Nsukka yellow in both locations. (Table 5). This could be as a result of Dan Damasak cultivar exhibits the potential of producing taller plants with more branches. This observation is in line with that Iheaturu *et al*. (2023), who confimed that for most crops there is a direct relationship between growth and yield. Similar finding was stated by Bayerie (2016) which repoted that there is significant relationship on plant height, number of branches and number of leaves at 6, 10 and 14 weeks after transplanting (WAT) with number of fruits harvested and fruit weight. The highest yield was obtained by application with the application of 3 tonsha^{-1} of poultry manure at both locations which washigher than other levels. Raghunauth *et al,* (2023) reported similar result on sweet pepper varieties using poultry manure, which stated that, application of 3 tons/ha gave the highest fruit yield of (265 fruits) compared to 2.5 ton/ha.

The Nsukka yellow contained higher capsaicin than other cultivars at both locations (Table 5). Similarly, the application of 3 tons ha^{-1} of poultry manure recorded the highest capsaicin content at both locations while the lowest capsaicin content was recorded from the control. This result was supported by Andréia *et al*. (2015) who stated that, Capsaicinoids content of red pepper fruits (*C. baccatum*) may vary according to different organic fertilizer concentrations used in growing the crop. Bayerie *et al.* (2016) added that, increasing poultry manure rate from 5 to 10 t/ha increased the quantity of phytochemicals in both the red and yellow fruits of sweet paper. The interaction between poultry manure and bell pepper cultivars on capsaicin content at BUK was been discovered. So also, Nsukka yellow with 3 tons ha^{-1} of poultry manure recorded significantly the highest capsaicin content (22.23 mg kg^{-1}).

CONCLUSION

The result of the experiment indicated that Dan Damasak cultivar out performed other cultivars with respect to growth and yield parameters whileNsukka yellow cultivar excelled in terms of capsaicin content. So also, the application of 3 tons ha^{-1} of poultry manure resulted in the highest growth, yield and capsaicin content of sweet pepper and can therefore be recommended for bell pepper cultivation in the study area.

REFERENCES

Aderemi, F.T.,Olunloyo, A. A., Alarepe, A.B., Adedokun, S.A., Aderemi, A.M., and Olomola D. B. (2019). Comparative growth and yield response of sweet pepper (*capsicum annum* linn) to poultry manure and inorganic liquid fertilizer. *International Journal of Advanced Academic Research Sciences, Technology and Engineering*, 5(10),

Aliyu, L. (2012). Growth and yield of pepper (*Capsicum annum* L.) as affected by nitrogen and phosphorus application and plant density. *Crop Research*, 23 (3), 467-475

Andréia AssamyGuinoza, JackelineGuinozaSiraichi, ZildaCristianiGazim, DiógenesAparício Garcia Cortez1 and Lucia Elaine Ranieri Cortez (2015). Effects of organic fertilizer in the capsaicinoids of red pepper (*Capsicum baccatum* L.). *Journal of Medicinal Plants Research*, 9(29), 787-791.

Ansa, J.E.O. and Woke, C. (2018) Effect of spacing and poultry manure rates on growth, yield and quality of cayenne pepper (*Capsicum frutescens*. L) in southern rain forest of Nigeria. *International Journal of Environment, Agriculture and Biotechnology,* 3(2), *(IJEAB) Vol-3, Issue -4, 2456-1878*

Baiyeri, P. K., Otitoju, G. T., Abu, N. E., and Umeh, S. (2016). Poultry manure influenced growth, yield and nutritional quality of containerized aromatic pepper (*Capsicum annuum*L., var 'Nsukka Yellow'). *African Journal of Agricultural Research*,11(23), 2013- 2023.

Bosland, P. W. and E. J. Vatava (2002). Peppers, Vegetables and Spices, *Capsicum* CABI publishing. Walling Ford; United Kingdom. Pp. 204

EmekaChibaby Chigozie1, AkpanAnnah Udo1, EmekaChidiebere Prince Osuji (2023). World Journal of Agricultural Science and Technology.1(2): 19-23

FiBL and IFOAM, The World of Organic Agriculture, Statistics and Emerging Trends, 2014.

Grace – Claver, A., Arnedo-Androx, M.S., Abadia, J., Gu-Ortega, R. and Alvarez-Fernadex, A. (2006). Determination of capsaicin and Dihydrocapsaicin in capsicum fruit by liquid chromatography-Electro-Spray/Time-of Flight Mass Spectometry. *Journal of Agric Science and Food Chemistry. 54: 9303-11.*

Idowu-Agida, O. O., Nwanguma, E. I. and Adeoye, I. B. (2010). Cost implication of wet and dry season pepper

Iheaturu, D.E,Agu, L.I., okoli, N.A., Ibeawuchi, I.I (2023) .Effect of Poultry Manure

Iwuagwu C.C, Agbodo M.I, Nwogbaga A.C, Aguwa U.O, Iheaturu D.E, and Ejoifor M.E (2022). Influence of Variety and Poultry Manure Rates on Growth, Yield, Incidence and , Incidence and Severity of Fusarium Wilt Disease on Three Pepper (*Capsicum annum*) Varieties.*Sumerianz Journal of Agriculture and Veterinary,* , 5(3), 44-57.

Knoema (2022).Nigeria production-chillies and peppers report. World data atlas in agricultural production.

Mansor H.., Diganta K.., Michael E. B., and Sastry S. J. (2019) Capsaicinoids, Polyphenols and Antioxidant Activities of Capsicum annuum: Comparative Study of the Effect of Ripening Stage and Cooking Methods. *Pubmed Central Journal*, 8(9), 64-?.

NiccolòPampuro, Vincenzo Tebaldo, Debora Fabbri, Paola Calza, Maria Giulia Faga, Eugenio Cavallo (2017). Effect of Organic Fertilization on Capsaicin Content inTrinidad Scorpion (*Capsicum Chinese*) Peppers: Preliminary Results. *chemical engineering transaction*, 58 (10), 2283-9216

Paul KayodeBaiyeri, Grace TaiwoOtitoju, NgoziEucharia Abu3 and Simon Umeh (2016) Poultry manure influenced growth, yield and nutritional quality of containerized aromatic pepper (*Capsicum annuum*L., var 'Nsukka Yellow'). *African Journal of Agricultural Research*,11(23),2013-2023.

Raghunauth, R. , Chandranauth, R. , Bacchus, Z. , Chibi, S. and Singh, J. (2023). Evaluating two varieties of sweet pepper using different nutrient sources to increase productivity. *Journal of Agricultural Sciences*, 14, 751-766. doi: 10.4236/as.2023.146050

Rates on Growth and Yield of Three Species of P.epper (*Capsicum spp.*) in Awka, Southeastern. Nigeria. *Journal. Applied. Science. Environmental. Managemant*, 27 (10), 2181-2187

Shaheen, A.M, Abd El-Samad E.H., Fatma A Rizk, Faten S Abd El-Al and Awatif G Behairy (2016).GrowthweetPapper (*Capsicum annum* L) in relation to Organic and Bio-fertilizer

Aplication. *Research Journal of Pharmaceutical, Biological and Chemical Science. 1545-1559..*

Vijayalaskshmi, K. (1996). Preparation of Neem pesticide at Farm level. A funded project guide "*alternatives to the use of synthetic pesticide in vegetables production among women farmers in central river region*" Gambia.*Pg 165-169.*

Table 1: Physical and Chemical properties of soil of the experimental sites at BUK and Bunkure in 2018 Rainy Season

Properties	BUK	Bunkure
Physical (%)		
Sand	73.90	77.80
Clay	14.80	12.70
Silt	11.30	9.50
Textural class	Sandy loam	Sandy loam
Chemical composition		
pH in water	6.77	6.93
pH (cacl$_2$)	6.20	6.54
Organic carbon (%)	0.68	0.45
Total nitrogen (%)	0.42	0.34
Available phosphorus (mg kg^{-1})	9.89	10.17
Exchangeable bases (cmolkg^{-1})		
Ca++	2.27	2.18
Mg++	1.17	1.37
K+	0.33	0.20
Na+	0.11	0.12

Table 2: Chemical composition of poultry manure used during the experimental period in BUK and Bunkure

Chemical composition	Analytical value
Total nitrogen	4.27%
Total phosphorus	949.21 mg kg^{-1}
Potassium	6919.37 mg kg^{-1}
Organic carbon	6.37%

Table 3: Plant height of bell pepper cultivars as influenced by varying levels ofpoultry manure at BUK and Bunkure in 2018 rainy season

Treatment	Plant height (cm) at weeks after transplanting (WAT)					
	BUK			Bunkure		
	3	6	9	3	6	9
Variety						
Dan Damasak	17.19a	22.55a	28.95a	17.04a	21.92ab	28.87a
Nsukka yellow	13.17b	18.32c	24.37c	12.94c	18.50b	23.95c
Yolo wonder	13.65b	19.04b	25.22b	13.59b	18.79b	25.23b
SE±	0.022	0.076	0.076	0.038	0.108	0.463
Poultry Manure						
0	11.43d	16.53d	21.93d	11.35d	16.39d	22.49d
1	13.68c	18.91c	24.68c	13.42c	18.36c	24.37c
2	15.94b	21.27b	28.10b	15.96b	20.61b	27.96b
3	17.63a	23.17a	29.99a	17.38a	23.60a	29.26a
SE±	0.026	0.087	0.087	0.044	0.124	0.534
Interaction						
Variety x Poultry manure	<0.001	<0.001	<0.001	<0.001	<0.001	0.663

Means followed by the same letters in a column are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

Table 4. Number of branches per plant of bell pepper cultivars as influenced by varying levels of poultry manure in BUK and Bunkure during 2018 rainy season.

Treatment	Number of branches At WAT			Bunkure		
	BUK					
	3	6	9	3	6	9
Variety						
Dan Damasak	0.25a	3.65a	4.19a	0.075a	3.56a	4.13a
Nsukka yellow	0.00b	2.55c	3.09c	0.025b	2.65c	3.09c
Yolo wonder	0.00b	2.90b	3.51b	0.00c	2.90b	3.51b
SE±	0.019	0.043	0.063	0.029	0.057	0.052
Poultry Manure						
0	0.00c	2.13d	2.72d	0.00c	2.20d	2.72d
1	0.00c	2.68c	3.19c	0.03b	2.63c	3.15c
2	0.12b	3.50b	4.09b	0.33a	3.47b	4.12b
3	0.22a	3.82a	4.38a	0.33a	3.85a	4.32a
SE±	0.022	0.049	0.073	0.033	0.065	0.060
Interaction						
Variety x Poultry manure	0.632	<0.001	0.021	0.871	<0.001	<0.001

Means followed by the same letters in a column are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

Table 5; Total fruits yield ha^{-1} and Capsaicin content of bellpepper cultivars as influenced by varying levels of poultry manure in BUK and Bunkure in 2018 rainy season

Treatment	BUK		Bunkure	
	Fruit yield	Capsaicin	Fruit yield	Capsaicin
Variety				
Dan Damasak	9861.00a	15.87b	10063.00a	16.89b
Nsukka yellow	7199.00c	17.43a	7430.00c	18.83a
Yolo wonder	9113.00b	11.78c	9912.00b	12.69c
SE±	236.100	0.122	353.000	0.170
Poultry Manure (t/ha)				
0	2178.00d	10.59d	2313.00d	11.33d
1	6375.00c	13.66c	6743.00c	14.81b
2	12191.00b	16.57b	12324.00b	18.58b
3	14154.00a	19.29a	15160.00a	19.83
SE±	272.600	0.141	407.600	0.196
Interaction				
Variety x Poultry manure	0.392	<0.001	0.684	0.194

Means followed by the same letters in a column are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

EVALUATION OF THE EFFECTS OF MOISTURE STRESS ON THE GROWTH AND YIELD COMPONENTS OF SWEETPOTATO (*Ipomoea batatas* L.) IN SUDAN SAVANNA AGRO-ECOLOGY

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ABSTRACT

Field trials were conducted during 2018/2019, 2019/2020 and 2020/2021 dry seasons at Zakirai (12° 60" N, 8° 53' 0" E), Gabasawa Local Government, Kano State, Nigeria to assess the effects moisture stress on growth and root yield of sweetpotato genotypes. The treatments consisted of three sweetpotato genotypes (EA/11/025, NARSP 12/097 and *Danchina*) and three moisture stress periods (control, 6 – 9 WAP and 10 – 12WAP). These were laid in a split plot design with three replications. Moisture stress was allocated to the main plot while sweetpotato genotypes were assigned to the sub-plot. Results of the trials indicated that moisture stress had no significant (p> 0.05) influence on number of leaves plant-^{1}, number of branches plant-^{1} and average root weight (kg) Plot^{-1}. This was however significant (p<0.05) on soil moisture plot^{-1} (%), total number of root plot^{-1} and root yield. The results further revealed that plots stressed at 6 – 9 weeks after planting (WAP) outperformed those stressed at 10 – 12WAP and control in most of the growth, yield components and root yield. The genotype NARSP 12/097 also outperformed EA11/025 and *Danchina* in this study. The general outcome of the trials indicated that sweetpotato stressed at 6 – 9WAP produced the highest root yield. NARSP 12/097 also outperformed EA/11/025 and *Danchina* in all the sampling seasons of the study. Sustained productivity of sweetpotato is thus advocated by limiting moisture at 6 – 9WAP using sweetpotato genotype NARSP 12/097 in the study area.

Keywords: Moisture stress, *Danchina,* sweetpotato, genotype

INTRODUCTION

Sweetpotato (*Ipomoea batatas* L. Lam.) belongs to the morning glory family *Convolvulaceae.* It is believed to have originated from Latin America and is cultivated in all tropical and subtropical regions particularly in Asia, Africa and the Pacific. China is the largest producer of sweet potato with 80% of annual world supply. It is the second and seventh most important food and root crops in the world, (FAO, 2016). The genus *Ipomoea* consists of 600-700 species. The plants are mainly perennial vines with adventitious roots and are usually propagated vegetatively using both roots and stem cuttings and grown primarily for the edible root which takes about 4-5 months to mature. Sweetpotato produces edible root and leaves and is usually grown on ridges or mounds. Under favourable conditions, the vines grow quickly to cover the soil, eliminating weeds and hence minimising the labour required after planting. Although known for its tolerance to drought, however it is sensitive to saturated soil condition and requires sufficient water and nutrients, to produce good yield (Kivuva *et al.*, 2005).

A number of factors have been identified as contributing to the rapid rise of sweet potato to dominance in agriculture. Sweetpotato has a wider tolerance of soil conditions, allowing extended rotations, and it requires less labour and produces yield earlier. Increasing population pressure, and the use of land and labour for cash cropping, continue to promote the shift to sweet potato production. These factors play roles in other countries which have adopted sweet potato as a subsistence crop. Sweetpotatoes are relatively low in calories and have no fat. They are rich in beta-carotene, having five times the recommended daily allowance of Vitamin A in ones sweet potato**,** as well as loaded with potassium. These nutrients help to protect against heart attack and stroke. The potassium helps maintain fluid and electrolyte balance in the body cells, as well as normal heart function and blood pressure (Kassali, 2011).

The yellow to orange-fleshed sweetpotato cultivars contain particularly high levels of carotenoids, and are equaled only by carrot as a source of provitamin A. Vitamin A deficiency is a common and serious health problem in many countries with rice-based diets, being the main cause of blindness in children. Less acute deficiency decreases children's resistance to infectious diseases, contributing to infant mortality. In response to this problem, efforts are being made in some countries to promote the use of yellow to orange-fleshed cultivars **(**Berberich *et al*., 2005). The production, marketing and utilization of sweet potato have expanded in the last decade to almost all ecological zones of Nigeria, presently between 381,000 and 510,000t/ha of land area under Sweetpotato cultivation in Nigeria (FAO, 2008).

Despite the usefulness and nutritional values of Sweetpotato for human and animal consumption productivity in Nigeria is still very low compared to other fifteen (15) world major producers (FAO, 2010). This could be as a result of poor agronomic practices, use of local varieties, prevalence of pests and diseases or moisture deficiency or stress especially in the dryland areas. Plant growth and productivity are adversely affected by water stress. In dryland areas, irrigation strategies need to be devised to save water with marginal yield reduction. Water stress during early or vegetative growth stage usually reduces growth characters, inhibit leaf expansion, stem elongation and this can slow down or stop the growth of the affected plant **(**Jasmine *et al*., 2007**).**

Studies have shown that moisture stress is the major abiotic constraint for Sweetpotato production in the dryland areas where it is grown under rain fed conditions (Anselmo *et al*., 1998). Prolonged period of moisture stress can also considerably reduce Sweetpotato yield, as well as the quality of roots and causes huge economic losses to farmers (Ekanayake, 2004).

The growing population of Nigeria call for increase in food production to improve health and living conditions of the citizens, provision of quality fodder for livestock, improve soil and control erosion, increases farmers income, provision of employment opportunities and poverty reduction. However, agronomic practices that will reduce plant transpiration rate and at the same time enhance stands establishment by conserving plant water and reducing irrigation frequency were not been appropriately employed. It is therefore essential to improve the water use efficiency of the crop particularly in the dryland areas. This can be done by reducing transpiration rates without a comparable reduction in photosynthesis.

There is a need for critical balance between water requirement and water consumption of Sweetpotato. Thus, conserving water is an important aspect for agricultural expansion particularly in the dryland areas where inadequate water and high temperature are the major limiting factors for plant growth and productivity. Thus, it is essential to find ways by which available water could be cheaply utilized. One way to achieve this goal is by reducing the transpiration rate using antitranspirants. Antitranspirants, when sprayed to plants may reflect the radiant energy thereby reducing leaf temperatures and transpiration rates, hinder the escape of water vapor from the leaves or reduces stomatal opening, thus decreasing the loss of water vapor from the leaf. Sweetpotato is cheaper and source of high quality nutrition than some food crops on value/calorie. The early maturing cultivar could be produced 3-4 times annually with minimum production cost. Research is therefore required to identify the efficacy of foliar applied benzoic acid and induced moisture stress on the growth, yield and quality of Sweetpotato. Therefore, this research was conducted in order to determine the effect of moisture stress on growth, yield components and yield of Sweetpotato and also **to** identify Sweetpotato cultivar that can perform well under moisture stress without lost in yield and quality.

MATERIALS AND METHODS

The experiment was conducted during 2018/2019, 2019/2020 and 2020/2021 dry seasons at Zakirai (12° 60" N, 8° 53' 0" E) Gabasawa Local Government, Kano State**.** The location is in the Sudan savanna agro ecological zone, Nigeria**.** The treatments consisted of three sweetpotato genotype (EA/11/025, NARSP 12/097 and Danchina) and three moisture stress periods (Control, 6-9WAP and 10-12WAP). These were laid in a split-plot design with three replications. Stress period was allocated to the main plot while genotype was assigned to the sub-plot.

Soils of the experimental field were collected at 3 random spots in each plot using soil auger at 0-30cm depths. The samples were air dried, sieved and analyzed for physical and chemical properties using standard procedure as described by Black *et al.* (1965).

Vines were sourced from the National Root Crops Research Institute (NRCRI) Umudike. Healthy and vigorous vines of 30 cm length were used as planting materials. Vines of 30cm length were planted at a spacing of 30cm between plant and 75cm between ridges. Supplying to the defective stands was done 3 weeks after planting (WAP).

Surface irrigation was done by allowing water to fill the furrows at 5-day intervals before imposing the treatments. Fertilizer (N.P.K) at the rate 40: 50: 80kgha^{-1} was applied at three weeks after transplanting as recommended by Babaji (2015).

Harvesting was done manually when the crop reached physiological maturity 135 days after planting as shown by yellowing and falling of leaves and also cracking of the soil. The field was irrigated 3 days prior to harvesting to facilitate easy lifting of the tubers in order to minimize bruising of tubers. Data was collected on Emergence Count (%). Number of leaves plant^{-1}:, Number of branches plant^{-1}, Soil Moisture Plot^{-1} (%), Total number of root plot^{-1}:, Average root weight (kg): and Root yield (t ha^{-1}**.** Data collected on above parameters were subjected to analysis of variance using Genstat 17th edition. Significant means were ranked using Tukey HSD.

RESULTS

Emergence Count (%)

The results of emergence count as influenced by moisture stress, genotypes and benzoic acid during 2018/2019, 2019/2020, 2020/2021 and combined dry seasons at Zakirai are presented in Table 1. These showed that emergence counts in sweetpotato were not significantly affected by moisture stress and genotypes in both seasons and the combined. Interaction of stress and genotype,

Number of Leaves Plant-^{1}

Table 2 shows the results of the influence of moisture stress and genotypes on the number of leaves plant^{-1} during 2018/2019 and 2019/2020 dry seasons at Zakirai. The results revealed that moisture stress did not significantly influenced number of leaves in all the sampling periods. Number of leaves was however significantly influenced by genotypes in these seasons. More leaves were observed from EA11/025 in both seasons. These were also similar to Dan china at 6 and 8WAP during 2019/2020 dry season but differed from NNARSP 12/097 which bears the lowest number of leaves plant-^{1} in both seasons. The results further revealed that, moisture stress had no significant effect on the number of leaves plant-^{1} in sweetpotato during 2020/2021 and combined dry seasons (Table 3). There were however, significant effects of genotype on the number of leaves plant-^{1} during 2020/2021 and the combined dry seasons. The genotype EA11/025 consistently produced more leaves plant-^{1} in all the sampling periods. This was followed by Dan china while the least number of leaves plant-^{1} were recorded from NARSP 12/097.

Number of Branches Plant-^{1}

The effects of moisture stress and genotypes on number of branches plant-^{1} of sweetpotato during 2018/2019 and 2019/2020 dry seasons at Zakirai are presented in Table 4. The results showed that moisture stress and genotype had no significant influence on the number of branches plant-^{1} in all the sampling period. The results of the study further indicated significant influence of moisture stress and genotype on number of branches plant-^{1} during 2020/2021 dry season only at 8WAP (Table 5). More branches plant-^{1} was recorded at 10-12WAP stage. This was also different from plant stressed at 6-9WAP stage and the control that bears the lowest number of branches... Similarly, NARSP 12/097 bears more branches plant-^{1} but different from Danchina and EA11/025 that bears the lowest number of branches plant-^{1}.

Soil Moisture Plot^{-1} (%)

Results of the influence of moisture stress and genotypes on soil moisture plot^{-1} during 2018/2019 and 2019/2020 dry seasons is presented in Table 6. This indicated that soil moisture plot^{-1} was significantly influenced by moisture stress in all the sampling periods. More soil moisture plot^{-1} was observed from the control (no stress in the sampling periods across the two seasons. equally, more and statistically similar soil moisture plot^{-1} were recorded from the 10-12WAP stage at 6 and 8WAP, from 6-9WAPat 10 and 12WAP during 2018/2019 dry season. Similar trend was observed during 2019/2020 dry season were more soil moisture plot^{-1} was recorded at the 6-9WAPat 10 and 12WAP. Soil moisture plot^{-1} was however not significantly influenced by varieties in all the sampling periods across the two dry seasons.

Total Number of Roots Plant^{-1}.

Results of total number of roots plant^{-1} as influenced by moisture stress and genotypes during 2018/2019, 2019/2020 and 2020/2021 and combined dry seasons at Zakirai are presented in Table 7. This showed that total number of roots plot^{-1} in Sweetpotato were not significantly affected by moisture stress, genotypes and applied benzoic acid in both seasons and the combined during the study.. The result further revealed significant interactions of stress and genotype on the total number of roots plant^{-1} during 2018/2019 and 2019/2020 dry seasons only (Table 8). This indicated that highest number marketable roots plant^{-1} (38.75 and 31.92) were observed from NARSP 12/097 stressed at 10-12WAP stage. These were also at par with Danchina and EA/11/025 that was not stressed during 2019/2020 dry season.

Average Root Weight (kg)

Results of the influence of moisture stress and genotypes on the average root weight plot^{-1} of Sweetpotato during 2018/2019, 2019/2020 and 2020/2021 and combined dry seasons at Zakirai are presented in table 9. This indicated that moisture stress had no significant effect on the average root weight plot^{-1} of Sweetpotato in all the study periods and the combined. However, significant Varietal influence on average root weight was noticed in 2018/2019, 2020/2021 and combined dry seasons. This showed that NARSP 12/097 produced the heaviest roots. Similarly, Danchina and EA/11/025 produced statistically similar and the least average root weight in all the sampling seasons.

Root Yield (t ha^{1})

Table 10 presents the results of the influence of moisture stress and genotypes on root yield per hectare during 2018/2019, 2019/2020 and 2020/2021 and combined dry seasons at Zakirai. This indicated root yield per hectare was significantly influenced by moisture stress in all the study periods and the combined. Highest root yield per hectare was observed from plots that were stressed at 6-9WAP stage during 2018/2019, 2019/2020 and combined dry seasons. However, in 2020/2021, the highest root yield per hectare was recorded from plot stressed at. 10-12WAP. similarly, significant influenced of genotypes on the root yield was observed in 2018/2019dry season and the combined this indicated that the highest root weight (yield) per hectare was recorded from Danchina and NARSP 12/097. These were different from EA/11/025 which produced the lowest root yield.

CONCLUSION

Results of the study indicated that Sweetpotato stressed at 6-9WAP stage gave the highest root yields higher root yields were also obtained from NARSP 12/097 in all the sampling seasons. Based on the results obtained from the experiment, farmers in the study area could be recommended to limit water application to Sweetpotato to 10-12WAP stage for better and higher root yields. To use NARSP12/097 as planting materials for its potentials in producing more and higher root yields per hectare.

REFERENCES

Amira, M. S., Yahaya S. U. and Mohammad S. G. (2015). Evaluation of the Performance of Improved Sweetpotato (*Ipomoea batatas* L.) Varieties in Kano, Sudan Savanna Agroecology, Nigeria

Anselmo, B.A., Ganga Z.N., Dadol E.O., Heimer Y. M. and Neijidat A. (1998). *Screening Sweetpotato for drought tolerance in the Philippines highlands and genetic diversity among selected genotypes*. Tropic. Agric. (Trinidad) 75, 189- 196.

Babaji, A. I (2017). Best ways to farm Sweetpotato, by expert, publisher: Daily trust newspaper: Feb 2 2017

Berberich, T., Takagi, A., Miyazaki, M., Otani, T. and Kusano, T. (2005). Production of mouse adiponectin, an anti-diabetic protein, in transgenic Sweetpotato plants. J. Plant Physiology. 162: 1169-1176

Black, C.A., D.D. Evans, I.E. Evsminger, F.E. Clerk and J.L. White, (1965). Methods of Soil Analysis: Part 1, American Society of Agronomy, Inc., Madison, USA.

Ekanayake, I.J. (2004). Studying drought stress and irrigation requirements of potatoes. CIP Research Guide 30

F.A.O.(2008). Food and Agricultural Organization Statistics, **in**: http:/www.apps.fao.org Food and Agricultural Organization. Rome, Italy

F.A.O.(2010). Food and Agricultural Organization Statistics, **in**: http:/www.apps.fao.org Food and Agricultural Organization. Rome, Italy

F.A.O.(2016). Food and Agricultural Organization Statistics, **in**: http:/www.apps.fao.org Food and Agricultural Organization. Rome, Italy

Kassali, R. (2011). *Economics of Sweetpotato Production*. International Journal of Vegetable Sciences. 17(4): 313-321, DOI: 10.1080/19315260.2011.553212.

Kivuva, B.M., Mburu, W.M.K., Maina J.M., and Alistair, M. (2005). The effect of planting density and water regime on maize grain and forage yield. M.Sc. Thesis, Univ. of Nairobi, Kenya

Laurie, R.N., Du Plooy, C.P. and Laurie, S.M. (2009). Effect of *Moisture Stress on Growth and Performance of Orange Fleshed Sweetpotato Varieties*. African Crop Science Conference Proceedings, 9, 235-239.

May, D. M. and Gonzales. J., (1999). Major Californian tomato cultivars respond differently in yield and fruit quality to various level of moisture stress. *ActaHorticulture* 487:525-529

Sokoto, M. B and Gaya M. I. (2016) Growth and Yield of Sweetpotato (Ipomoea batatas (L.)) as Influenced by Irrigation Interval and Variety in Sokoto Sudan Savannah, Nigeria

Yasmin, F., Othman, R. Sijam, K. and Saad, M.S. (2007). Effect of PGPR inoculation on growth and yield of Sweetpotato . *Journal of. Biological Science*., 7: 421-424.

Table 1: Emergence Count as Influenced by Moisture Stress and Genotypes during 2018/2019, 2019/2020, 2020/2021 and Combined Dry Seasons at Zakirai

Treatments	2018/2019	2019/2020	2020/2021	Combined
Stress (S)				
No Stress	92.39	94.56	94.39	93.78
6-9WAP	92.19	93.61	94.19	93.33
10-12WAP	91.86	93.67	93.86	93.13
SE±	0.490	0.354	0.491	0.357
Genotype (G)				
Dan China	91.81	94.36	93.81	93.32
EA/11/025	92.31	94.28	94.31	93.30
NARSP 12/097	92.33	94.19	94.33	93.62
SE±	0.430	0.480	0.431	0.459
Interaction				
S x G	NS	NS	NS	NS

Table 2: Number of Leaves Plant-1 as Influenced by Moisture Stress and Genotypes during 2018/2019 and 2019/2020 Dry Seasons at Zakirai

	2018/2019(WAP)				2019/2020(WAP)			
Treatments	6	8	10	12	6	8	8	12
Stress (S)								
No Stress	12.00	30.11	52.80	106.30	20.83	40.08	52.40	108.50
6-9WAP	11.44	33.58	59.20	110.70	22.61	44.25	53.30	112.00
10-12WAP	12.33	31.97	57.60	104.90	23.19	44.11	56.5	118.40
SE±	2.170	2.920	5.952	5.383	1.002	2.610	3.860	8.002
Genotype (G)								
Dan China	13.53	32.03b	58.14b	92.8b	23.00ab	42.89	56.5	118.00a
EA/11/025	12.42	42.81a	78.11a	155.80a	24.89a	45.54	60.40	135.10a
NARSP 12/097	8.83	20.83c	33.36c	73.30c	18.75b	39.92	45.20	85.90b
SE±	1.815	2.223	2.673	4.973	1.460	1.832	3.790	8.951
Interaction								
S x G	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter (s) are not significantly different at 5% level of probability using SNK, NS = Not Significant

Table 3: Number of Leaves Plant-1 as Influenced by Moisture Stress and Genotypes during 2020/2021 and Combined Dry Seasons at Zakirai

	2020/2021(WAP)				Combined(WAP)			
Treatments	6	8	10	12	6	8	10	12
Stress (S)								
No Stress	20.67	32.81	56.60	110.3	17.83	34.33	53.94	108.40
6-9WAP	17.08	36.97	62.20	114.70	17.05	37.94	58.23	112.50
10-12WAP	18.83	35.67	61.00	108.90	18.12	37.25	56.36	110.70
SE±	1.203	3.250	6.120	5.360	1.235	3.782	6.408	8.260
Genotype (G)								
Dan china	19.83b	34.42b	61.10b	96.80b	18.76a	36.44b	58.58b	102.50b
EA/11/025	23.53a	44.81a	81.10a	159.80a	20.61a	44.42a	73.21a	150.20a
NARSP 12/097	13.22c	25.22c	37.60c	77.30c	13.60b	28.66c	36.74c	76.60c
SE±	0.803	1.729	2.520	4.970	1.376	2.414	3.550	6.360
Interaction								
S x G	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter are not significantly different at 5% level of probability using SNK, NS = Not Significant.

Table 4 Number of Branches Plant-1 as Influenced by Moisture Stress and Genotypes during 2018/2019 and 2019/2020 Dry Seasons at Zakirai

	2018/2019 (WAP)				2019/2020(WAP)			
Treatments	6	8	10	12	6	8	10	12
Stress (S)								
No Stress	1.92	3.67	5.14	7.06	1.92	2.92	4.94	5.81
6-9WAP	2.06	3.83	5.31	7.25	2.11	3.11	5.36	6.36
10-12WAP	1.83	3.56	4.97	7.00	2.00	3.00	5.17	6.42
SE±	0.111	0.130	0.121	0.150	0.121	0.120	0.110	0.230
Genotype (G)								
Dan china	2.03	3.89	5.19	7.25	2.08	3.08	5.08b	6.17
EA/11/025	1.94	3.58	5.14	7.08	2.08	3.08	5.44a	6.58
NARSP 12/097	1.83	3.58	5.08	6.97	1.86	2.86	4.94b	5.83
SE±	0.120	0.111	0.121	0.131	0.101	0.110	0.111	0.242
Interaction								
S x G	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter (s) are not significantly different at 5% level of probability using SNK, NS = Not Significant, * = Significant

Table 5: Number of Branches Plant-[1] as Influenced by Moisture Stress and Genotypes during 2020/2021 and Combined Dry Seasons at Zakirai

	2020/2021(WAP)				Combined(WAP)			
Treatments	6	8	10	12	6	8	10	12
Stress (S)								
No Stress	1.47	2.61b	5.25	6.89	1.77	3.06	5.11	6.58
6-9WAP	1.50	2.67b	5.19	7.28	1.89	3.20	5.29	6.96
10-12WAP	1.69	3.00a	5.47	7.17	1.84	3.19	5.20	6.86
SE±	0.070	0.058	0.504	0.666	0.089	0.092	0.315	0.360
Genotype (G)								
Dan china	1.50	2.69ab	5.31	6.92b	1.87	3.22	5.19	6.78
EA/11/025	1.39	2.44b	4.28	5.44b	1.81	3.04	4.95	6.37
NARSP 12/097	1.78	3.14a	6.33	8.97a	1.82	3.19	5.45	7.36
SE±	0.123	0.183	0.538	0.603	0.078	0.086	0.267	0.346
Interaction								
S x G	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter (s) are not significantly different at 5% level of probability using SNK, NS = Not Significant

Table 6: Soil Moisture Plot- [1] as Influenced by Moisture Stress and Genotypes during 2018/2019 and 2019/2020 Dry Seasons at Zakirai

	2018/2019 (WAP)				2019/2020 (WAP)			
Treatments	6	8	10	12	6	8	10	12
Stress (S)								
No Stress	90.28a	90.44a	90.00a	89.97a	90.03a	90.11a	90.10a	89.88a
6-9WAP	66.36b	42.14b	90.17a	90.64a	66.11b	41.81b	90.26a	90.53a
10-12WAP	90.31a	90.72a	66.64b	40.50b	90.06a	90.39a	66.534b	40.49b
SE±	0.32	0.62	0.28	0.42	0.32	0.62	0.27	0.42
Genotype (V)								
Dan china	82.47	74.97	82.33	73.33	81.69	74.87	82.34	73.93
EA/11/025	82.53	74.14	82.58	73.72	82.26	73.61	82.67	73.80
NARSP 12/097	81.94	74.96	81.89	73.56	83.22	74.03	81.78	73.46
SE±	0.20	0.35	0.44	0,31	0.20	0.28	0.44	0.31
Interaction								
S x V	*	NS	NS	NS	*	NS	NS	NS

Means in a column of any set of treatments followed by same letter are not significantly different at 5% level of probability using SNK, NS = Not Significant, * = Significant

Table 7. Interaction of Stress and Genotype on Soil Moisture Plot^{-1} of Sweetpotato at 6WAP during 2018/2019 and 2019/2020 Dry Seasons

Treatment	Stress (A) 2018/2019			Stress (A) 2019/2020		
Genotype (V)	No Stress	6-9WAP	10-12WAP	No Stress	6-9WAP	10-12WAP
Dan china	89.75b	91.08a	90.00b	89.50b	90.83a	89.75b
EA/11/025	65.67d	66.25cd	67.17c	65.42d	66.00cd	66.92c
NARSP 12/097	90.42ab	90.25ab	90.25ab	90.17ab	90.00ab	90.00ab
SE±		0.424			0.422	

Table 8; Total Number of Roots Plant^{-1} as Influenced by Moisture Stress and Genotype during 2018/2019, 2019/2020, 2020/2021 and Combined Dry Seasons

Treatments	2018/2019	2019/2020	2020/2021	Combined
Stress (S)				
No Stress	30.06	25.30	31.56	28.98
6-9WAP	31.31	25.30	39.31	31.97
10-12WAP	32.50	24.50	34.06	30.36
SE±	1.332	1.820	2.220	1.738
Genotype (G)				
Dan china	32.86	26.70	34.33	31.29
EA/11/025	31.00	24.00	34.69	29.91
NRSP 1	30.00	24.50	35.89	30.12
SE±	1.160	1.890	1.612	1.821
Interaction				
S x G	*	*	NS	NS

NS = Not Significant, * = Significant

Table 9: Average Root Weight ((kg) Plot^{-1} as Influenced by Moisture Stress and Genotypes during 2018/2019, 2019/2020, 2020/2021 and Combined Dry Seasons at Zakirai

Treatments	**2018/2019**	**2019/2020**	**2020/2021**	**Combined**
Stress (S)				
No Stress	0.84	0.78	0.74	0.79
6-9WAP	0.95	0.71	0.85	0.83
10-12WAP	0.88	0.76	0.78	0.81
SE±	0.027	0.050	0.026	0.043
Genotype (G)				
Dan china	0.85b	0.73	0.75b	0.78b
EA/11/025	0.85b	0.74	0.75b	0.78b
NARSP 12/097	0.98a	0.77	0.88a	0.89a
SE±	0.029	0.040	0.029	0.028
Interaction				
S x G	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter are not significantly different at 5% level of probability using SNK, NS = Not Significant,

Table 10: Root yield (t ha^{1}) as influenced by Moisture Stress and Genotypes during 2018/2019, 2019/2020 and 2020/2021 and combined dry seasons at Zakirai

Treatments	**2018/2019**	**2019/2020**	**2020/2021**	**Combined**
Stress (S)				
No Stress	11.11b	11.97b	10.47c	11.18b
6-9WAP	13.67a	13.78a	12.22b	12.62a
10-12WAP	11.51b	12.40b	15.62a	11.69b
SE±	0.602	0.0.6	0.494	0.678
Genotype (G)				
Dan china	11.84a	12.72	11.07	12.10a
EA/11/025	11.33b	12.22	11.16	11.58b
NARSP 12/097	12.16a	12.98	11.65	12.26a
SE±	0.440	0.454	0.0.4	0.574
Interaction				
S x G	NS	NS	NS	NS

Means in a column of any set of treatments followed by same letter are not significantly different at 5% level of probability using SNK, NS = Not Significant

EFFECT OF AQUEOUS EXTRACTS OF MORINGA *(Moringa oleifera* LAM*)* RESIDUES ON THE GROWTH AND YIELD OF TOMATO (*Solanum lycopersicum* L.) IN DADINKOWA, GOMBE STATE

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ABSTRACT
The study was conducted to evaluate the effect of extracts from *moringa oleifera* residues (twigs and seed shells) as alternative source of bio-stimulants on the growth and yield of tomato in the field. The experiment was conducted in the Teaching and Research Farm of Federal College of Horticulture Dadinkowa Gombe State, Nigeria during the 2021/2022 cropping season. It was laid in randomized complete block design (RCBD) with three replications. Tomato plants were foliar-sprayed with the extracts at 2 and 4 weeks after transplanting. Data were collected on plant height, canopy spread, number of branches, number of fruits and total yield. The results obtained showed significant differences among the extracts with leaf extract having superior performance in all the parameters measured, though not statistically different in plant height, number of branches and number of fruits with twig extract. The use of moringa residues as foliar spray to enhance growth and yield of tomato could be explored in the study area.
Key words: moringa, extract, tomato, foliar, growth, yield

INTRODUCTION

Tomatoes (*Solanum lycopersicum* Mill*)* are grown as a vegetable crop of economic significance around the world, prized for its nutritional value and culinary versatility (FAO, 2023). Despite its importance, optimizing tomato plant growth and increasing yield pose persistent challenges in agriculture. Decreasing soil nutrient quality and rising cost of inputs, especially fertilizer, plague tomato production in Nigeria, resulting in the dwindling yields of tomato plants in the country (Ogunwole, 2006). The exploration of natural bio-stimulants has emerged as a promising avenue, with Moringa oleifera, commonly known as the "Miracle Tree," gaining attention for its rich bioactive compounds (Siddhuraju and Becker, 2003). Moringa is eco-friendly and the leaf extract of moringa poses it as an interesting alternative for synthetic growth regulators and fertilizers. This aligns with the escalating awareness of the environmental consequences associated with conventional agricultural inputs Adekiya *et al.* (2017). The multifaceted challenges in tomato cultivation, such as nutrient deficiencies, soil quality, environmental stressors, and disease pressure, necessitate innovative solutions. Traditional approaches involving synthetic fertilizers, pesticides, and growth regulators, while effective, raise concerns about environmental sustainability and potential health risks (Kumar and Agarwal, 2017). In this context, the exploration of natural bio-stimulants provides a promising avenue for sustainable agriculture *Moringa oleifera* leaf extract has gained recognition as a potential bio-stimulant for its rich composition of bioactive compounds, including vitamins, minerals, antioxidants, and growth-promoting substances (Silva *et al*., 2020). These compounds have demonstrated potential in enhancing plant growth, nutrient uptake, and stress tolerance across various crop species. Several research works have shown the positive effects of moringa leaf extract on tomato plants, indicating its efficacy as a growth enhancer and yield booster (Khan *et al*., 2018). Recently, moringa plant has attained enormous attention because of having cytokinin, antioxidants, macro and micro nutrients in its leaves (Abdalla and El-Khoshiban, 2012; Abdalla, 2013). The ecological friendliness of Moringa leaf extract positions it as an appealing substitute for synthetic growth regulators and fertilizers. This aligns with the escalating awareness of the environmental consequences associated with conventional agricultural inputs (Adekiya *et al.*, 2017). This study therefore seeks to investigate the alternative use of residues from moringa plants as bio-stimulants for the growth and yield components of tomato.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research farm of Federal College of Horticulture Dadin kowa, Gombe State-Nigeria, during the 2021 wet season. The experimental site is located at latitude 10^0 18'N and longitudes 11^0 18'E at an altitude 434 m above sea level. The station lies in the Sudan Savanna belt characterized by a single peak of rainy season with an average rainfall of 800 mm. The annual rainfall ranges from 850 -1000 mm per annum mostly distributed between the months of May and October. Mean daily temperature ranges from 20 to 35^oc (Morgado *et al.*, 2003).

The field used for the experiment had been used in the cultivation of pepper and tomato a year prior to the conduct of this experiment. Seeds of Roma VF variety was used for the experiment after raising from the nursery. The tomato seedlings were transplanted 25 days after germination when seedlings had reached 15 cm (6 inches) high with 5-6 leaves. Transplanting activities was done at 45 cm between rows and 30 cm within rows. The experiment was laid in a Randomized

Complete Block Design (RCBD) with three replications. The total number of unit plots were 12 and the size of unit plot were 3 m × 4.5 m. The distance between two-unit plots were 1 m and 1.5 m between blocks. The experiment had four treatments which consisted of T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract, T4 = Control (distilled water).

Preparation of Moringa Aqueous Extracts

Young leaves, stem/twigs and seed shells of moringa were sourced from mature trees within the premises of Federal College of Horticulture Dadinkowa Gombe State. The materials were washed with clean water, dried and ground into powder before use. One hundred grams (100 g) powder from each of these powders were mixed with 1000 ml of distilled water and the suspension was stirred using a homogenizer to help maximize the amount of the extract. The solution was then filtered by wringing the solution using a mutton cloth. Using a method developed by Fuglie (2000), each of the stock solution was diluted with distilled water at a 1:32 ratio. After two weeks of transplanting the tomato plants, the respective dilutions and distilled water (Control) were applied as a foliar spray. The extracts were applied 100 ml per plant.

Data were collected on plant height, number of leaves, canopy spread, number of fruits and total yield. All data collected were subjected to analysis of variance (ANOVA) appropriate to RCBD as described by Gomez and Gomez (1984) using SAS version 82 (2011) and means that were significantly different were compared using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Effect of aqueous extracts from residues of moringa on plant height (cm) of tomato

The result of the effect of aqueous extracts from residues of moringa on plant height of tomato is presented in Table 1. There were no significant (P>0.05) differences among the treatments at 2 weeks after transplanting (2WAT), 4WAT, 6WAT and 8WAT. The moringa leaf extracts (T1) application recorded the highest values of plant height (23.8 cm, 89.0 cm and 136.8 cm) at 2 WAT, 4 WAT and 8 WAT respectively followed by T3 which had values of 19.2 cm at 2 WAT while T2 was highest 33.7 cm at 4 WAT. The least plant height was however observed in the control treatment (T4) throughout the weeks. This result confirms the works done by Chattha *et al.* (2015), who reported that application of moringa leaf extract can enhance the growth rate, number of leaves/plants, plant height, shoot and root length and fresh weight and dry weight of shoot and root of maize.

Effect of aqueous extracts from residues of moringa on plant canopy spread (cm) of tomato

The result on the effect of aqueous extracts from residues of moringa on plant canopy spread (cm) of tomato is presented in Table 2. The result showed significant ($P<0.05$) differences among the treatments in all the period of study except at 2 WAT. The result revealed that moringa leaf extract T1 had the highest canopy spread at 2, 6 and 7WAT having values of 26.33 cm, 73.47 cm and 77.23 cm respectively, although these did not differ significantly with T2. The lowest canopy spread values were obtained in the control (Table 2). This study is in agreement with the results of Saini *et al*. (2018); Goudarzi *et al*., (2019) who reported that moringa leaves contains compounds that promote the activity of beneficial soil microorganisms, improving nutrient availability and uptake by the roots. The increased nutrient uptake contributes to enhanced plant growth, development, and overall productivity.

Effect of aqueous extracts from residues of moringa on number of branches per plant of tomato

The result on the effect of aqueous extracts from residues of moringa on numbers of branches/plant of tomato is presented in Table 3. The number of branches were significantly ($P<0.05$) influenced by moringa extracts throughout the growing season. The results obtained revealed that highest number of branches plant^{-1} were observed moringa leaf extract treated plots, followed by moringa stems treated plots. Control treatment however, recorded the least number of branches in this study. These results are in agreement with Mahmood and Mugal (2010) who found that foliar application of moringa leaf extract contains an adequate number of stimulating substances that promote cell division and enlargement at a faster rate. Zeatin, a growth hormone found in moringa leaf extract, encourages the growth of lateral buds, which leads to an increase in the number of branches. After pounding 100 g of moringa leaves in 8 L of water, foliar spray of moringa leaf extract enhanced branches plant^{-1} in okra (Anyaegbu, 2015).

Effect of aqueous extracts from residues of moringa on numbers of fruit/plant of tomato

The result on the effect of aqueous extracts from residues of moringa on numbers of fruit/plant of tomato is presented in Table 4. The results indicated that no significant ($P>0.05$) were observed among the treatments during the season. Even though the results did not differ significantly, moringa leaf treated plots had the highest number of fruits (20.0 and 29.7) at 11 and 12 WAT respectively. The significant increase in the number of fruits per plant can be attributed to the growth-promoting regulators present in moringa leaf extract, such as gibberellins and other phytohormones (Solaimalai *et al.,* 2001; Brady and MeCourt. 2003; Harris *et al.,* 2007). The present study supports the findings of Ofosu-Anim *et al.* (2007) that application of bio-stimulants increased the number of fruits per plant in tomato by ensuring rapid plant nutrients uptake that optimized fruit setting and activated the development of bigger and more quality fruits (Saimbhi *et al*., 2012).

Effect of aqueous extracts from residues of moringa on fruit yield in t/ha of tomato

The result of the effect of extracts from residues of moringa on fruit yield is presented in Table 5. The result shows that fruit treated with moringa leaf extracts had the highest value (3.14 and 5.32 t/ha) at 10 and 12 WAT but not significantly different with the moringa seed shell treated plants (2.98 and 5.32 t/ha) and other treatments at 10 and 12 WAT respectively. The lowest fruit yield value was obtained in the control treatment (2.34 and 3.70 t/ha). Moringa leaf extract contains natural plant growth regulators, including cytokinins, auxins, and gibberellins, which can modulate hormone levels and balance in tomato plants. These hormonal changes influence various physiological processes, such as cell division, differentiation, and flowering, leading to enhanced growth and yield (Bharathi *et al.*, 2012).

CONCLUSIONS AND RECOMMENDATIONS

The application of residues from moringa leaf extracts significantly impacted the growth and yield of tomato plants. Notably, moringa leaf extract demonstrated the most favorable outcomes across multiple parameters, including the plant height, canopy spread, number of branches, number of fruits/plant and fruit yield per plant. The extract from moringa leaves exhibited a higher number of branches per plant, suggesting potential for increased fruit production. No significant differences were observed among other residues. The findings recommend the use of moringa leaf extract concentration as a foliar spray to enhance the growth and yield of tomato plants. However, further research is recommended to optimize extraction methods of these plant residues to maximize their effectiveness in tomato cultivation.

REFERENCES

Abdalla M.M., El-Khoshiban N. (2012). The influence of water stress on growth, relative water content, photosynthetic pigments, some metabolic and hormonal contents of two Triticium aestivum cultivars. *Journal of Applied Science Research*, 3,2062–2074.

Adekiya, T.M., Agbede, J.T., & Ogeh. (2017). Growth, yield and fruit quality of tomato (*Solanum lycopersicum*) as influenced by poultry manure and NPK fertilizer. Sci Hortic (Amsterdam), 215, 71-76.

Anyaegbu, P. O. (2015). Comparative evaluation of effects of leaf extracts of selected fallow species and NPK (15: 15: 15) fertilizer on the performance of okra, *Abelmoschus esculentus* in Abuja, Nigeria. *Rep. Opin.* **7**(10), 39–46.

Bharathi, M. Ramanjaneyulu, G., Rao, V. K., & K.V. Ravishankar. (2012). Plant growth-promoting rhizobacteria-mediated induction of phenolics and plant defense enzymes contribute to induced systemic resistance against Xanthomonas campestris pv. vesicatoria in tomato. *Journal of Phytopathology*, 160(12), 674-686.

Brady, S. M., & McCourt, P. (2003). Hormone cross-talk in seedling development: perspective from Arabidopsis. Molecular Plant, 4(5), 964- 70.

Chattha, M.U., Sana, M.A., Munir, H., Ashraf, U., Haq, I., Zamir, S. (2015). Exogenous application of plant growth promoting substances enhances the growth, yield and quality of maize (*Zea mays* L.). *Plant Knowledge J.*, 4(1): 1-6.

Gomez, K. A., Gomez, K. A. & Gomez, A. A. *Statistical Procedures for Agricultural Research* (Wiley, 1984).

Goudarzi, M. Asgharzadeh, A. Alizadeh, A., & A.H. Shirani Rad. (2019). Effect of foliar application of *Moringa oleifera* leaf extract on vegetative growth, yield, and fruit quality of tomato (*Solanum lycopersicum* L.). *Journal of Applied Research on Medicinal and Aromatic Plants*, 12, 1-7.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT): https://www.icrisat.org/wp-content/uploads/2023/06/Annual_Report_2022.pdf

Khan, Z Abbas, MA Khan, S. Ahmad, M. Naushad. (2018). Impact of *Moringa oleifera* leaf extract on growth, yield, and fruit quality of tomato. *Sarhad Journal of Agric*, 34(3), 685-692.

Kumar, V Agarwal. (2017). Effect of *Moringa oleifera* leaf extracts on seed germination and seedling growth of tomato. *International Journal of Agric Environ Biotechn*, 10(1), 63-67.

Mahmood, K. T., Mugal, T. & Haq, I. U. 775 (2010). *Moringa oleifera*: A natural gift—a review. *J. Pharm. Sci. Res.* **2**(11), 775-777.

Morgado,L. B. & Willey, R. W. (2003). Effect of plant population and nitrogen fertilizer Echinochloa Crugalli, 4 (2), 24 – 30.

Ogunwole, J.O. (2006). Potential of Soil Carbon Sequestration under Various Landuse in the Sub-humid and Semi-arid Savanna of Nigeria: Lessons from Long-term Experiments

Ofosu-Anim**,** J., Blay, E.T., & Bening, L. (2007). Effect of Biozyme T.F. on yield and quality of tomato (*Lycopersicon esculentum*). *Ghana Journal of Agricultural Science* 40: 113-17.

Saimbhi, M. S., Padda, D. S., & Singh, G. (2012). Ascorbic acid content of chilli varieties as affected by fruit maturity. J. Res., 9: 248-50.

Saini, R. K. Shetty, N. P., Giridhar, P., & Ravishankar, G.A., G (2018). Enhancement of growth, photosynthetic capacity and secondary metabolite content in Mentha spicata L. by application of *Moringa oleifera* Lam. leaf extract. *Plant Physiology and Biochemistry*, 129, 73-83.

Siddhuraju, K. Becker. (2003). Antioxidant properties of various solvent extracts of total phenolicconstituents from three different agroclimatic origins of drumstick tree *(Moringa oleifera* Lam.) leaves. *Journal of Agric Food Chem*, 51(8), 2144-2155.

Silva, S.J. Ramos, A.T.S. Rocha, H.C. Oliveira, CV. Santos, R.L. Ferreira. (2020). Foliar application of *Moringa oleifera* leaf extract improves growth and nutrient uptake of tomato plants. Rev Bras Eng Agric Ambient, 24(1), 59-65.

Solaimalai, A., Amutha, R., & K. Mathalaimuthu. (2001). Biochemical changes in growth and development of tomato plants (Lycopersicon esculentum Mill.) treated with growth substances and different nutrients. *Journal of Tropical Agriculture*, 39(1-2), 14-17.

Table 1: Effect of aqueous extracts from residues of moringa on plant height (cm) of tomato

Treatment	2WAT	4WAT	6WAT	8WAT
T1	23.8	32.4	89.0	136.8
T2	17.8	33.7	77.3	125.5
T3	19.2	31.7	79.1	93.3
T4	22.4	30.4	54.8	67.4
P<F	0.460	0.937	0.388	0.109
LSD (0.05)	9.68	13.06	45.63	61.61

T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract, T4 = Control, WAT = Weeks after transplanting

Table 2: Effect of aqueous extracts from residues of moringa on canopy spread (cm) of tomato

Treatment	2WAT	3WAT	4WAT	5WAT	6WAT	7WAT
T1	26.33	46.41	58.50	65.17	73.47	77.23
T2	24.50	48.64	61.37	67.93	72.00	74.27
T3	24.77	36.90	54.47	63.67	67.03	69.77
T4	21.90	35.33	47.30	55.50	63.00	66.40
P<F	0.435	0.016	0.006	0.020	0.010	0.011
LSD(0.05)	6.190	8.221	6.053	6.852	5.351	5.371

T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract,

T4 = Control, WAT = Weeks after transplanting

Table 3: Effect of aqueous extracts from residues of moringa on number of branches/plant of tomato

Treatment	3WAT	4WAT	5WAT	6WAT	7WAT	8WAT	9WAT
T1	2.47	3.73	4.00	5.20	5.30	5.53	5.53
T2	2.46	3.33	3.70	4.43	4.57	4.80	4.80
T3	1.90	2.67	2.93	3.60	3.87	4.17	4.17
T4	1.80	2.17	2.57	2.97	3.13	3.37	3.37
P<F	0.049	0.006	0.004	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	0.566	0.702	0.625	0.659	0. 647	0.515	0.515

T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract, T4 = Control, WAT = Weeks after transplanting

Table 4: Effect of aqueous extracts from residues of moringa on number of fruit/plant of tomato

Treatment	9WAT	10WAT	11WAT	12WAT
T1	2.7	6.7	20.0	29.7
T2	2.7	7.0	14.3	21.7
T3	3.0	5.0	11.3	26.7
T4	1.3	5.3	10.0	18.3
P<F	0.939	0.899	0.249	0.203
LSD (0.05)	2.90	4.43	4.70	11.81

T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract, T4 = Control, WAT = Weeks after transplanting

Table 5: Effect of aqueous extracts from residues of moringa on fruit Yield in t/ha of tomato

Treatment	Yield (t/ha)	
	10 WAT	12 WAT
T1	3.14	5.32
T2	2.68	4.99
T3	2.98	5.33
T4	2.34	3.70
P<F	0.127	0.016
LSD	0.720	0.939

T1 = Moringa leaf extract, T2 = Moringa stem extracts, T3 = Moringa seed shell extract, T4 = Control, WAT = Weeks after transplanting

EFFECT OF CO-INCORPORATION OF FRESH RICE STRAW AND GREEN MANURE APPLIED WITH UREA ON SOILS FERTILITY, GROWTH AND YIELD OF RICE (*Oryza sativa* L.) IN RICE-WHEAT-RICE CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted during 2020 and 2021 wet seasons at the Irrigation Station, Kadawa Nigeria to determine the effects of co-incorporation of rice straw residue and green manure on rice crop and chemical properties of the soil, in a rice-wheat-rice cropping system, in the Sudan savannah ecological zone of Nigeria. The treatments were: (i) Control, (ii) 100 kg N ha^{-1}, (iii) 150 kg N ha^{-1}, (iv) Green Manure (GM), (v) GM + rice Straw, (vi) Wheat Straw + 150 N kg ha^{-1}, (vii) Green Manure + Wheat straw. The experiment was laid out in Randomized Complete Block Designs (RCBD) with four (4) replications. The parameters measured involved; leaf area index, total dry matter (g), plant height (cm), effective tillers, filled grains panicle^{-1} and green yield (kg ha^{-1}). The results showed that plant height, leaf area index, total dry matter, number of effective tillers hill m^{-2}, number of filled grain panicles^{-1} and grain yield ha^{-1}were significantly higher in the treatment of green manure incorporated with rice straw or wheat straw compared to the other treatments. The co-incorporated cowpea green manure of rice straw increased rice yield by the average of 58% but was at par with co-incorporation of wheat straw and GM compared to rice without incorporation. The available N, P and K in the first 15.0 cm layer increased by more than 15% when compared to plots without co-incorporation of the straw incorporated soil increased the CEC and carbon content of the soil by 9% and 17% respectively compared to non-incorporated fields.

Keyword: Rice Straw, Green manure, Urea, Soils fertility, Cropping system

INTRODUCTION

Rice is one of the most important staple cereal crops cultivated in Nigeria because of its palatability and ease of preparations and cooking. The rice crop offers variety of uses to the farming community. Rice is also being considered as one of the best and cheapest alternative technology available to farmers for efficient utilization of natural resources. Nigeria rough rice production has now reach 7.4 million metric tonnes (USDA, 2019). This rising increase is as a result of rice demand which is largely due to rapid population growth increased urbanization and people's preference for rice as a convenient food (FOA, 2003).

Rice in Nigeria is planted in June and depending on the requirement of a particular variety, it is grown in paddies or in upland. And because the crop responds very well to nitrogenous fertilizers it uses lesser fertilizer compared to other cereals like maize and even sorghum.

Kadawa in Kano is one of the main grains producing area in Nigeria where rice-rice and or rice-wheat rotation is the prevailing crop system and produces many heaps of crop residues every year. Rice is grown in both wet and dry seasons, because of the availability of irrigation water throughout the year in the area. Highlight on rice production by farmers in this area revealed that in this area, for the past five (5) years, rice yield harvested has declined to an average of 4.2 t/ha from the 6.2±0.2 – 6.4±0.2 t/ha initially harvested, some decade back with recommended rates of mineral N.P.K and sulfur (S) even when up to 150% of the recommended rate of fertilizers NPK and S was used the yield was not much better than what it used to be using the 100% NPK and S rate. Before 2019 for the past ten years the cultivation of rice was done in the wet season while wheat production followed immediately in the harmattan. From the above information, its suggested that the decline in yield might not have been due to low rate of N.P.K and S application. Traditionally in this area rice as well as wheat are manually harvested by cutting and carrying to a central threshing location for separation of grain antraw, with only a small portion of the straw retained in the field. Straw is considered a waist product and was either burnt or use for other purposes.

On one hand decline in yield may have been caused by deficiency of the other nutrients apart from NPK and S not able to sustain initial previous yield. On the other hand, because of the way farmers managed their fields for the past years may have been responsible. It has been reported that extensive and inappropriate use of chemical fertilizers is degrading our soils to alarming level. Nutrient recycling by the use of organic manure is referred to restore nutrient removed by crops and organic matter removed or mismanaged by man. Despite the gaps in our knowledge of cropping system involving various long-term options including legumes have generally been found to be beneficial particularly in rice-wheat cropping systems (Abrol and Palaniappan 1988). The in-situ incorporation of rice straw in the soil has been shown to contribute to recycling of nutrient and increasing soil organic matter (Bijay-Singh *et al.*, 2004; Gupta *et al.*, 2007). Therefore the objective of the experiment is to shed light on more methods of N management in up-land rice.

MATERIALS AND METHOD

A field experiment was conducted during 2020 and 2021 wet seasons, at the Irrigation Station, Kadawa in the Sudan savannah, to determine the effect of crop residue management and green manuring on soil organic matter the growth and yield components of rice in rice-rice cropping system at Kadawa, Kano State ($11^0 29^1$N, $080^0 02^1$E at 500 m above sea level) in the Sudan savannah agro ecological zone of Nigeria. The rainfall pattern at the experimental site is bimodal, which begins in June and ends in September has its peak in August. During the crop growing season, average total rainfalls was 453.95 mm over the two years. The mean minimum temperatures over the two years were 16.5^0C respectively, while the mean maximum temperature was 35.7^0C. Soil samples were collected prior to the experiment at depths of 0-15 cm fertilizer application and analyzed for the physic-chemical properties of the soil and after harvesting maintaining the same plots throughout experiment. The soil was analyzed to determine soil texture, soil pH caution exchange capacity (CEC), total nitrogen, available phosphorus, exchangeable potassium and organic carbon. The results for soil analysis are shown in Table 1. There were seven (7) treatments: (i) Control, (ii) 100 kg N ha^{-1}, (iii) 150 kg N ha^{-1}, (iv) Green Manure (GM), (v) GM + Rice Straw, (vi) GM + Wheat Straw, (vii) Wheat Straw + 150 kg N ha^{-1}, the experiment was laid out in Randomized Complete Block Designs (RCBD) with four (4) replications. Land preparation began in March 03rd of both years after wheat harvests. The gross size of each plot was 12.9 m^2 (3.84 long and 3.36m wide) while a net plot size of 2m x 2m ($4m^2$) was used. Each plot was separated by 0.75m, while each block was separated by 1.5m.

Cowpea was sown at the spacing of 30cm x 15cm on 03rd of March with irrigation. The plants were uprooted and ploughed back into the soil of the respective plots on April 05th of each year. Rice Straw and Wheat Straw were collected and cut manually into pieces with the help of a knife and incorporated into the affected plots at 13 t ha^{-1} using a hoe at 15cm depth on the same date with green manure.

Thirty days after incorporation of organic materials rice seed were sown on 1st week of each year at 20 x 20cm spacing to give a density 750,000 plant ha^{-1}.

At the time of planting all inorganic phosphorus and potassium, gypsum and one third of the nitrogen was applied according the treatments. The remaining nitrogen fertilizer was applied at 6 weeks after sowing. Hand weeding was done at three and six weeks after sowing and regular disease control measures recommended for rice were followed to avoid any disease incidence.

Five plants from each net plot were chosen randomly and tagged for measuring plant height, leaf area index, weighing total dry matter, number of filled grains panicle $^{-1}$, effective tillers m^{-2}, and grain yield t ha^{-1}, at 6, 9WAS and harvest.

At the time of harvest four hills were selected from each plot for measuring, counting and weighing the following parameters: plant height (cm), panicle length, effective tillers, filled grains panicle $^{-1}$ and grain yield (kg ha^{-1}), using standard procedures.

RESULT AND DISCUSSION

The results depicted in Table 2 showed that, plant height, leaf area index, were significantly increased in all treatments over control.

Plant height (cm)

The green manure and straw management treatments had significant effect on the plant height at different growth stages. It was found that incorporation green manure and crop residue increase the plant height significantly where the maximum plant height (101.02cm) was observed in plots where GM + Wheat Straw was incorporation and the lowest plant height (70.20cm) was recorded for the control (Table 3). The increase in plant height in response to incorporation GM + Crop Straw is probably due to enhanced availability of nutrients which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation as reported by Liu *et al.* (2023).

Productive tillers m^{-2}

Green Manure and Rice Straw incorporation and wheat straw + Green manure incorporation significantly increased the productive tillers/m^2 in rice at harvest (95 days after transplanting) (Table 4). The use of GM and Rice Straw and GM + wheat straw produced maximum number of tillers/m^2 (326.0 and 333.1) respectively when averaged across both years. Number of tillers per unit area is the most important component of yield. The more the number of tillers, especially productive tillers, the more will be the yield. More number of tillers/m^2 in experiment might be due to the increased in essential nutrient and microbial activities that played a vital role in cell division. Similar observation was reported by Leigh *et al*. (2014).

Leaf area index

The data regarding leaf area index is presented in Table 4. The results revealed that GM + Rice Straw produced maximum leaf area index (5.04) and the minimum leaf area index (2.06) was produced by control at harvest. It might be due to improved nutrients availability and enhanced growth of plant.

Dry matter accumulation

The data presented in Table 3 and 4 revealed a statistically significant increase due to GM and Straw Incorporation throughout the measurement period. Significantly highest dry-matter accumulation (501.0gm^2) was obtained from rice straw incorporation with Green Manure. These results were statistically at par with that of treatment of wheat incorporation with GM. It was as expected since vegetative growth resulting from higher photosynthetic activities is well known to be influenced by better nutrition. In general, dry-matter accumulation increased at slow rate up to 6 WAP after planting due nutrient release from Green Manure and thereafter increased at faster rate up to harvest due to effect of rice and wheat straw on soil properties. The higher dry mater of GM + Residue treated plants could be connected with the positive effect of GM in some physiological processes at early stages and the effect of straw at later stages (Yang *et al* 2016).

Grain Yield

The mean grain yield revealed that rice crop responded significantly to GM and straw from rice and wheat compared to non-incorporation (Table 5). The GM + Rice Straw grain yield of (6.39 g/ha) and significantly lowest grain yield of (2.10 t/ha) was obtained from the plots where nothing was applied. The control gave the lowest grain yield in the experiments and these reductions were significant in all of the experiments. Under some circumstances the reduction in yields from the application of urea may also be attributed to volatilization of ammonia. The available N, P and K increased by more than 15% when compared to plots without Green Manure and crop straw residue. It has been reported that straw incorporation has significant beneficial affect crop yield effectives on and soil properties (Zhang *et al.,* 2015) for instance straw incorporation can increase crop yields (Yang *et al.,* 2016) soil organic matter and other soil nutrients. (Wang *et al.,* 2015) and improve penetration of roots.

In addition, the positive effect of straw incorporation on soil micro-organisms have also been reported. The soil CEC and carbon increased by 7% and 22% in incorporation compared to non-incorporation. (Liu *et al.,* 2010).

Rice straw significantly increase rice yield by the average of 58% compared straw removal. Soil available NP and K in the first 15.0 in increased by more 15% with incorporation straw compared to non-incorporation. Jin *et al*. (2009) and Wu *et al.,* (2012) reported that the layer and the soil microbial increases the carbon and nitrogen content of the soil. Therefore full straw incorporation could significantly improve soil fertility and maintain crop yields for the study area.

CONCLUSION

From the experiment, the treatment of rice straw and wheat straw which were at par gave significant yield increases in growth and yield in most of the parameters and chemical properties. Thus in this regards we find that rice straw and wheat straw where found to be optimum option yield in rice-wheat-rice system. Therefore, full straw incorporation significantly improves soil fertility and maintain crop yields.

REFERENCES

Abrol, I. P., and Palaniappan, S. P. (1988). Effect of Stubble Incorporation on Soil Properties and Wheat yield/ *journal of Agricultural Science*, 111(2); 147-153.

Bijay-Singh, *et. al*. (2004). Long-term effects of crop reside management on soil fertility and productivity in a rice-wheat rotation. *Journal of Agricultural Science*, 142 (4), 359-368.

Food and Agriculture Organization of the United Nations (2003). World Agriculture: Towards 2015/2030.

Gupta, J. J.; Doley, S.; Bujarbaruah, K. M. (2007). Evaluation of forage based feeding system for rabbit production in northeastern region of India. *Indian J. Anim. Nutr*., 24 (4): 216-218

Liu, S., Wang, L. Chang, L., Khan, I., Nadeem, F., Rehman, A. and Suo, R. (2023). Evaluating the influence of straw mulching and intercropping on nitrogen uptake, crop growth and yield performance in maize and soybean. *Front. Plant Sci.* 14:1280382. Doi: 10.3389/fpls2023.1280382

USDA, (2019). Crop Production Report. National Agricultural Statistics Service.

USDA, (2019). Soil Health and sustainability. Natural Resources Conservation Service.

Leigh, G. Monahan, Isabella, V. Hajduk, Sinead P. Blaber, Ian G. Charles, Elizabeth J. Harry (2014). Coordinating Bacterial Cell Division with Nutrient Availability: A Role for Glycolysis. *ASM Journals, Vol. 5, No. 3*

Wang, X. H.; Yang, H. S.; Liu, J. S.; Chen, S. P.; Wu, J; Zhy, L. Q.; Bian, X. M. (2015). Effects of ditch-buried straw return on soil organic carbon and Rice-*Wheat Rotation System Catena*, 127, 56-63 (Cross Ref).

Wu Chihhui, Burton Neuner, Jeremy John, Andrew Milder, Byron Zollars, Steve Savoy and Gennady Shvets **(2012).** Metamaterial-based integrated plasmonic absorber/emitter for solar thermo-photovoltaic systems. *Journal of Optics*, Vol. 14, Number 2. **14** 024005**DOI** 10.1088/2040-8978/14/2/024005

Yang, H. S., Xu, M. M.; Joide, R. T; Liu Q.; Y.J.; Liu, L.; Bian, X.M. Effects of ditch-buried. Straw return on water percolation, nitrogen teaching and crop yields in a rice-wheat rotation system. *J. Sci. Food Agric*. 2016, 93, 11 41-1149. (Cross Ref) (Pub Med).

Zhang Y.; Liu, Y.; Zhang, G.; Guo, X.; Sun, Z.; Li, T. The effects of rice straw and Biochar Applications on the Microbial Community in a soil with a History of Continuous Tomato.

Zhang, P., Chen, X., Weit.; Yang, Z., Yang, B., Han, Q., Ren, X. Effects of straw incorporation on the soil nutrient contents, enzyme activities, in a semi region of China. *Soil Tillage. Res*. 2016, 160, 65-72 (Cross Ref).

Table 1: Mineral fertilizer, green manure and rice/wheat crop residue management practices averaged over two years 2020 and 2021 at Kadawa Kano state

Treatment	Description
Control	No fertilizer
NPK[a]	NPK at a rate of 100 – 60 – 30 kg N – P – K ha^{-1}+ S (Sulfur)
NPK[a]	NPK at a rate of 150 – 60 – 30 kg N – P – K ha^{-1}+ S (Sulfur)
GM	Green Manure
GM + Rice Straw	Green Manure + Rice Straw (Fresh weight)
GM+ Wheat Straw	Green Manure + Wheat Straw (fresh weight)
Wheat Straw + 150 kg N ha^{-1}	$N_{150}P_{60}K_{30}$ ha.$^{-1}$ and Rice Straw (fresh weight)

[a]NPK used were urea, triple superphosphate and muriate of potash

Table 2: Impact of rice/wheatresidue, green manure and mineral fertilizer on the growth component of rice averaged over two years of 2020 and 2021at Kadawa.

	Plant height			Leave area index			Total dry matter (g m^{-2})		
Treatments	6WAS	9WAS	Harvest	6WAS	9WAS	Harvest			
Control	22.14^{c}	29.80^{c}	70.20^{c}	0.60^{b}	1.62^{c}	2.06^{d}	1.10^{c}	260.2^{d}	501.0^{d}
100 kg N ha^{-1}	24.36^{c}	33.76^{b}	76.21^{c}	0.66^{b}	1.84^{b}	3.07^{c}	130.5^{b}	427.9^{b}	853.0^{c}
150 kg N ha^{-1}	28.11^{b}	55.97	99.38^{b}	0.80^{a}	2.68^{a}	4.71^{b}	148.2^{a}	665.5^{a}	1242.6^{b}
Green Manure (GM)	28.33^{a}	54.35^{a}	100.20^{b}	0.79^{a}	2.67^{a}	4.77^{b}	142.2^{a}	656.2^{b}	1085.7^{b}
GM + Rice Straw	29.72^{a}	56.54^{a}	101.02^{a}	0.83^{a}	2.94^{a}	5.04^{a}	155.8^{a}	709.1^{a}	1332.9^{a}
GM + Wheat Straw	29.87^{a}	56.62^{a}	104.9^{a}	0.83^{a}	2.94^{a}	4.97^{a}	158.9^{a}	717.2^{a}	1426.7^{a}
Wheat straw +150 kg N ha^{-1}	24.00^{b}	35.31^{b}	72.33^{c}	0.66^{b}	1.87^{b}	3.08^{c}	133.3^{b}	474.0^{c}	915.5^{c}
SE (±)	0.5133	0.6447	0.4256	0.0095	0.0885	0.050	7.8495	18.66	27.89

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level **= significant at 1% probability level NS = Non-significant, SE = Standard error, + GM = with Green manure, -GM = without green manure

Table 3: Impact of rice residue, green manure and mineral fertilizer on the yield and yield component of rice averagedover two years of 2020 and 2021at Kadawa.

Treatment	Panicle length (cm)	Effective tillers hiil^{-1} (No.)	Filled grains panicle (No.)	Grain yield (kg ha^{-1}) (g)	Straw yield (kg ha^{-1})
Control	23.41^{c}	150.6^{d}	50.91^{d}	2.42^{d}	3.20^{c}
100 kg N ha^{-1}	24.72^{c}	220.8^{c}	56.82^{c}	3.67^{c}	3.28^{c}
150 kg N ha^{-1}	27.22^{b}	302.5^{b}	87.58^{b}	5.82^{b}	6.84^{a}
Green Manure + Rice Straw	28.32^{a}	326.0^{a}	92.06^{a}	6.45^{a}	5.80^{b}
Wheat Straw + 150 kg N	24.32^{c}	214.7^{c}	56.04^{b}	3.68^{c}	3.26^{c}
Green Manure	27.22^{b}	302.5^{b}	89.80^{a}	5.68^{b}	6.89^{a}
Green Manure + Wheat Straw	28.72^{a}	333.1^{a}	90.48^{a}	6.58^{a}	5.70^{b}
SE (±)	0.3364	6.3853	0.9741	0.1931	0.2959

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.
* = significant at 5% probability level **= significant at 1% probability level NS = Non-significant, SE = Standard error, + GM = with Green manure, -GM = without green manure

Table 4: Effect of rice residue, green manure and mineral fertilizer on the soil properties of rice averaged over 2020 and 2021 at Kadawa.

Treatment	pH(1:2:5)	CEC (c mol kg^{-1})	Total N (%)	Extr. P (ppm)	Exch. K (ppm)	OM (%)
Control	5.18	10.87	1.76	0.65	9.64	3.80
NPK 150 kg	5.06	10.87	1.79	1.65	13.73	3.06
NPK 120 kg	5.03	10.50	1.74	1.75	13.069	3.10
Green Manure (GM)	6.10	10.87	1.76	1.85	13.67	4.0
GM + Residue	6.17	11.50	1.77	1.93	13.74	4.60
Residue + NPK (150 kg N ha)	6.36	11.25	1.77	1.93	13.72	4.69
Ash + NPK (150 kg N ha)	6.23	10.50	1.77	1.97	13.72	3.99
Initial soil status	5.5	9.86	1.5	0.73	9.81	3.4
SE (±)	NS	NS	NS	NS	NS	NS

NS = Non-significant.

RESPONSE OF OKRA (*Abelmoschus esculentus* (L) Moench) VARIETIES TO 4-CHLOROPHENOXY ACETIC ACID IN SUDAN SAVANNA ZONE OF NIGERIA

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ABSTRACT

Field trials were conducted during the 2022 rainy season at two different locations; Teaching and Research Farm (Latitude $12^0 58^1$N and Longitude $8^0 25^0$E) of the Faculty of Agriculture, Bayero University, Kano and Institute for Agricultural Research (IAR) Research Farm ($12^0 10^1$N $8^0 39^1$E 444m above sea level) located at Minjibir. Both sites are situated within the Sudan savanna agro-ecological zone of Nigeria, to determine the response of Okra varieties to different levels of 4-chlorophenoxy acetic acid The treatment consisted of four Okra varieties (NHAe 47-4, LD-88, Clemson Spineless, and Yarballa and five levels of 4-chlorophenoxy acetic acid (0, 25, 50, 75 and 100mg/L). These were laid out in a Split Plot Design (SPD) and replicated three times. Varieties were assigned to the main plots, while levels of 4-chlorophenoxy acetic acid were assigned to the subplots. Data were collected on both growth and yield characters. Three plants were randomly selected and tagged from each plot. Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 17th edition. Treatment means were separated using Students Newman Keuls (SNK) at a 5% probability level. The results showed that okra varieties (NHAe 47-4, LD-88, Clemson Spineless, and Yarballa) had a significant effect on days to 50% flowering, leaf area, leaf area index, pod number, pod weight, marketable and non-marketable yield. Application of 4-Chlorophenoxy acetic acid had a significant effect on days to 50% flowering, pod weight, and final yield. NHAe 47-4 performed better than other varieties, while 50 mg/L recorded the highest pod yield. Further research should be done with various levels and more varieties to have wider coverage and to establish an optimum level.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench) is a flowering plant belonging to the family Malvaceae. It is valued for its edible green pods. The economic importance of okra cannot be overemphasized. According to Uzowuru (2010), all parts of the okra plant are useful, its leaves and tender shoots which are rich in nutrients that can be cooked and eaten. The pods are either consumed in fresh or dried form. The edible portions of the pod are good sources of protein as well as ascorbic acid and high levels of calcium, fiber, and ash, mature seeds contain about 21% of edible oil. Okra is also a potential oil and protein crop that has an export value (Uguru, 2011). The total commercial production of okra in the world was estimated at 9.7 million tons, with India (6m tons) and Nigeria (2.06m tons) being the predominant producers, followed by other minor producers which include Sudan, Mali, Cote d'Ivoire, Niger, Pakistan, Cameroon, Ghana and Iraq

(FAOSTAT, 2018). In 2019, India produced 5,507,000 tons and the yield was 11.4 tons ha^{-1} while Nigeria produced 1,978,286 tons and the yield was 1.6 tons ha^{-1}. In countries like the USA and India, several okra varieties have been developed through breeding efforts. Many of these were introduced into West and Central African countries and are still popular (Sanjeet *et al.*, 2010). Fruit yield and several yield contributing characters lack stability among the developed okra varieties due to strong environmental influence, suggesting the need for the selection of appropriate improved varieties for specific environments (Sanjeet *et al.*, 2010).

Growth regulators are chemical substance, other than nutrients and vitamins which regulate the growth of plant when applied in small quantities (Arteca, 2015). In case of vegetables, growth regulators are used mainly to improve seed germination, increase yield, plants become resistant to diseases and unfavourable growth conditions (Halter *et al*., 2005; Jankauskienė and Survilienė, 2009; Mukhtar, 2008). Synthetic Auxin 4-CPA (4-chlorophenoxy acetic acid) is highly effective in reducing pre-harvest fruit drop with increased number of fruits per plant and yield (Sasaki, *et al.*, 2005). Application of 4-CPA is more effective during anthesis period than one week after anthesis (Poliquit *et al.*, 2007). In fact, the use of growth regulators had improved the production of okra including other vegetables in respect of better growth and quality. In view of this, the present trail was conducted with the aim of evaluating the response of okra varieties to 4-chlorophenoxy acetic acid in the study areas.

MATERIALS AND METHODS

Field experiment was conducted during 2022 rainy season at two different locations; Teaching and Research Farm (Latitude $12^0 58^1$N and Longitude $8^0 25^0$E) of Faculty of Agriculture, Bayero University, Kano and Institute for Agricultural Research (IAR) Research Farm ($12^0 10^1$N $8^0 39^1$E 444m above sea level) located at Minjibir. Both sites are located in Sudan Savanna Zone of Nigeria. The treatments consisted of four okra varieties (LD 88, NHAe 47-4, Clemson spineless and Yarballa) and five levels of 4-chlorophenoxy acetic acid (0, 25, 50, 75 and 100gm/L). These treatments were laid out in a Split Plot Design (SPD) and were replicated three times. Varieties were assigned to the main plots, while 4-chlorophenoxy acetic acid was assigned to the sub plots. Data were collected on both growth and yield characters. Data collected was subjected to analysis of variance (ANOVA) using GENSTAT 17th edition. Treatment means were separated using Student Newman-Keuls (SNK) test at 5% probability level on yield of okra. Correlation analysis was also done to measure the association between yield and other characters as described by Little and Hills (1978).

RESULTS AND DISCUSSION

Effects of 4-Chlorophenoxy Acetic Acid Levels and variety on Plant height and Number of leaves of Okra

There was no significant difference (P>0.05)on plant height among varieties at both locations.. There was no significant effect of 4-Chlorophenoxy acetic acid on plant height at both locations. The interaction between varieties and 4-Chlorophenoxy acetic acid on plant height and number of leaves at both locations were not significant.

Effects of 4-Chlorophenoxy Acetic Acid Levels and variety on Number of Pods Plot^{-1} and Pods Weight Plot^{-1} (kg) of Okra

There was no significant difference (P>0.05) between varieties on pods number an pod weight per plot.At However, at Minjibir, a significant difference (P<0.05) was observed on pods number and pod weight per plot, where the, Clemson variety had significantly higher number of pods per plot as well as pod weight per plots although statistically comparable with other varieties. On the other hand, the application of various levels of 4-Chlorophenoxy acetic acid had no significant effect (P>0.05) on pods number at BUK. Although, 50 mg/L had the highest podsweight which was at par with other levels at BUK.,. At Minjibir, the application 100mg/L significantly recorded the highest pods number and pod weight per plot, although statistically at par with 25, 50 and 75mg/L, and control (0mg/L). Interaction between variety and 4-Chlorophenoxy acetic acid on number of pods per plot and pod weight per plot were not significant at both locations.

Effects of 4-Chlorophenoxy Acetic Acid Levels and variety on yield of okra

A significant difference was observed between varieties at both locations. At both BUK and Munjibir, NHAe 47-4 had the highest marketable pods, but was at par withother varieties.. The application of various levels of 4-Chlorophenoxy acetic acid did not influence marketable pods significantly at both locations. Interaction between varieties and various levels of 4-Chlorophenoxy acetic acid on marketable pods was not significant.

Non marketable pods of okra varieties were significantly influenced by varietyat both locations whereLD-88 recorded the highest non marketable pods, although statistically at par with Clemson and Yarballa, while NHAe 47-4 had the lowest non marketable pods at BUK. At Minjibir, a different trend was observed, where Yarballa had the highest non marketable pods, while NHAe

47-4 recorded the least number of non-marketable pods, although statistically at par with Clemson. Application of various levels of 4-Chlorophenoxy acetic acid did not significantly influence non marketable pods at both locations. Interaction between varieties and 4-Chlorophenoxy acetic acid on non-marketable pods was not significant at both locations.

CONCLUSION

Based on the outcome of the research, it can be concluded that application of various levels of 4-chlorophenoxy acetic acid significantly affected Okra varieties in the study areas. This is so because the region is low in fertility, rainfall, flower abortion and prone to diseases and pest. It is a known fact that growth regulators if properly applied compliment growth and development, which subsequently result to higher yield and yield attributes.

Having said this, it can be concluded that, a complex interaction exist between environment, varieties and 4-chlorophenoxy acetic acid in determining the final yield of Okra. NHAe 47-4 and Clemson performed better than other varieties at BUK and Minjibir respectively, while 50mg/L and 100mg/L recorded the highest pod yield at both locations.

REFERENCES

Arteca, R. N. (2015). Olericulture. **Introduction to Horticultural Science**, 2nd edition. Nelson Education. pp. 189, 494-496.

Aslam, M., Ahmad, E., Suguu, A. G., Hussain, K., Ayaz, M., Ullah, I. and Hussain, A. (2010). Effect of Plant Growth Regulator (NAA) and Available Soil Moisture Depletions on Yield and Yield Components of Chickpea. *Sarhad Journal of Agriculture*, 26(3), 325-335.

FAOSTAT, (2018). *Provisional 2017 Production data*. Retrieved from food and agricultural organisation online statistical data bases. available: www.fao.org/faostat/en/data/QC

Halter, L., Habegger, R. and Schnitzler, W. H. (2005). Gibberellic Acid on Artichokes (*Cynara scolymus* L.) Cultivated in Germany to Promote Earliness and to Increase Productivity. Acta Horticulturae., 681:75–82.

Jankauskiene, J. and Surviliene, E. (2009). Influence of Growth on Seed Germination Energy and Biometrical Parameters of Vegetables. Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture, 29 (3):69–77.

Little and Hills (1978). Little, T. M. and Hills, F. J. (1978). Agricultural Experimentation Design and Analysis, John Willey and Sons Inc. new York, pp350Poliquit, R. D., & Diputadu, M. T. (2007). Tomato fruit parthenocarpy and yield increase in response to chlorophenoxyacetic acid. *Ann. Trop. Res*, *29*(1), 14-25.

Prajapati, S., Jamkar, T., Singh, O. P., Raypuriya, N., Mandloi, R., & Jain, P. K. (2015). Plant Growth Regulators in Vegetable Production: An Overview. *Plant Archives*, 15(2), 619–626.

Pundir J. P. S and Yadav P. K. (2001). Effect of GA_3 and NAA on Growth, Yield and Quality of Tomato. Current Agric 32 (1&2): 137-138.

Ranjan, R., Purohit, S. S. & Prasad, V. (2003). Plant Hormones: Action and Application (pp. 183–189). India: Agrobios.

Rumman Shafi Quaderi, S. M., Islam, A., Hossain, A. F., Hoque, M. M. and Haque, M. S. (2006). Influence of Seed Treatment with In3dole Acetic Acid on Mungbean Cultivation. *International Journal of Botany*, 2(1): 42-47.

Sarkar, P. K., Sahidul Haque, M. D., & Abdul Karim, M. (2002). Effects of GA_3 and IAA and their Frequency of Application on Morphology, Yield Contributing Characters and Yield of Crops. *Journal of Agronomy*, 1(3), 119–122.

Sasaki, H., T. Yano and A. Yamasaki, (2005). Reduction of High Temperature Inhibition in Tomato Fruit Set by Plant Growth Regulators. JARQ, 39: 135-138

Sestak, Z., Catsku, J and Jarvis, P. G. (1971). Plant Photosynthetic Production: Manual of Methods. Dr. W. Jimic N. V. Publishers, the Haque. pp 528-529

Seufert, V., Ramankutty N., and Foley J. A. (2012). Comparing the Yields of Organic and Conventional Agriculture. *Nature*, 485, 229–232.

Singh, S., George, R., and Prafull B. (2012). Organic Farming Practices of Plains and Hills Farmers and Their Extent of Compliance with National Program for Organic Production (NPOP) Guidelines. *Journal of Agricultural Science 3:55–62.*

Singh, S. P. (1995). Response of Tomato (*Lycopersicon esculentum* Mill.) to Plant Growth Substances. *Advances in Horticulture and Forestry* 10(2): 29-31.

Uguru, M. I. (2011), **Crop Production: Tools, Techniques and Practice**. Nigeria, Nsukka: Full adu publisher, 37-136. (1)

Uzowuru, P. (2010). The Effect of Inorganic and Organic Fertilizers on Okra, Retrieved On 21/10/2010 from http:www.indiastudychannel.com/attachment/resources/107413-28747.

Table 1: Effects of 4-Chlorophenoxy Acetic Acid Levels on Plant Height (cm) and Number of Leaves of Okra Varieties During 2022 Rainy Season at BUK and Minjibir.

Treatment	BUK		Minjibir	
	Plant Height	No of Leaves	Plant Height	No of Leaves
Variety(V)				
NHAe 47-4	7.52	7.07	4.19	5.07
LD 88	7.10	6.33	4.88	5.07
Clemson	6.63	6.53	4.56	5.47
Yarballa	7.52	6.53	5.01	4.87
P of F	0.104	0.212	0.163	0.298
SE±	0.384	0.313	0.333	0.287
Chemical 4-CPA (C) [mg/L]				
0	6.92	6.25	4.47	5.00
25	6.79	6.67	4.59	4.92
50	6.85	6.92	4.75	5.17
75	6.83	6.17	4.71	5.17
100	7.20	7.08	4.76	5.33
P of F	0.854	0.163	0.566	0.828
SE±	0.406	0.430	0.198	0.377
Interaction				
V x C	0.475	0.325	0.133	0.384

Means followed with the same letter (s) within a treatment group are not significantly different at 5% probability level using Student Newman-Keuls (SNK)

Table 2: Effects of 4-Chlorophenoxy Acetic Acid Levels on Number of Pods Plot^{-1} and Pods Weight Plot^{-1} (kg) of Okra Varieties During 2022 Rainy Season at BUK and Minjibir.

Treatment	BUK		Minjibir	
	No. of Pods Plot^{-1}	Pods Weight Plot^{-1}	No. of Pods Plot^{-1}	Pods Weight Plot^{-1}
Variety (V)				
NHAe 47-4	174.1	4.13	91.38ab	1.49ab
LD 88	139.6	3.76	74.50b	1.22b
Clemson	147.9	4.09	127.67a	2.22a
Yarballa	137.9	3.41	67.82b	0.98b
P of F	0.196	0.399	0.042	0.028
SE±	16.13	0.569	16.63	0.303
Chemical 4-CPA (C) [mg/L]				
0	154.8	4.25ab	79.47b	1.39ab
25	136.8	3.52b	76.88ab	1.31ab
50	176.2	5.40a	78.80ab	1.16b
75	132	3.09b	93.07ab	1.52ab
100	149.5	3.33b	123.50a	1.99a
P of F	0.494	0.033	0.045	0.00
SE±	26.35	0.764	16.73	0.28
Interaction				
V x C	0.512	0.819	0.114	0.055

Means followed with the same letter (s) within a treatment group are not significantly different at 5% probability level using Student Newman-Keuls (SNK)

Table 3: Effects of 4-Chlorophenoxy Acetic Acid Levels on Marketable Pods and Non Marketable Pods (%) of Okra Varieties During 2022 Rainy Season at BUK and Minjibir.

	BUK		**Minjibir**	
Treatment	MarketablePods	Non Marketable Pods	MarketablePods	Non Marketable Pods
Variety (V)				
NHAe 47-4	91.85a	8.15b	93.08a	6.92c
LD 88	87.86b	12.14a	87.22ab	12.78b
Clemson	89.46ab	10.54ab	82.74ab	10.60bc
Yarballa	89.20ab	10.80ab	73.45b	19.88a
P of F	0.05	0.05	0.028	0.001
SE±	1.103	1.103	4.68	1.57
Chemical 4-CPA (C) [mg/L]				
0	89.14	10.86	85.59	14.41
25	89.07	10.93	80.01	11.66
50	90.15	9.85	86.32	13.68
75	90.06	9.94	80.81	10.85
100	89.54	10.46	87.88	12.12
P of F	0.71	0.71	0.69	0.303
SE±	0.97	0.97	6.57	1.85
Interaction				
V x C	0.12	0.13	0.520	0.454

Means followed with the same letter (s) within a treatment group are not significantly different at 5% probability level using Student Newman-Keuls (SNK)

EFFECT OF INTRA ROW SPACING AND NITROGEN ON SOME GROWTH CHARACTERS OF PEARL MILLET *(Pennisetum glaucum* (L.R.Br.) IN JIGAWA STATE, NIGERIA.

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ABSTRACT

Field trials were conducted during 2020 rainy season at Birnin Kudu Local Government (11°21' 48.4"N, 9°52' 35.3"E) and Jikas area in Maruta ward under Gwaram Local Government (11°28' 16.4"N, 9°27' 33.2"E). Both sites were located in Jigawa State and fall within Sudan Savannah agro ecological zone of Nigeria; The experiment evaluated the performance of pearl millet as affected by intra row spacing and nitrogen levels. The treatments consisted of three intra row spacing (25, 50 and 75cm) and four nitrogen levels (0, 40, 80 and 120kg N/ha). The treatments were factorally combined and laid out in a randomized complete block design and replicated three times. Plant height, number of leaves, leaf area, leaf area index, were observed as growth characters. Results revealed that, intra-row spacing had significant (P<0.05) effect on plant height, leaf area, leaf area index and leaf area ratio. The interaction between the intra-row spacing and nitrogen fertilizer application was statistically significant (P<0.05) on plant height, number of leaves, leaf area, leaf area index and leaf area ratio. From this study, it could be concluded that an intra-row spacing of 75cm combined with application of 120kgN/ha may be recommended to farmers in the study area, as such would be beneficial to improve the production of pearl millet.

Keywords: Intra Row Spacing, Nitrogen, Pearl Millet

INTRODUCTION

Pearl millet is one of the most important cereals and a staple grain for over 150 million people in West Africa and India (FAOSTAT, 2019). It makes up about two-third of the total cereal production in Africa therefore, regarded as one of the world's essential cereal crops (millet, rice, wheat, maize and sorghum) (Umar, 2018). It has the ability to withstand stress and thrive in hot region, with wide range of soil, which has made it quite popular in hot region and especially across many African countries (Bhagavatula *et al*, 2019). African countries have accounted for about 55 percent of the global total pearl millet and also take up to 59 percent of the global total area under pearl millet cultivation (FAO, 2015). The global production of pearl millet has estimated to 26 million hectares spreaded over 40 countries that are mostly arid and semi-arid, where rain fall is not sufficient (200-600mm).

Within Africa, more than 13.65 million hectares were put in use; accounting for about 74 percent of the total area cultivated in Africa and 28 percent of the world total production is in West Africa. Nigeria, as one of the most important millet producing country in the world, produces almost half

(40 percent) of total African millet production (FAO, 2019). The Northern part of Nigeria provides an ideal agro-ecological condition for the production of pearl millet. For this reason it is predominantly produced and consumed within the region, which made staple for over 40 percent of the populace (Jirgi *et al*., 2010).

Pearl millet has become a valuable component of the people's livelihood, because no part of the plant is wasted (Umar, 2018). As a regional staple, the people have created diverse method and forms of processing it for consumption, such as thick paste (Locally called 'tuwo'), thick dough (Locally called 'fura'), dumpling, grits, porridge and gruel. Beyond food, it is used as animal feed while the stalks of some varieties are traditionally used as building materials and for fire wood (Usman *et al*, 2014). The importance of pearl millet extends beyond food; its production also serves as an important source of income to farmers (Akinsuyi, 2011).

Pearl millet is the fifth most important cereal crop globally and ranks fourth amongst important tropical cereals (Ismail, 2012). In recognition of the vital role the pearl millet plays in food security, the Nigerian government in 1975 established 'lake chad-Research institute' (LCRI) mandated to facilitate research in millet production in the country. Over the years, the institute has made great achievement by releasing many varieties, such as LCICMV-1(SOSAT-C88) and LCICMV-3 (Super SOSAT) among others, with potential yields of 3.0-5.0 tones/ha (LCRI, 2018) Other special agencies, such as International Crops Research Institute for the semi-Arid Tropics (ICRISAT) with the similar purpose also have been in existence since 2008. With all the above mentioned government's effort, to promote pearl millet production in Nigeria, the last decade has seen a decline in millet production. (Umar, 2018). FAO in 2018 listed the main factors undermining crop production in Nigeria, which include; law fertilizer application and plant population density among others.

Although Pearl Millet plays important roles in food security and Nigerian economy, the yield recorded by the farmers in the country is still very low compared with the current increase in population (FAOSAT, 2019), there is therefore a need for measures that will increase millet production to meet the demand of the rapid growing population. However, it was generally observed that Millet fail to grow better and produces good grains in plots without adequate nutrients (Singh *et al*., 2016). To achieve optimum grain production, appropriate fertilizer application is essential. Being the most important plants nutrient, the use of Nitrogen fertilizers will increase the productivity of the millet Crops and inadequate available Nitrogen will reduce the crop growth and yield

(Choudhary *et al*., 2017). It is also possible to lower the cost of millet production while maximizing its potentialities by limiting supply of N to the appropriate quantity using suitable spacing.

It is within this context that, this study was initiated to use Nitrogen and Intra-row spacing for Pearl Millet Variety, LCICMV-3 (Super Sosat) production at Correctional Farm Center, Birnin Kudu and Jikas area in Maruta ward under Gwaram Local Government in Jigawa State.

The use of suitable spacing encourages the production of tillers (Ajeigbe *et al*., 2019). That is why the research (Growth of pearl millet as affected by intra row spacing and levels of Nitrogen) has been conducted, to determine the influence of intra- row spacing and different nitrogen levels on some growth of pearl Millet.

MATERIALS AND METHODS

Experimental sites

The trial was conducted at two locations; Correctional Farm Center, located in Birnin Kudu Local Government Area, Latitudes (N 11°21'48.4") and Longitudes (E 009°52' 35.3") with an Elevation of (413m) above sea level , the mean annual rainfall is (1021.22mm/an), mean minimum annual temperature range of (29°C) and mean maximum annual temperature of (42°C) and Jikas Area, located in Matura Ward, under Gwaram Local Government Area in Jigawa State, latitudes (N 11°28' 16.4") and longitudes (E 009° 27' 33.2") with an Elevation of (442m) above sea level, the mean annual rainfall is (915.12mm/an), mean minimum annual temperature range of (26°C) and mean maximum annual temperature of (43°C). The two sites, lie within the Sudan savanna agro-ecological zone of Nigeria. The trials were concurrently conducted from June to August, 2020.

Treatments and experimental design

The experiment consisted of twelve (12) treatments, which were replicated three (3) times in a Randomized complete block design (RCBD), with a total of Thirty six (36) plots. The treatments comprised of three (3) intra-row spacings (25cm, 50cm and 75cm) and four levels of nitrogen (0kgN/ha, 40kgN/ha, 80kgN/ha and 120kgN/ha) The plot size was 3.0m x 3.75m (11.25 m^2).

CULTURAL PRACTICES

Land Preparation

The land was cleared, harrowed, followed by ridging. The ridges were later marked out in to plots, discard and pathway using measuring tape, ropes and pegs.

Seed and Seed Protection

The Millet seed was obtained from ICRISAT and treated with Imidacloprid 10% + Thiram 10% (Seed Care), before planting which is a very effective systemic insecticide and fungicide seed treatment on cereals.

Description and Major Features of the Variety

Pearl millet variety PEO5532, was released as LCICMV-3 and called Super SOSAT by Lake Chad Research Institute (LCRI) and ICRISAT in the year 2011. It is recommended for production in the Sudan and Sahel savanna Agro ecological Zones of Nigeria (Angarawai *et al.*, 2015).

Data Collection

The data was collected on crop Growth parameters. Five Millet plants were selected at random from three inner Ridges of each plot, tagged, measured and then recorded. The Growth Parameters (plant height, number of leaves per plant, leaf area leaf area index and leaf area ratio) were observed at 2wks, 4wks, 6wks, and 8wks after sowing.

Plant height (cm)

The Plant Height was measured from the ground level to the tip of each of the five tagged Plants at 2, 4, 6, and 8 weeks after sowing, using a meter Rule. The mean value for each plot was computed and recorded in cm as the Plants height.

Number of leaves per plant

The number of leaves per plant from each of the five tagged Plants was obtained by manual counting at 2, 4, 6, and 8 weeks after sowing. The mean value per Plot was recorded.

Leaf area (L.A) cm^2

The leave area per plant was determined at 2, 4, 6, and 8 weeks after sowing by measuring and multiplying the Length by Breath of the Leaves of each of the five tagged Plants, The mean value of the product was also recorded.

It is given by:

L.A=L ***x*** B ***x C***

Where; L is Length and B is the Breath of the leave and C is the coefficient of the crop (0.75) which is constant (Sticker and Pouli, 1961).

Leaf area Index (LAI)

The Leave Area Index per Plant was also determined at 2, 4, 6, and 8 weeks after sowing by dividing the total leaf area of each of the five tagged Plants by the Ground area occupied by each Plant.

It is given by:

$$LAI = \frac{\text{Total leaf area of a plant cm}^2}{\text{Ground area occupied by the plant (cm}^2\text{)}}$$ (Sticker and Pouli,1961).

Leaf Area Ratio (cm²/g)

The Leave Area Ratio per Plant was determined at 2, 4, 6, and 8 weeks after sowing by dividing leaf area of each of the five tagged Plants by the Plant dry weight expressed in grams.

It is given by:

$$LAR = \frac{\text{Leaf area per plant cm}^2}{\text{Plant dry weight (g)}}$$ (Radford, 1967).

Data analysis

Statistical analysis was conducted with standard procedure, all the data collected were subjected to analysis of Variance (ANOVA) using the Genstat statistical package, as described by Snedecor and Cochran (1967). Finally, Students new Mann Kurl (SNK) was used to separate and compare the treatment means at 5% level of significance.

RESULTS AND DISCUSSION

Plant height

The effect of intra row spacing and nitrogen levels on the growth and yield of pearl millet on plant height at Birnin Kudu and Jikas in 2020 rainy season is presented on (Table 1). At Birnin Kudu the intra row spacing did not have significant effect on plant height across the sampling stages. There was significant effect at Jikas across the weeks except at 2WAS. At 6 and 8WAS plant height increased with an increase in intra row spacing, while at 2 and 4WAS, the effect was statistically similar. The nitrogen levels have significantly affected the plant height at both location accept at 2WAS, 120kg N/ha and 80kg N/ha gave the tallest plants at 6 and 8WAS while the least effect was observed in control plots, which increased with an increase in nitrogen application rate. At Jikas the effect is statistically similar at 2WAS, however, at 4 and 8WAS, 120kg N/ha produced the tallest plants while 80kg N/ha has the highest mean value at 6WAS and the least values obtained from the control plot. The plants height increases with an increase in nitrogen application rate.

The interaction between the intra row spacing and nitrogen levels on plant height at 4WAS and 6WAS at Jikas was presented on Table: 2 and 3 respectively.

Number of leaves

Table 4 presents the effect of intra row spacing and nitrogen levels on growth and yield of pearl millet on the number of leaves at Birnin-kudu and Jikas in 2020 rainy season. The intra row spacing was not significantly affected the number of leaves at both locations. The nitrogen application rates had significantly affected the number of leaves only at 6WAS in Birnin-kudu but 4 and 6WAS at Jikas (Table 6). 120kg N/ha had recorded the highest number of leaves while the control plots indicated the least number in each location.

The interaction between the intra row spacing and nitrogen levels on number of leaves per plant at 4WAS in Jikas was presented in Table 5.

Leaf area

Table 6 presents the effect of intra row spacing and nitrogen levels on the growth and yield of pearl millet, on plant leaf area at Birnin Kudu and Jikas in 2020 rainy season, The intra row spacing has no significant effect on the leaf area throughout the sampling stages at Birnin Kudu. At Jikas there was significant effect on leaf area throughout the weeks except at 2WAS. At 2 and 4WAS, the leaf areas were statistically similar but at 6 and 8WAS there were significant differences among the three spacing; the smallest leaf area was observed at closer spacing (25cm) while (75cm) spacing recorded the largest leaf area. The effect of nitrogen levels on leaf area at Birnin Kudu was significant at 6 and 8WAS but not significant at 2 and 4WAS (Table 8). The result shows that, at 2 and 4WAS, the leaf area were statistically similar at all levels of nitrogen. However at 6 and 8WAS there were significant differences, followed by 80kgN/ha at 6WAS. The interaction between the intra row spacing and nitrogen levels on leaf area at 4WAS at Jikas was presented in Table 7.

Leaf area index

The effect of intra row spacing and levels of nitrogen on growth and yield of pearl millet on leaf area index (LAI) at Birnin Kudu and Jikas in 2020 rainy season is present in Table 8. At Birnin Kudu, the intra row spacing has significant effect on leaf area index throughout the sampling stages. Evidently, the mean values recorded were statistically different at all the stages; the leaf area index increases with an increase in intra row spacing, the least leaf area index was recorded at closer spacing (25cm) and plot with wider spacing (75cm) gave the highest leaf area index across the sampling stages. Similar observation was recorded in Jikas, as there were significant different across the sampling weeks. The mean value recorded against the three (3) intra row spacing (25, 50, and 75cm) were statistically different.

Leaf area ratio

Table 10 shows the effect of intra row spacing and levels of nitrogen on the growth and yelled of Pearl millet on leaf area ratio (LAR) at Birnin Kudu and Jikas in 2020 rainy season. At Birnin Kudu the intra row spacing shows significant effect on the leaf area ratio at 2 and 8WAS, while at 4 and 6WAS there were no significant effect observed. The mean value recorded at plot with wider spacing (75cm) provide the least value while the higher values were observed at plot with closer spacing (25). At Jikas, there were no significant effect in all the weeks and the values recorded were statistically similar. The interaction between the intra row spacing and nitrogen levels on leaf area ratio at 8WAS at Birnin Kudu was presented on Table 11. The highest ratio was recorded from 0kgN/ha followed by 40kgN/ha at 25cm intra row spacing while, the least value was obtained from 120kgN/ha at 75cm intra row spacing. At Jikas, there was no significant effect observed.

Conclusion

The result of this experiment revealed that, the wider intra row spacing (75cm) has higher influence on the growth of pearl millet, as it was evidently observed from the plots served with wider intra row spacing (75cm), higher Nitrogen rates promotes the plant height and leaf area,. These parameters can be adversely affected with deficiency of nitrogen as the formation of enzymes, chlorophyll and protein necessary for growth and development get restricted. It was clearly observed that, plots served with 120kgN/ha gave the highest growth followed by 80kgN/ha while plots served with 0kg and 40kgN/ha were the lowest growth in all the experimental sites

References

Ajeigbe, H.A., Akinseye, F.M., Kunihya, A., Abdullahi A.I. and Kamara A. Y. (2019). “Response of pearl millet (*Pennisetum glaucum* L.) to plant population in the semi-arid environments of Nigeria,” *Net Journal of Agricultural Science*, volume. 7, no. 1, Pp.13–22.

Akinsuyi, Y. (2011). Local Government Intervention: Impact in Small-Scale Farming this Day Live. www.thisdaylive.com, Accessed 14th July, 2018.

Angarawai, I., Jada Gondah, Pucher Anna, Ousmane S.Y., Roger Zangre, Mahamadi Ouedraogo, Moussa, D., Sanogo, S., Boureima, C., Tom Hash,Bettina, I.G. Haussmann (2015). Agromophologlcal Characterization of West and Central African Pearl Millet Accessions. Crop Sci., Volume 55, Pp. 737 – 748.

Bamboriya, S.D., Bana, R.S., Pooniya, V., Rana, K.S., Singh, Y.V. (2017). Planting density and nitrogen management effects on productivity, quality and water-use effciency of rainfed pear lmillet (Pennisetum glaucum) under conservation agriculture.*Indian J. Agron.*, volume 62, Pp.363–366.

Bhagavatula, S., Rao, P.P., Basavaraj, G. and Nagaraj, N. (2013). Sorghum and Millet Economics in *Asia-Facts, Trends and Outlook*. International Crops Research Institute for the Semi-Arid Tropics.Volume 6, Pp.77-89.

Choudhary, S., Chopra, N.K., Chopra, N.K., Singh, M., Kumar, R., Kushwaha, M. (2017). Influence of Nitrogen Levels and Weed Management Practices on Yield and Quality of Forage Pearl Millet (Pennisetum glaucum L.). *Indian J. Anim. Nutr.*, volume 34, Pp. 64–69.

FAO (2019). Food consumption time series data provided online at http:// FAOSTAT .3.FAO.org/homa/index.hml/ accessed data base 20, 2019.

FAO (2015). Notions de nutrition des plantes et de fertilisation des sols. Manuel de formation, Projet Intrants, Niger, P.24.millet.

FAOSTAT (2019). Food and Agriculture Organization Statistical Data (unpublished) Available online at http://www.FAO.org. 2020 minor revision.

ICRISAT (International Crop Research Institute For Semi Arid Tropics), (2006). Pearl millet.Available online at hrrp://ww.Icrisat.org.Retrieved July 17-2009.Pp. 7.

Ismail, S.M. (2012), Optimizing productivity and irrigation water use efficiency of pearl millet as a forage crop in arid regions under different irrigation methods and stress. *Afr. J. Agric.*Vol. 7, Pp. 2509–2518.

Jirgi, A.J., Ogundeji, A.A., Viljoen, G. and Adiele, M.A. (2010). Resource Use Efficiency of Millet/Cowpea Intercropping in Niger State, Nigeria.In *Join 3rd African Association of Agricultural Economics (AAAE) and 48th Agricultural Economics Association of South Africa.*Volume 26(3), Pp.122-134.

Kamal, I. A., Siddig, A. M. A., Ali, H. B and Thabit,A. H. (2013). Effect of plant spacing and variety on performance of rain-fed pearl millet (*Pennisetumglaucum*) grown on two soil types Zalingei area, Sudan. ARPN *Journal of Science and Technology*, Volume3(5),Pp.512-517.

Lake Chad Research Institute (LCRI) (2018). Accessed 16th July, 2018 from http://www.lcrimaid.gov.ng/index.php/component/content/article/78-featured/72-article-a

Leonard, D. (2016). Soil, Crop, and Fertilizer Use: A Field Manual for Development Workers. Under contract with Peace Corps. 4th edition revised and expanded. United State Peace Corps.Information collection and exchange. Reprint R0008.

National Research Council (NRC) (1996). Lots of Crops in Africa Vol. 1.Grains.National Academy Press, Washington D. C., USA.Pp.231-135.

Singh, S.P., Maruthi, G.R., Nema, A.K., Singh, P.K., Srinivasa Rao, C., Mishra, P.K. (2016). Effect of moisture conservation, sowing methods and nitrogen levels on sustainable profitability of pearl millet under arid inceptisols.*Ind. J. Soil Cons.*, volume 44, Pp.206–215.

Umar, Mukhtar (2018), Efficiency and profitability of pearl millet production in the North-West Region of Nigeria, a thesis submitted to the School of postgraduate studies, University of Putra Malaysia, Pp.1-13.

Usman, Y.M., Hussaini, M., Baba-Masami, B. and Sheriff, B. (2014). Effect of Different Tillage Method on the Growth and Yield of Pearl Milletunder Rainfed Condition. *The International Journal Of Science and Technoledge*, volume 2(11), Pp.62-67.

Wichelns, D. (2014), Investing in small, private irrigation to increase production and enhance livelihoods. *Agric.Water Manag.*,Vol. 131, Pp.163–166.

Table 1. Effect of Intra Row Spacing and Different Levels of Nitrogen on Plant Height of Pearl Millet at Birnin Kudu and Jikas in 2020 Rainy Season.

Treatment	**Birnin kudu**				**Jikas**			
Spacing (cm)	2WAS	4 WAS	6 WAS	8 WAS	2WAS	4WAS	6WAS	8WAS
25	21.09	29.50	102.5	181.73	22.44	33.62b	96.75b	183.25b
50	21.69	30.14	107.55	191.12	24.45	36.73a	97.80b	194.52b
75	21.23	29.61	109.02	195.43	23.50	36.29a	102.93a	208.50a
SE±	0.31	0.34	3.42	7.00	1.01	1.68	3.31	12.65
Significant level	NS	NS	NS	NS	NS	*	*	*
Nitrogen (kg/ha)								
0	20.62	27.44b	86.76c	153.00c	24.73a	31.45b	86.79c	143.82c
40	22.18	29.46ab	105.56b	190.44b	23.42a	32.74b	99.09b	196.00b
80	20.94	31.07a	116.09a	209.09a	25.50a	38.28a	108.07a	218.07a
120	21.61	31.03a	117.02a	205.18a	22.32a	39.72a	102.70b	223.80a
SE±	0.69	1.71	14.06	25.58	0.99	4.06	9.04	36.43
Significant level	NS	*	*	*	NS	*	*	*
Interaction								
Spacing*N levels	NS	NS	NS	NS	NS	*	*	NS
SE±	0.52	0.61	3.77	4.20	0.75	0.95	2.96	3.84

1. Means with the same letter in the same column of any set of treatments are not significantly different at P ≤ 0.05% using SNK (students Newmann -Keuls test).
2. WAS: Weeks after sowing.
3. NS: Non Significant.

Table 2. Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on Plant height at 4WAS at Jikas.

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	29.4600 b	31.7333	38.2867	35.0133 b
50	33.3400 a	32.7867	37.8800	42.9133 a
75	31.5533ab	33.6867	38.6867	41.2267 a
SE±		1.47		

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

Table 3.Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on Plant height at 6WAS at Jikas.

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	85.2600	98.2267 b	107.0867	96.4267 b
50	87.5800	88.7400 c	108.8533	106.0400 a
75	87.5200	110.3133 a	108.2600	105.6333 a
SE±		4.12		

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

Table 4. Effect of Intra Row Spacing and Different Levels of Nitrogen on Number of Leaves/plant of Pearl Millet at Birnin Kudu and Jikas in 2020 Rainy Season.

Treatment	**Birnin Kudu**				**Jikas**			
Spacing (cm)	2WAS	4WAS	6WAS	8WAS	2WAS	4WAS	6WAS	8WAS
25	4.73	5.78	9.19	10.05	4.58	6.43	9.55	10.73
50	4.65	5.77	9.26	9.98	4.97	6.55	9.20	10.30
75	4.65	5.70	9.52	10.11	4.92	6.65	9.46	10.38
SE±	0.05	0.04	0.17	0.06	2.10	0.11	0.18	0.08
Significant level	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen kg/ha)								
0	4.71	5.67	8.26c	9.63	4.51	6.00c	8.64b	9.69
40	4.71	5.84	9.26b	10.20	5.00	6.20c	9.44a	9.64
80	4.87	5.87	9.69ab	10.22	4.82	6.82b	9.60a	9.84
120	4.42	5.62	10.09a	10.13	4.8	7.16a	9.93a	10.13
SE±	0.19	0.12	0.79	0.28	2.56	0.54	0.55	0.22
Significant level	NS	NS	*	NS	NS	*	*	NS
Interaction								
Spacing*N levels	NS	NS	NS	NS	NS	*	NS	NS
SE±	0.08	0.14	0.18	0.20	2.21	0.15	0.13	0.17

1. Means with the same letter in the same column of any set of treatments are not significantly different at P ≤ 0.05% using SNK (students Newmann -Keuls test).
2. WAS: Weeks after sowing.
3. NS: Non Significant.

Table 5.Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on number of leaves per Plant at 4WAS at Jikas.

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	6.1333	6.0000 b	6.9333	6.6667 b
50	5.8000	6.0667ab	6.8667	7.4667 a
75	6.0667	6.5333 a	6.6667	7.3333 a
SE±		0.2343		

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

Table 6.Effect of Intra Row Spacing and Different Levels of Nitrogen on Leaf Area (cm^2) of Pearl Millet at Birnin Kudu and Jikas in 2020 Rainy Season.

Treatment	**Birnin Kudu**				**Jikas**			
Spacing (cm)	2 WAS	4 WAS	6 WAS	8 WAS	2WAS	4WAS	6 WAS	8 WAS
25	20.56	26.79	165.67	204.8	23.77	29.36b	190.06b	234.02b
50	20.35	30.0	167.39	214.66	24.75	30.85b	197.54b	256.65ab
75	21.01	28.98	187.47	227.05	24.60	33.63a	228.45a	273.81a
SE±	0.33	1.64	12.12	11.15	0.53	2.17	20.35	19.96
Significant level	NS	NS	NS	NS	NS	*	*	*
Nitrogen (kg/ha)								
0	21.93	26.67	143.48b	179.09b	23.60ab	25.86b	152.04c	210.68c
40	20.30	29.34	177.36ab	217.12a	26.17a	31.08a	197.18b	246.80b
80	20.27	29.45	168.37ab	239.24a	25.50a	34.17a	240.54a	276.21a
120	20.07	28.89	204.81a	226.57a	22.22b	34.00a	231.64a	285.62a
SE±	0.86	1.30	25.32	25.91	1.80	3.88	40.16	33.76
Significant level	NS	NS	*	*	*	*	*	*
Interaction								
Spacing* Nlevels	NS	NS	NS	NS	NS	*	NS	NS
SE±	0.69	1.13	10.44	5.65	1.04	1.53	8.92	9.84

Means with the same letter in the same column of any set of treatments are not significantly different at P ≤ 0.05% using SNK (students Newmann -Keuls test). WAS: Weeks after sowing, NS: No significant

Table 7. Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on Leaf Area (cm^2) at 4WAS at Jikas

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	23.5767	28.9867	35.2333 a	29.6267 b
50	26.8900	33.0667	29.2000 b	34.2300 a
75	27.1267	31.1800	38.0800 a	38.1300 a
SE±		2.16		

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

Table 8.Effect of Intra Row Spacing and Different Nitrogen Levels on Leaf Area Index of Pearl Millet at Birnin Kudu and Jikas in 2020 Rainy Season.

Treatment	**Birnin Kudu**				**Jikas**			
Spacing (cm)	2WAS	4WAS	6WAS	8WAS	2WAS	4WAS	6WAS	8WAS
25	0.34c	0.57c	0.81c	1.07c	0.42c	0.69c	0.98c	1.07c
50	0.45b	0.74b	1.06b	1.32b	0.48b	0.80b	1.14b	1.38b
75	0.57a	0.95a	1.36a	1.67a	0.58a	0.97a	1.39a	1.72a
SE±	0.12	0.19	0.27	0.30	0.08	0.14	0.20	0.32
Significant level	*	*	*	*	*	*	*	*
Nitrogen (kg/ha)								
0	0.33d	0.54d	0.77d	1.00d	0.36d	0.59d	0.84d	1.03d
40	0.41c	0.69c	0.98c	1.28c	0.44c	0.74c	1.06c	1.28c
80	0.50b	0.83b	1.19b	1.41c	0.54b	0.89b	1.27b	1.50b
120	0.57a	0.96a	1.36a	1.71a	0.63a	1.05a	1.50a	1.74a
SE±	0.11	0.18	0.26	0.29	0.12	0.20	0.28	0.30
Significant level	*	*	*	*	*	*	*	*
Interaction								
Spacing* N levels	NS	NS	NS	NS	NS	NS	NS	*
SE±	0.01	0.01	0.02	0.03	0.01	0.01	0.02	0.06

Means with the same letter in the same column of any set of treatments are not significantly different at P ≤ 0.05% using SNK (students Newmann -Keuls test).WAS: Weeks after sowing. NS: Non Significance.

Table 9.Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on Leaf Area Index at 8WAS at Jikas

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	0.9133 b	0.9400 c	1.0767 c	1.3600 c
50	0.9267 b	1.2700 b	1.5133 b	1.8133 b
75	1.2633 a	1.6233 a	1.9200 a	2.0600 a
SE±		0.0383		

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

Table 10.Effect of Intra Row Spacing and Different Nitrogen Levels on Leaf Area Ratio (cm^2/g) of Pearl Millet at Birnin Kudu and Jikas in 2020 Rainy Season.

Treatment	**Birnin Kudu**				**Jikas**			
Spacing (cm)	2WAS	4WAS	6WAS	8WAS	2WAS	4WAS	6WAS	8WAS
25	0.17a	0.27	0.92	1.66a	0.14	0.17	1.07	1.34
50	0.14b	0.28	1.02	1.41b	0.14	0.17	1.05	1.34
75	0.12b	0.15	0.95	1.16c	0.17	0.16	0.96	1.23
SE±	0.03	0.05	0.05	0.25	0.02	0.01	0.06	0.07
Significant level	*	NS	NS	*	NS	NS	NS	NS
Nitrogen (kg/ha)								
0	0.25a	0.30	1.30a	2.03a	0.21	0.23a	1.30a	1.77a
40	0.15b	0.22	1.07ab	1.58b	0.15	0.17b	1.05b	1.36b
80	0.10c	0.20	0.79b	1.14c	0.11	0.15bc	0.99b	1.13bc
120	0.08c	0.20	0.69b	0.89d	0.14	0.11c	0.78c	0.96c
SE±	0.08	0.06	0.27	0.50	0.04	0.05	0.22	0.35
Significant level	*	NS	*	*	NS	*	*	*
Interaction								
Spacing* N levels	NS	NS	NS	*	NS	NS	NS	NS
SE±	0.01	0.06	0.05	0.11	0.03	0.01	0.08	0.05

Means with the same letter in the same column of any set of treatments are not significantly different at $P \leq 0.05\%$ using SNK (students Newmann -Keuls test). WAS: Weeks after sowing, NS: Non Significance.

Table 11.Interaction between intra row spacing (cm) and nitrogen levels (kg/ha) on Leaf Area Ratio (cm^2/g) at 8WAS at Birnin Kudu.

	Nitrogen levels (kg/ha)			
Spacing (cm)	0	40	80	120
25	2.3000 a	2.0800 a	1.3067	0.9700
50	2.2233 a	1.4100 b	1.1667	0.8333
75	1.5633 b	1.2567 b	0.9633	0.8567
SE±			0.1874	

Means followed by the same letter(s) within a column are not statistically different at 5% level of significant using SNK.

EFFECT OF NITROGEN FERTILISER ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.) VARIETIES IN KANO STATE, NIGERIA

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ABSTRACT

Identifying appropriate nitrogen level for maize varieties is critical for optimizing grain yields. A field experiment was conducted at Teaching and Research Farm, Faculty of Agriculture Bayero University, Kano (11^0 52.5 N, 8^0 24'28E and 457 m above sea level) during 2023 cropping season,within the Sudan savanna agro-ecological zone of Nigeria. The experimental treatment consists of five levels of nitrogen fertilizer (0, 40, 80, 100, and 120 kgNha^{-1})) and three varieties of maize (SAMMAZ 15, SAMMAZ 51 and EVDT). The treatments were replicated three times. in a split-plot design arrangement. The Nitrogen fertilizer was allocated to the main plots while maize variety to sub plots. The result of the experiment showed that nitrogen fertilizer played a significant role in the growth and yield of maize. Nitrogen fertilizer had a significant effect on plant height, leaf area, number of leaves, stem girth, chlorophyll content and yield per hectare. The highest yield and other agronomic traits were recorded at 100 and 120kgNha^{-1}, but the economical was 100 kg N ha^{-1}. Among the varieties, EVDT produced highest grain yield than SAMMAZ 15 and SAMMAZ 51. The study suggests that farmers in the study area should adopt the use of EVDT for higher grain yield.

Keywords: Nitrogen, maize, SAMMAZ 15, SAMMAZ 51 and EVDT, grain yield.

INTRODUCTION

Maize (*Zea mays* L.*)* is an important cereal crop worldwide, especially in developing countries where it is eaten as a staple food. In Nigeria, every part of the plant is important. The grains are an important source of energy for humans and are also used as feeds for poultry and livestock, and as raw material for the manufacture of baby foods (Ranum *et al*., 2014; Ikenj *et al*., 2002). However, despite the increase in area under maize production in Nigeria, the amount produced cannot meet the demand for the crop due to low yield, as a result of declining soil fertility and insufficient use of fertilizers (Buresh, 1997).

Nitrogen is a vital plant nutrient and a major yield determining factor required for maize production (Adediran *et al.,* 1995; Shanti *et al.,* 1997). It is an important component of proteins and nucleic acids and when nitrogen is sub-optimal, growth is reduced (Haque *et al*., 2001). In 2013, Nigeria produced close to 8 million metric tons, making it the largest producer in Africa (Adams, 2018). Maize production in Kano State rose to 5 million tons in 2010, as against only 1.9 million tons in 2003 and has an average maize grain yield of 4.6 ton/ha, which shows a remarkable increase in productivity as against the national average yield of 3.825 tons/ha in 2012 (KNARDA, 2014). Poor soil fertility and nutrient depletion continue to present huge challenges to successful crop production in dryland savanna zones of Nigeria (Eifediyi & Remison, 2015). Most cultivated soils of the Nigerian savanna are deficient in organic matter and in major plant nutrients such as N, P and K, which will help in the better growth and development of maize and consequently increase yield.

Maize crop requires a high amount of fertilizer (organic and inorganic) for proper growth and increased yield (Adeboye *et al.*, 2011). About 30 to 70 % of nitrogenous fertilizer are lost due to volatilization, denitrification and leaching thus requiring multiple applications of fertilizer to obtain high yield (Adeboye *et al.*, 2011). However, the low N status of Nigeria soil had made it necessary to supply N through the use of chemical fertilizers which is believed to increase maize yield (Roth and Fox, 1990; Gordon *et al.*, 1993). Many studies have shown nitrogen to influence the growth and yield of maize (Hague *et al.*, 2001; Anasanya, 2009). Ibrahim *et al.* (2022) evaluated maize in Makurdi at 0 to 180 kg N ha^{-1} and reported obtained highest yield at 120 kg N/ha, which was similar to the findings of Tofa *et al.* (2022) and Elgizawy (2009). In a related study, El-Sheikh (1998) and Muhammadi Aghdameta *et al.* (2014) recorded the highest maize growth and grain yield at 150 and 160 kg N ha^{-1}, respectively. However, on the contrary, Hejazi and Soleymani (2011) obtained the highest grain yield and yield components at 100 kg N ha^{-1}.

Studies have shown that maize cultivars differ markedly in grain yield response to nitrogen fertilization (Kamprath, 1982; Oikeh, 1996). According to Solubo (1989) in Nigeria hybrid maize cultivars were found to require a high fertilizer rate for optimum maize yield, and in particular maize responded to nitrogen better in the Savanna than in the Forest ecology, attributing it to the presence of higher insolation in the Savanna. It is evident that maize varieties differ in their need for precise dose of one or more factor before they can grow and produce meaningful grain yield. Therefore, in the light of the foregoing this study was undertaken to evaluate the growth and yield of some improved maize varieties as affected by N level.

MATERIALS AND METHODS

The Experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture Bayero University, Kano (11°58 N, 8°25 E and 457 m above sea level) in the 2023 cropping season. The range of annual rainfall and temperature are between 787mm to 960mm and 21^0C - 39^0C respectively (KNARDA, 2001). The experiment was laid out in a split-plot design with three replications. The main plots had four nitrogen fertilizer rates (0, 40, 80, 100, and 120 kg/ha) and the sub plots were occupied by three varieties (SAMMAZ 15, SAMMAZ 51 and TZE-EVDT99-W-STR). Each plot contains four rows and 3-meter long. The net plots are 3 × 1.5m which is 4.5 m^2. The prepared plots were sown with two maize seeds at a spacing of 75 cm x 25 cm, and seedlings were later thinned to one plant per stand. The N fertilizer rates were applied as per treatment plus 50 kg P_2O_5 and 50 kg K_2O. Data were collected on the following growth and yield characters; plant height, number of leaves, stem girth, leaf area, ear length, ear girth, number of grains per ear, weight of grains per ear, weight of grain per plot, weight of 100-grain and grain yield using standard procedures.

RESULTS AND DISCUSSION

The results showed that plant height, leaf area, stem girth and chlorophyll content of maize were increased with application of nitrogen upto the highest rate - 120 kg ha^{-1} (Tables 1 - 5). The successive increase with application could be due the importance nitrogen in plant growth especially in cell division and elongation. Similarly nitrogen has been reported as an essential component of chloroplast and therefore photosynthesis (Brandy, 1984). Maize yield response (Table 7) was significant at 100 kgNha^{-1} and further increase to 120 kgNha^{-1} did not result in yield response. The significant yield response at 100 kg N could be due to the effects of N in promoting plant growth which led to an increase in the final grain yield. Similar reports were made by Zeidan *et al.* (2006) and Kamara *et al.* (2020). However, at 120 kg N ha-^{1} yield was depressed probably because other nutrients were limiting particularly phosphorus as observed by Tofa *et al.* (2022) and N toxicity (Brandy, 1984). The lower value recorded at control attests to the lower N content of the soil. Several reporters have shown that savanna soil is inherently low in N. In Sudan Savannah of Nigeria, Alfisol & Inceptisols are the dominant soil types. These are characteristically low in organic matter, CEC and plant nutrients especially N and P. Low soil N is one of the most important abiotic factors limiting maize yield. The soil in Savanna is generally sandy with low water holding capacity (Lafitte and Banziger, 1997). The lack of significant response from 40-60 kg N ha^{-1} could be due to nutrient imbalance. Similar study in the Sudan savanna observed a higher maize response to N due to an increase in other nutrients like P and K as well as other micro-nutrient Soils in the Savanna are known to be poor in N and P, to some extentK in heavily deposited soils. Hence improvement of these nutrients most especially in combination has been reported to enhance the productivity of maize (Anon, 1998). Nitrogen and Phosphorus are the two most essential nutrients ensuring food production and security (Krouk and Kiba *et al.*, 2020).

The maize varieties recorded different growth characters. At 8 and 10WAS, SAMMAZ 15 had the tallest plants and higher number of leaves compared with other varieties. While for the other characters examined, the varieties were statistically similar. However, EVDT out yielded the other varieties. The superiority of EVDT could be because it is drought tolerant and *Striga* tolerant (Ashley, 1993; Ado *et al.*, 2005), and adapted to the Sudan savanna ecology. The variation observed among the maize varieties evaluated could be due to their genetic differences. Ladan and Hassan (2020) evaluated maize varieties and reported varied grain yields, which they attributed to different genetic composition among the varieties which could be affected by the environment. However, the similarity exhibited by some of the varieties could be because they were developed from similar parents and environment, and have become adapted over the years.

CONCLUSION

Based on the result of this experiment it could be concluded that the application of nitrogen fertilizer at 120 kg N ha^{-1}, gave the highest maize grain yield, thought statistically similar with 100 kg N ha-^{1}. Variety EVDT produced more yield than the other maize varieties evaluated. Therefore, for better grain yield, farmers in the study area should adopt the use of 100 kg N ha-^{1} which appeared more economical. Farmers in the study area should also adopt the use of EVDT for higher grain yield.

REFERENCES

Adams, O. (2018). Economic Analysis of Maize Production in Kano State. Economic, Agricultural and Food Sciences. *Journal of Poverty, Investment and Development*.

Adeboye, M. K. A., A Bala, A. O. Osunde, A. O. Uzoma, A. J. Odofin, B. A. Lawal (2011). Assessment of soil quality using soil organic carbon and total nitrogen and microbial properties in tropical agroecosystems. *Fertility_and_plant_nutrition*

Adediran, J.A., Banjoko, V.A. (1995). Response of maize to N, P, and K fertilizers in the savanna zone of Nigeria. *Communications in Soil Science and Plant Analysis 26(3): 593-606.*

Adediran, j. A, Akande, M. O., L. B and Sobulo, R. A (1999). Comparative effectiveness of organic based Fertilizers with mineral fertilizer on crop yield. *Soil science society Nigeria proceedings*. Pp91-95.

Adesike Oladoyin Kolawole (2023). Evaluation of the Relationship between Nitrogen Fertilization and Agronomic Performance of Maize (*Zea mays* L.) Varieties. Open Access *Journal of Agricultural Research*, ISSN: 2474-8846 Volume 8 Issue 4,

Anonymous, (1998). *Qualit*y protein Maize. Report on Ad Hoc panel of the advisory Committee on technology innovation board of science and technology for international development. *Notional Research Council, Washington D. D. U. S. A.*

Anonymous, 2000.” Fertilizer and their use “FAO, international industry Association, Rome. Pp:35-38.

El-gizawy, N. Kh. (2009). Effect of nitrogen rate and plant density on agronomic nitrogen efficiency and maize following wheat and Faba Bean. *Amerian-Eurasian J. Agric. And Environ. Science*. 5 (3): 378-386.

Hejazi, L. and A. Soleymani (2014). Effect of different amounts of nitrogen fertilizer on grain yield of forage corn cultivars in Isfahan. *International journal of Advanced Biological and Biomedical Research* Volume 2, Issue 3: 608-614.

Gordon, N. B. and Whitney (1993). Nitrogen Management in Furrow Irrigated Ridge Tilled Corn. *Journal of Production Agriculture*. 6:213-217.

Brandy, N. C, 1984. The nature and properties of soil. MacMillan publishing company, New York, Pp 152-158.

Brandy, N. C. And Weil. R. R (2002). **Nature and properties of soil**. Pearson Education Ltd.

Bundy, G. L., Carter, P. R., (1988). Corn hybrid response to nitrogen fertilization in northern corn belt. *Agricultural Journal*.1(2): 99-104.

Buresh, R. J., P. A. Senchez, and F. Calhoun (1997). Replenishing Soil Fertility in Africa. *SSSA Spec. Publ. 51. SSSA and ASA, Madison, WI*.

El-Sheikh FT. (1998). Effect of soil application of nitrogen and foliar application with manganese on grain yield and quality of maize (*Zea mays* L.) proc. 8th Conf. A*gronomy Suez Canal University. Ismailia, Egypt*. 28-29:174-181.

FAO, (2006). Food and Agricultural Organisation Statistics. Www.fao.org.

FAO. Production year book. Rome Italy; food and Agriculture Organisation of United Nations; 2014.

Haque, M. M., A Hamid and N. I Bhuiyan, (2001). Nutrients uptake and productivity as affected by nitrogen and Potassium application level in Maize /Sweet potato intercropping system Korean. *J. Crop Sci., 46(1): 1-5*

Ibrahim, A. K, Ahmed, U, and Girei, A. H (2022). Effect of NPK Fertilizer and Agrolyser on Growth, Yield and Yield Components of Maize in North Eastern Nigeria. *Ife Journal of Agriculture*, 34 (2):61-74

Ikenj, E., Amusa, N. A. and Obatolu, V. O. (2002). Nutrients Composition and weight evaluation of some newly developed Maize varieties in Nigeria. *Journal of food technology in Africa*.; 7(1); pp 25-28. Doi: 10.4314, jpta. V7:19325.

Kamara, A.Y., S.U. Ewansiha, A. Menkir, A.I. Tofa (2012). Agronomic response of drought-tolerant and Striga-resistant maize cultivars to nitrogen fertilization in the Nigerian Guinea savannas, *Maydica* 57 114–120.

Kamprath, E. J., R. H. Moll and N. Rodriquez 1982. Effect of nitrogen Fertilization and recurrent selection on performance of hybrid population of Corn *Agron. J*. 74:955-958.

Krouk, Gebriel and Takotorli Kiba(2020) Nitrogen and Phosphorus interaction in plants from agric physiology and molecular insights. *Current opinion plant biology*. Vol 57: 104-109.

Ladan, K. M. and A.H. Hassan (2020). Yield Performance of Three Maize (Zea Mays L.) Varieties As Influenced By Time Of Nitrogen Fertilizer Topdressing In Savannah Zone Of Nigeria. *Journal of Agriculture and Environment* Vol. 16 No. 2: 43-52.

Lafitte, H. R. & Bänziger, M. (1997). Maize population improvement for low soil N; Selection gains and the identification of secondary traits. In Developing Drought- and Low-N Tolerant Maize. *Proceedings of a Symposium El-Batan, Mexico, 25–29 Mar 1996*(E dsEdmeades, G. O., Bänziger, M., Mickelson, H. R. & Pena-Valdivia, C. B.), pp. 485–489.

Leila Hejazi, Ali Soleymani (2014). Effect of different amounts of nitrogen fertilizer on grain yield of forage corn cultivars in Isfahan *International journal of Advanced Biological and Biomedical Research* Volume 2, Issue 3, 2014: 608-614.

Oikeh, S.O., J. G. Kling, V. O chude and W. J. Horst, 1997. Yield and N-use efficiency of five tropical maize genotype under N levels in the moist Savanna of Nigeria. P. 163-167 Inj.

Mohammadi Aghdam, Sina, F. Yeganehpoor, B. Kahrariyan, E. Shabani (2014). Effect of Different Urea Levels on Yield and Yield Components of Corn 704. *International journal of Advanced Biological and Biomedical Research* Volume 2, Issue 2: 300-305.

Onasanya, R.O. O.P. Aiyelari, A. Onasanya, S. Oikeh, F.E. Nwilene and O.O. Oyelakin (2009). Growth and Yield Response of Maize (Zea mays L.) to Different Rates of

Nitrogen and Phosphorus Fertilizers in Southern Nigeria. *World Journal of Agricultural Sciences* 5 (4): 400-407.

Ranum, P, Rosas, J. P., Casal, M. N. (2014). Global maize production, utilization, and consumption. Annals of the New York Academy of Sciences, , 105-112. 20.

Roth, G. W. and Fox, R. H. (1990). Soil Nitrate Accumulation following Nitrogen fertilizer Corn in *Penny Environment Quuail* vol. 19 pp 243 – 248.

Shanti, K. V. P., M. R. Rao, M. S. Reddy and R. S. Sarma, (1997). Response of Maize (*Zea mays*) hybrid and composite to different levels of nitrogen. *Indian J. Agric. Sci., 67 424- 425.*

Sobulo, R. A. (1980). Nitrogen and Potassium Balance in Maize in the Humid Tropics: 311-375. In the Proceedings of International Conference on Nitrogen Cycling in West Africa‟s Ecosystems.

Tofa, I. A.,_ A. Y. Kamara, B. A. Babaji, B. J. Fatima (2022). Maize yield as affected by the interaction of fertilizer nitrogen and phosphorus in the Guinea savanna of Nigeria. *Heliyoh* 8 e11587.

Table 1. Effect of nitrogen level on plant height (cm) of maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	**Weeks After Sowing**			
	4	**6**	**8**	**10**
N- levels (kg ha^{-1})				
0	56.58	110.1	136.2b	139.4b
40	57.49	126.4	163.5a	164.3a
80	55.90	119.5	160.3a	162.3a
100	58.73	126.9	166.8a	168.4a
120	56.36	123.6	168.1a	170.6a
P value	0.955	0.389	0.004	0.004
SE ±	2.846	6.39	4.30	4.01
Varieties				
SAMMAZ 51	51.58b	106.4b	146.2b	148.7b
SAMMAZ 15	58.47a	127.3a	169.3a	170.6a
EVDT	61.05a	130.2a	161.4ab	163.4ab
P value	0.003	0.003	0.023	0.023
SE ±	1.727	4.57	5.49	5.21
Interaction				
N×V	0.620	0.867	0.939	0.965

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 2. Effect of nitrogen level on leaf area (cm^2) on maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	**Weeks After Sowing**			
	4	**6**	**8**	**10**
N- levels (kg ha^{-1})				
0	131.7	356.0	468.9	451.0b
40	138.4	423.6	523.0	516.0a
80	110.7	402.9	504.1	512.9a
100	149.6	449.1	548.3	550.8a
120	122.0	461.9	539.2	560.8a
P value	0.225	0.471	0.106	0.004
SE±	12.65	42.3	19.4	14.0
Varieties				
SAMMAZ 51	102.7b	358.9	511.7	5161
SAMMAZ 15	137.1a	473.7	507.6	498.8
EVDT	145.5a	423.6	530.8	540.0
P value	0.002	0.014	0.554	0.263
SE±	7.87	25.0	15.88	17.3
Interaction				
N×V	0.669	0.875	0.716	0.464

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 3. Effect of nitrogen level on leaves number on maize during 2023 raining season at BUK, Nigeria

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg ha^{-1})				
0	6.733	10.02	12.73	12.41
40	7.133	10.89	13.03	13.04
80	6.711	10.53	12.84	12.87
100	7.044	10.69	12.87	12.91
120	6.956	10.11	12.40	12.67
P value	0.849	0.230	0.519	0.556
SE+	0.3252	0.281	0.249	0.275
Varieties				
SAMMAZ 51	6.56.0b	9.75b	12.27b	12.43b
SAMMAZ 15	7.133a	10.99a	13.32a	13.22a
EVDT	7.053a	10.61a	12.73ab	12.69ab
P value	0.030	0.001	0.007	0.050
SE +	0.1517	0.210	0.209	0.216
Interaction				
N×V	0.844	0.806	0. 276	0.388

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 4. Effect of nitrogen on stem girth on maize varieties during 2023 raining season at BUK, Nigeria

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg ha^{-1})				
0	8.356	18.72	19.06b	15.77b
40	8.978	18.57	20.12a	19.73a
80	7.667	20.38	20.72a	19.49a
100	8.189	21.21	20.78a	20.39a
120	7.911	19.07	20.44a	19.98a
P value	0.080	0.489	0.028	0.028
SE+	0.283	1.191	0.319	0.756
Varieties				
SAMMAZ 51	7.260a	17.95	20.00	18.61
SAMMAZ 15	8.727b	20.43	20. 41	19.48
EVDT	8.673b	20.39	20.27	19.3
P value	<0.01	0.016	0.888	0.616
SE+	0.260	0.628	0.598	0.624
Interaction				
N×V	0.644	0.472	0.820	0.887

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 5. Effect of nitrogen on chlorophyll content on Maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	**Weeks After Sowing**			
	4	**6**	**8**	**10**
N- levels (kg ha^{-1})				
0	34.78	40.08b	33.17b	25.01b
40	34.67	45.67a	37.69ab	31.76ab
80	38.23	47.98a	44.17a	37.54a
100	40.06	47.68a	44.49a	32.63ab
120	36.79	45.99a	37.67ab	31.59a
P value	0.441	<0.01	0.016	0.018
SE±	2.253	0.700	1.99	1.88
Varieties				
SAMMAZ 51	35.57	44.99	41.87	32.10
SAMMAZ 15	37.55	44.89	37.53	33.32
EVDT	37.60	46.55	41.87	29.70
P value	0.449	0.558	0.270	0.533
SE±	1.269	1.204	1.87	2.29
Interaction				
N×V	0.507	0.528	0.068	0.395

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 6. Effect of nitrogen level on ear girth (mm), length (cm), number of grains per ear and weight of 100 grain weight (g) on maize varieties. During 2023 raining season at BUK, Nigeria.

Treatment	Ear girth	Ear length	number of grains per ear	100 grain weight
N-levels(kg ha^{-1})				
0	10.51	10.49	204.2	19.32
40	11.36	12.27	238.2	16.66
80	11.22	12.51	246.7	15.01
100	11.79	12.69	305.3	17.81
120	11.26	11.99	215.9	19.98
P value	0.173	0.231	0.137	0.153
SE±	0.317	0663	25.4	1.340
Varieties				
SAMMAZ 51	11.03	11.77	241.4	16.42
SAMMAZ 15	11.23	11.97	240.9	17.77
EVDT	11.42	12.23	243.9	19.07
P value	0.637	0.784	0.993	0.211
SE±	0.258	0.458	19.1	1.023
Interaction				
N×V	0. 748	0.527	0.499	0.776

Table 7. Effects of nitrogen on weight of grain per ear (g) and weight of grain per plot (kg) of maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	Weight of grain per ear (g)	Yield per hectare (kg)
N levels (kg ha^{-1})		
0	34.03	318c
40	38.04	1052b
80	36.46	970b
100	47.58	1657a
120	36.13	1692a
P value	0.426	<.001
SE ±	5.09	170.4
Varieties		
SAMMAZ 51	34.33	824b
SAMMAZ 15	39.85	765b
EVDT	41.16	1824a
SE ±	3.85	89.59
P value	0.428	0.002
Interaction	0.615	0.067
N×V		

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

EFFECT OF DIFFERENT LEVELS OF NPK 15: 15: 15 FERTILIZER AND RATES OF POULTRY MANURE ON THE GROWTH, YIELD AND QUALITY OF OKRA (*Abelmoschus esculentus* L. Moench) VARIETIES IN SUDAN SAVANNAH OF NIGERIA

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ABSTRACT

The experiment was conducted during 2023/2024 dry season at Teaching and Research Farm of the Binyaminu Usman Polytechnic Hadejia Jigawa state (old campus) (12°145'2.49" N 8°86'22.14" E). The mean annual temperature ranges from 27°C to 38°C and the soil is silty loam and Zakirai farm in Gabasawa Local Government Kano State 11^0 $86^'$ North latitude, and 9^0 $01^'$ East and 430 meters above sea level. The mean annual temperature range is 27 to 30.6^{0}C and soil type is sandy – loam. The two locations are located in the Nigerian Sudan Savanna agro-ecological zone. The treatments consisted of three varieties of okra (Nhar47-4, Clemson Spineless and Yarballe), three levels of NPK 15:15:15 fertilizer (0, 9 and 120kg/ha^{-1}) three rates of poultry manure (0, 4 and, 6t/ha^{-1}). The treatment were laid out in a Split Split Plots Design and replicated three times. Data were collected on growth parameters and yield component (Plant height, number of branches and number of fruits per plant). Results obtained indicated that the improved varieties (Nhar47-4 and Clemson spineless) performed better than Yarballe (local variety). Application of poultry manure at rate of 6 and 4t/ha significantly influenced better growth and development of okra compared to 0kg/ha (control). Level of NPK 15: 15;15 fertilizer at 120kg/ha supplied adequate nutrients which increased growth followed by 90kg/ha and control recorded lowest in the study area.

Keywords: Okra, Growth, Yield, quality, Poultry Manure, NPK 15:15:15 Fertilizer

INTRODUCTION

Okra (*Abelmoschus spp*, (L) Moench), is very important vegetable crop in tropical and sub-tropical regions ((Sanni *et al.,* 2023). The crop is a dicotyledonous plant, of the family *Malvaceae* which comprises a number of species including other foods, fibre, and medicinal crops such as cotton and kenaf (Sanni *et al.*, 2023). Okra is a perennial often cultivated as annual in temperate climates and often grows to around 2m tall. It is related to such species as cotton, cocoa and hibiscus (Zubairu and Gaya, 2022). It is one of the oldest cultivated crops and presently grown in many countries and is widely distributed in Asia, Africa, Southern Europe and America ((Sanni *et al.*, 2023). It is a good source of minerals, calories and amino acid found in seeds and compared favorably with those in poultry, egg and soybean (Zubairu and Gaya.; 2022). Okra can be eaten grated raw or cooked. The seeds of okra have been used as coffee substitute and edible oil could also be extracted from dried okra seeds. The amino acid profile of the seed indicates that it could be used to complement other partially complete protein sources such as soybean. Apart from its nutritive value, matured fruits and stems containing crude fiber are used in paper industry (Ibrahim *et al.*, 2022).

Okra pod is a common ingredient of soups and sauces, and fresh fruits are conserved by drying. The leaves are sometimes used as a substitute for spinach (Fakai**;** *et al.*, 2022). It is produced and consumed all over Nigeria for the mucilaginous property of the fruit that aids easy consumption of the staple food (cassava flour, yam flour, maize flour, rice and pounded yam) (Fakai**,** *et al.*, 2022).

In Nigeria the limiting factors in okra production and other vegetables among others include fertile soils (organic and inorganic fertilizer), tillage practices, low yielding varieties and sub-optimal planting density (Iyagba *et al.,* 2016). A number of researchers have shown that inorganic fertilizers have deleterious effects on the soil environment, which has made it a necessity for organic sources like poultry litter and poultry manure for soil amendment more popular in recent times (Sanni *et al.*, 2023).

Poultry manure is an efficient organic fertilizer and also an important source of plant nutrient, its addition improves the physical properties of the soil (Bayu *et al.*, 2006). Its average nutrient content is 3.03 % N, 2.63 % $P_2O_5$and 1.4 % K_2O. It has been reported that 30% of nitrogen from poultry litter is in urea or ammonium form and hence readily available (Sunassce, 2001). Poultry manure also increased soil organic matter, nitrogen, pH, phosphorous and cation exchange capacity (Adeniyan, 2003). Poultry manure has a fairly high nutrient composition when compared with other sources of animal manure. Poultry manure is a good source of major mineral elements that are capable of enhancing soil fertility (Dauda.; *et al.* 2005).

Inorganic fertilizers are synthetic, chemical, artificial material added to the soils that supply one or more required materials for plant growth. Inorganic fertilizers are one of the major inputs in crop production. They play a vital role in the improvement of soil fertility and enhancement of crop growth and yields. Fertilizer application to crops is a necessary condition for good yield of crops in Nigeria due to inherent low fertility status of the soils, particularly in the savannah regions the stability of production depends on replenishing nutrients removed from the soil by crops, maintaining desirable physical condition of the soil, preventing an increase in soil acidity and toxic elements and minimizing or preventing erosion, use of fertilizers is reported to be responsible for over 50% yield increase in crops (Babatola, 2006).

The approximate nutrient content of the edible fresh pod is as follows: water, 88%; protein, 2.1%; fat, 0.2%; carbohydrate, 8.0%; fibre, 1.7% and ash, 0.2% (Adeyemi *et al.,* 2008). However, the nutritional quality of okra can be influenced by the application of organic or inorganic fertilizers, such as cow dung, droppings of sheep and goat, slaughter house wastes and poultry drop or NPK fertilizer. The oil content in the seeds could be as high as that in poultry eggs and soybeans (Kolawole *et al.*, 2008).

MATERIAL AND METHODS

Experimental Sites

The experiment was conducted during 2023/2024 dry season at Teaching and Research Farm of the Binyaminu Usman Polytechnic Hadejia Jigawa state (old campus) (12°145'2.49" N 8°86'22.14" E) The mean annual temperature ranges from 27°C to 38°C and the soil is silty loam and Zakirai farm in Gabasawa Local Government Kano State 11^0 $86^'$ North latitude, and 9^0 $01^'$ East and 430 meters above sea level. The mean annual temperature is between 27^0C to 30.6^0C and soil type is sandy – loam. The two locations are located in the Nigerian Sudan Savanna agro-ecological zone.

Treatment and Experimental Design

The treatments consisted of three varieties of okra (Nhar47-4, Clemson Spineless and Yarballe local), three levels of inorganic fertilizer at 90kg/ha^{-1} (36g/plot), 120kg/ha^{-1} (48g/plot) and 0kg/ha^{-1} (0g/plot) three rates of poultry manure 4t/ha^{-1} (3.6kg/plot), 6t/ha^{-1} (5.4kg/plot) and 0t/ha^{-1} (control). The treatment was laid out in a Split Split Plots Design and was replicated three times.

Data Collection

Data was collected for the following characters of five plants were sampled from the sampling rows each plot and these five plants were tagged for observation on growth parameters and yield component of the crop.

RESULTS AND DISCUSSION

Plant Height

Plant height of okra as affected by the treatments is presented in Table 1. The results showed that plant height at Zakirai was significantly affected by the variety. At 4th and 8th WAS variety Nhar47-4 outperformed the other varieties with (12.53a) and (27.07a), followed by Clemson spineless (12.24b) and (26,91b), however at 6WAS Nhar47-4 and Clemson spineless varieties were statistically ranked similar with (17.16a and 17,03a) the lowest plant height was recorded with the local variety (Yarballe) at both locations of the experiment. At Hadejia similar result was recorded at 4th and 6th WAS Nhar47-4 variety were statistically higher with (12.21a) and (16.56a) while Clemson spineless recorded second (12.13b) and (15.08b). However, at 8th WAS the result shows no significant difference between the two improved varieties was statistically produced similar rank (26.52a) and (26.48a) respectively. The lowest plant height was recorded with the local variety (Yarballe) at location of the experiment. Moreover the results show that plant height of okra was affected significantly by poultry manure at all the sampling period and locations of the experiment. At Zakirai Plant treated with 6t/ha produces the highest plant height at 4, 6, and 8 WAS, followed by 4 t/ha. Similar trend was observed at Hadejia in 4 and 8WAS, while at 6WAS 4t/ha and 6t/ha were statistically ranked same. The lowest plant height was recorded with the control.

Similar trend was also observed with NPK fertilizer treatments the effect levels of NPK 15: 15: 15 fertilizer on plant height during 2023/2024 dry season at Zakirai and Hadejia affected at two locations across 4, 6 and 8 WAS. Application of different levels of NPK fertilizer 90kg/ha (36g/p), 120kg/ha (48g/plot) and 0kg/ha (control) had a significant ($P \leq 0.05$) level of NPK fertilizer at 120kg ha^{-1}produced tallest plant across 4, 6 and 8 WAS at Zakirai location and 4, 8WAS at Hadejia while at 6WAS 4t/ha and 6t/ha were statistically ranked same , followed by 90kg/ha while the shortest mean value of plant height was recorded from the 0kg/ha control which resulted in statistically shorter plant.

Number of Branches

Number of branches of okra as affected by the treatments is presented in Table 7. The results show that Number of branches at Zakirai was significantly affected by the variety. At 4th and 6th WAS variety Nhar47-4 and Clemson spineless statistically ranked same (3.91a, 3.87a) and (5.21a, 5.19a) was recorded. At 8th WAS, Nhar47-4 variety outperformed Clemson spineless variety 5.65a and 5,61b while yarballe was recorded with lowest number of branches 5.27c. While at Hadejia in 4th WAS Nhar47-4 has outperformed Clemson spineless 3.84a, 3.79b, however Nhar47-4 and Clemson spineless similar result was recorded at 6th WAS which plant statistically ranked same 4.19a and 4.18a . However, at 4th and 6th WAS the result show no significant difference between the two improved varieties at Zakirai and 6th and 8th WAS at Hadejia respectively. The lowest number of branches was recorded with the local variety (Yarballe) at both location of the experiment.

Moreover the results show that number of branches of okra was affected significantly by poultry manure at all the sampling period and two locations of the experiment. Plant treated with 6t/ha produces the highest number of branches followed by 4 t/ha. While the lowest number of branches was recorded with the control.

Similar trend was also observed with NPK fertilizer treatments the effect levels of NPK 15: 15: 15 fertilizer on number of branches at Zakirai and Hadejia were effected at two locations across 4, 6 and 8 WAS. Application of different levels of NPK fertilizer 90kg/ha (36g/p), 120kg/ha

(48g/plot) and 0kg/ha (control) was a significant (P≤ 0.05) level of NPK fertilizer at 120kg ha^{-1}produced highest number branches across 4, 6 and 8 WAS at both two locations, followed by 90kg/ha while the smallest mean value of number branches was recorded from the 0kg/ha control which resulted in statistically smallest mean value of number branches.

Number of fruits per plant

The effect of levels of NPK fertilizer, rates of poultry manure and quality of okra varieties on number of fruits per plots during 2023/2024 dry season at Zakiari and Hadejia, is presented on Table 32. At Zakirai 9WAS number of fruits per plots were recorded significant effect between three varieties; Nhar47-4 is significantly highest with (30.32a) than Clemson spineless with (29.29b) while Yarballe variety recorded lowest number of fruits per plots with (26.23c). While at Hadejia there were no significant difference in number of fruits per plots in two varieties Nhar47-4 and Clemson spineless which statistically ranked similar with (30.18a and 29.18a) while local variety Yarballe recorded lowest number of fruits per plots with (26.13b). Different rates Poultry manure had significant (P≤0.05) effect on the number fruit per plot across the locations. There were no significant influences among the rates of poultry manure over the 4t/ha and 6t/ha which ranked similar at both locations while 0t/ha (control) on number of fruits per plot at two experimental sites resulted least number of fruits per plant (27.56 and 27.42) respectively. Significant effect of NPK 15: 15: 15 fertilizer was however observed on the number of fruit per plot in 2023/2024 dry season at 9 WAS at all the sampling period and locations of the experiment. Number of fruit per plot was however significantly influenced by different levels of NPK 15: 15:15 fertilizer with 120kg/ha, 90kg/ha and 0kg/ha. At Zzakirai and Hadejia experimental locations 120kg/ha (48g/plot) consistently in two locations produced heights number of fruit per plot and statistically ranked similar in all the sampling periods with (30.79a and 30.27a) than followed by 90kg/ha (36g/plot) with (28.77b and 28.58b) while the lowest fruit per plot in two experimental locations were recorded from 0kg/ha 0g/plot with (26.39c and 26.31c). There was no significant interaction observed between factors studied in both characters.

At 10WAS (second harvest) at zakirai there was significant difference among the three varieties, Nhar47-4 variety is significantly highest with (31.33a) than Clemson spineless which recorded second with (30.34b) while yarballe variety recorded lowest number of fruits per plots with (27.51c). At Hadejia similar trend was recorded in varieties, Nhar47-4 variety is significantly highest with (31.12a) than Clemson spineless which recorded with (30.25b) while Yarballe variety recorded lowest means value in number of fruits per plots with (27.32c). Moreover the results showed that number of fruits per plots of okra was not affected significantly by levels of poultry manure in 10WAS at Zakirai all the sampling period at location of the experiment, Plant treated with 4t/ha and 6t/ha statistically ranked similar number of fruits per plots with (30.12a and 30.32a)). While the lowest number of fruits per plots was recorded with the 0kg/ha (control) at 10 WAS with (28.74b). At Hadejia 6t/ha is significantly highest with (30.22a) than 4t/ha which recorded second with (29.98b) while control recorded lowest number of fruits per plots with (28.49c). Significant effect of NPK fertilizer however was observed on the number of fruit per plot at 10 WAS. Number of fruit per plot was however significantly influenced by different levels of NPK fertilizer with 120kg/ha, 90kg/ha and 0kg/ha. At Zzakirai and Hadejia experimental locations 120kg/ha consistently in two locations produced heights number of fruit per plot and statistically ranked similar in all the sampling periods with (32.27a and 32.01a) than followed by 90kg/ha with (29.61b and 29.49b) while the lowest fruit per plot in two experimental locations were recorded from 0kg/ha with (27.30c and 27.19c).

DISCUSSION

Significant effect was observed at both locations between varieties on plant height. At 4 and 8WAS in Zakirai Nhar47-4 significantly produced high plant height same trend was observed in Hadejia at 4 and 6WAS. The results obtained in this study is supported by the findings of (Ibrahim *et al*.,2020), where significant differences were observed between LD88 and NHAe47-4 regarding vegetative parameters like plant height. The significance observed could be as a result of differences in genetic make-up of the cultivars as reported by (Elhag *et al*., 2014) who observed significant among okra genotypes in their previous study. However at 6WAS in zakirai and 8WAS in Hadejia the result shows no significant difference between two improved varieties was statistically produced similar rank. Anyaoha *et al*., (2023) and Osawaru *et al.,* (2013) reported similarities and morphological differences between accessions. The growth parameters evaluated also indicated that at least two or more cultivars have similar growth rate which may be due to the parental lines used to develop them. On the hand the differences observed among the three varieties could be attributed to their genetic make-up. Ayoub and Afra (2014) affirmed that differential growth of crops under similar environment condition is normally the result of difference in the genetic-up of these crops.

The significant increase in plant height and number of branches as a result of the application of poultry manure across the two experimental locations may be attributed to the beneficial role of poultry manure in enhancing soil nitrogen, phosphorus, potassium and other essential nutrients which in turn improved growth and development of the plants across the locations. The result is in consonance with finding of (Mahadi *et a.; l*2013) that, poultry manure provide an excellent source of organic matter, restoring some organic matter depleted by many agricultural activities as well as improving the structure of the soil.

A significant response in fruit yield (kg ha^{-1}) to poultry manure were observed in both trials, and this could be attributed to the fact that the environment of locations were homogenous and there were an evenly distribution of water at the later stage of the trials by irrigation. The results agreement with the findings of (Nehra *et al.;* 2001) and (Sanwal.; *et al*. 2007) whore ported that higher yield response due to organic manure is ascribed to the movement in physical and biological properties of soil resulted in better supply of nutrients that led to good crop yield. The reason for increase in yield could also be attributed to the solubilization effect of the major essential nutrients with addition of poultry manure thereby resulting to increased uptake of N. P and K (Sendurkunaran.; *et al*., 1998).

The significant response of growth components such as plant height and number of branches in both trials could be attributed to the role of applied NPK to the plants during the trials, which were essential in plant growth and development. This is supported by the findings of (Smith.; *et al.* 2001) who reported that the use of NPK under good environmental conditions significantly influenced the growth and fruit yield of okra. This also agrees with the findings of Adediran and Banjoko (2003) which showed that application of these nutrients (N, P and K) is important for enhanced fruit number and yield of okra. Another study has shown that the application of N and or NPK led to significant increase in the growth and yield of okra (Katung *et al*., 1996).

CONCLUSION

Based on the finding from the this study it can be concluded that Nhar47-4 and Clemson spineless improved varieties that performed better than Yarballe local variety, application of poultry manure at rate of 6t/ha and 4t/ha significantly influence better growth and development of okra compared to 0kg/ha (control). Level of NPK 15: 15: 15 fertilizer at 120kg/ha supplied adequate nutrients which increased its growth followed by 90kg/ha and control recorded lowest in the study area.

REFERENCES

Adeniyan, O. N. Ojeniyi,S. O. (2023). Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. *Moor Journal of Agricultural Research***2**:191 -197.

Adeyemi, O.R., Smith, M.A. K. and Ojeniyi, S.O. (2008). Effect of land preparation techniques on weed control effectiveness in okra (*Abelmoschus esculentus* L.) Moench. Nigerian *Journal of Weed Science*21:72-83.

Akintunde, B. (2000): Growth and yield response of okra (*Abelmoschus esulentus* (L.) Moench) to NPK fertilizer rates and weed interference in South-eastern Nigeria. *International Research Journal of Agricultural Science and Soil Science* 3:328-3

Anyaoha C. O., Arogundade O., Akinkunmi O. Y., Okoyo M. E. and Ikoro J. I. (2023). Agro-morphological characterization of Okra (Abelmoschus species) for biotic stress and yield contributing traits under rainfed conditions in South Western Nigeria. *Plant Physiology Reports*. Atchison farmers' Market. Featured Speciality Crop-Okra. 2018.

Ayoub, Z. E. and Afra, A. A. (2014) Effect of cultivar and sowing date on okra (*Abelmoschus esculentus* (L) Moench) seed yield: *Universal Journal of Applied Science* 2: 64-67.

Babatola L.A. (2006). Effects of NPK 15:15:15 fertilizer on the performance and storage of okra (*Abelmoschus esculentus*). Proceedings of the Horticultural Society of Nigeria Conference. Pp: 125-128.

Dauda, S. N., L. Aliyu., U. F. Chiezey, (2005) Effect of seedling age at transplant and poultry manure on fruit yield and nutrients of garden egg (S. gilo L) Varieties. *J. Trop. Sci.* **5**:38-48.

Elhag, A. Z., and Ahmed, A. A. (2014). Effect of cultivar and sowing date on Okra (*Abelmoschus esculentus* L. Moench.) seed yield. *Universal Journal of Applied Science*. 2(3): 64-67.FAOSTAT Database 2019. Okra world production statistics

Fakai, A. U. Sanda, H. Y., and Khadija, U. Z. (2022) growth and yield of okra (*abelmoschus esculentus* [l.] moench) varieties as influence by sole and combined organic and inorganic fertilization *proceedings of 40th annual conference of hortson* ISBN: 978-978-794-197-3, *(pp. 281-287)*

Ibrahim, I.S., 1Ishaka, A., 2Kyari, I.U, 1Adamu, A. and 2Usman, A. (2022), effects of different levels of poultry droppings on growth and yield of okra (*abelmoschus esculentus* (l.) *proceedings of 40th annual conference of HORTSON* ISBN: 978-978-794-197-3, *(pp. 149-154)*

Ibrahim, H., Aniyikaye, R., Adewoyin, D. T. E., Osunde A. O., Bala, A. (2020). Effect of different combinations of organic and inorganic nitrogen sources on growth and pod yield of Okra (Abelmoschus esculentus) in Minna, Niger State. *Proceedings of the 44th conference of the soil science society of Nigeria* Colloquia series: 243-248 Resources, IBPGR (1984).

Iyagba A.G., Onuegbu B.A. and Ibe A.O. (2016). Growth and yield response of okra (*Abelmoschus esculentus* (L.) Moench varieties to weed interference in South- Eastern Nigeria. *Global Journal of ScienceFrontier Research* (D.).**12**(8): 19-27.

Kolawole G.O, Olapede A.O, Alade C.R, Olaniyi J.O (2008). Response of okra (*Abelmoschus esculentus*) varieties to NPK fertilizer in the South Guinea Savanna of Nigeria. Niger. *Journal of Horticult. Sci*. 13: 99-108.

Mahadi, M.A. Dadari, S.A. Tanimu, B. Kuchinda, N.C. Sharifai A.I. and Bature M.S. (2013).Effects of Weed Control and Cow Dung Manure on Growth Performance of Quality Protein Maize in Samaru, Zaria, Nigeria. *Nigerian Journal of Basic and Applied Science* 21(2): 85-95.

Sanni, K. O., Godonu, K. G., Adenubi, O. O. Oduntan, A. O. Abdulrasak, L. Y Bello, A. A., and Oladega L. A. (2023) influence of poultry litter biochar and poulrty manure on the performance and antioxidant of okra (*abelmoschus spp*, (l) moench) *proceedings of 41st annual conference of HORTSON, (pp. 206-209)*

Sendurkunaran, P., Singh, P. and Yadav, R. L. (1998) Effect of organic manures and nitrogen levels on growth, yield and quality of okra. *Indian Journal of Horticulture* 63: 215-217

Smith, I. J., Samnotra, R. K., Kumar, V., Rai, A. P. and Dhotra, B. (2001) Effect of organic and inorganic fertilizers on the growth and yield of okra under subtropical region. *Ann Plant and Soil Res*17: 215-218.

Table 1: Plant height (cm) as affected by different levels of NPK 15:15:15 fertilizer and rates of Poultry manure on Okra varieties in Zakirai and Hadejia 2023/2024 dry season.

	Plant height (cm)					
	Zakirai			Hadejia		
Treatments	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
Variety						
Nhar47-4	12.53a	17.16a	27.07a	12.21a	16.56a	26.52a
Clemson spineless	12.24b	17.03a	26.91b	12.13b	15.08b	26.48a
Yarballe (local variety	12.05c	16.49b	26.01c	12.01c	14.64c	26.15b
p-Value	<.001	<.001	<.001	<.001	0.178	<.001
SE±	0.04	0.04	0.03	0.01	0.74	0.02
Poultry Manure (t ha^{-1})						
4	12.29b	16.86b	26.52 b	12.16b	16.58a	26. 24b
6	12.79a	18.28a	27.93a	12.58a	17.29a	27.31a
0	11.74c	15.54c	25.81c	11.60c	13.42b	25.32c
p-value	<.001	<.001	<.001	<.001	0.008	<.001
SE±	0.03	0.03	0.06	0.01	0.75	0.02
NPK (15:15:15 kg ha^{-1})						
90	12.59b	17.11b	26.51b	12.41b	16.04a	26.49b
120	12.89a	19.19a	29.26a	12.63a	17.15a	27.92a
0	11.34c	14.39c	24.73c	11.30c	13.10b	24.24c
p-value	<.001	<.001	<.001	<.001	0.001	<.001
SE±	0.03	0.02	0.03	0.02	0.74	0.02
Interactions						
N x V	0.2666	<.001	<.001	0.026	0.448	<.001
N x P	<.0001	<.001	<.001	<.001	0.287	<.001
P x V	<.0001	0.002	<.001	0.096	0.401	<.001
N x P x V	0.6985	<.001	<.001	0.462	0.461	<.001

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using DMRT.

Table 2: Number of Branches as affected by different levels of NPK 15:15:15 fertilizer and rates of poultry manure on okra varieties in Zakirai and Hadejia 2023/2024 dry season.

	Number of branches					
	Zakirai			Hadejia		
Treatments	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
Variety						
Nhar47-4	3.91a	5.21a	5.65a	3.84a	4.19a	5.17
Clemson spineless	3.87a	5.19a	5.61b	3.79b	4.18a	5.16
Yar balle (local variety	3.78b	5.04b	5.27c	3.68c	4.04b	5.09
p-Value	<.001	<.001	<.001	<.001	<.001	0.190
SE±	0.01	0.01	0.004	0.01	0.01	0.02
Poultry Manure (t ha^{-1})						
4	3.86b	5.25b	5.49b	3.77b	4.19b	5.06b
6	4.03a	5.61a	5.90a	3.95a	4.36a	5.59a
0	3.67c	4.58c	5.15c	3.59c	3.86c	4.78c
p-Value	<.001	<.001	<.001	<.001	<.001	<.001
SE±	0.02	0.01	0.01	0.01	0.01	0.04
NPK (15:15:15 kg ha^{-1})						
90	3.80b	5.15b	5.49b	3.79b	4.09b	5.15b
120	4.20a	5.85a	6.24a	4.04a	4.59a	5.93a
0	3.55c	4.44c	4.81c	3.48c	3.73c	4.35c
p-value	<.001	<.001	<.001	<.001	<.001	<.001
SE±	0.02	0.01	0.01	0.01	0.01	0.06
Interactions						
N x V	0.08	0.007	<.001	0.229	0.017	0.687
N x P	<.001	<.001	<.001	<.001	<.001	<.001
P x V	0.673	<.001	0.149	0.190	0.002	0.777
N x P x V	0.863	<.001	<.001	0.027	0.005	0.898

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using DMRT. NS = Not Significant * = Significant at 5% probability level ** =Significant at 1% probability level

Table 3: Number of fruits per plants at 9WAS and 10WAS as affected by different levels of NPK 15:15:15 fertilizer and rates of poultry manure on okra varieties in Zakirai and Hadejia 2023/2024 dry Season

Number of fruits per plants (9 and 10WAS)

	Zakirai		Hadejia	
Treatments	9WAS	10WAS	9WAS	10WAS
Variety				
Nhar47-4	30.32a	31.33a	30.18a	31.12a
Clemson spineless	29.39b	30.34b	29.18a	30.25b
Yarballe(local variety	26.23c	27.51c	26.13b	27.32c
p-value	<.001	<.001	<.001	<.001
SE±	0.03	0.08	0.22	0.02
Poultry Manure (t ha^{-1})				
4	29.06a	30.12a	29.06a	29.98b
6	29.11a	30.32a	28.99a	30.22a
0	27.56b	28.74b	27.42b	28.49c
p-value	<.001	<.001	<.001	<.001
SE±	0.03	0.08	0.23	0.02
NPK (15:15:15 kg ha^{-1})				
90	28.77b	29.61b	28.58b	29.49b
120	30.79a	32.27a	30.62a	32.01a
0	26.39c	27.30c	26.31c	27.19c
p-value	<.001	<.001	<.001	<.001
SE±	0.03	0.09	0.22	0.02
Interactions				
N x V	<.001	0.005	0.126	<.001
N x P	<.001	<.001	0.015	<.001
P x V	0.008	0.463	0.652	<.001
N x P x V	<.001	<.001	0.156	<.001

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using DMRT.

INFLUENCE OF PLANT DENSITY AND NUTRIENT SOURCES ON THE GROWTH AND YIELD OF MILLET (*Panicum milliaceum*) IN SUDAN SAVANNA OF BAUCHI STATE, NIGERIA

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ABSTRACT

The field experiment was conducted to study the effect of spacing and nutrient sources on the growth and yield of millet in Bidir village, Katagum local government area of Bauchi state (11^0 50'08" N 10^0 10'02" E) during the rainy season of 2023. The treatments consisted of three spacing (50x75, 75x75 and 100x75cm), three nutrient sources (NPK, Poultry manure, Cow dung and control). These were factorially combined to give twelve treatments combinations and laid out in a randomized complete block design (RCBD) with three replications. The results of the experiment indicated that, there was a significant (P<0.05) difference among the treatments used throughout the study period. The results further revealed that, growing millet at wider spacing (75x75 and 100x75 cm) with the application of poultry manure and NPK was found to be significantly (P<0.05) better than the other treatments and all the treatments were better than control in all the parameters observed. Based on the finding of this study, planting millet at a spacing of 75x75 cm with application of poultry manure stimulates the growth and yield of millet. Growing millet at a spacing of 75 x 75 cm intra and inter row spacing with application of poultry manure at a rate of 5 t/ha is recommended for farmers in the study area for sustainable millet production.

Key words: cowdung, millet, nutrients, poultry manure, spacing

INTRODUCTION

Millet (*panicum milliaceum)* originated from the highlands of Ethiopia and is presently grown in eastern and southern Africa (Mengistu and Yamoah, 2012). It is an important crop in eastern and southern Africa where small-scale farmers grow it in low input farming systems (Alkass *et al*., 2010). The crop has food security, nutritional, cultural, medicinal, and economic value with high industrial potential (Basavaraj *at al*., 2011). It was found to adapt better on poor soils, erratic rain and droughts than main food grains like maize and wheat (Chakraborty and Newton, 2011). While its production has been declining, there is still a significant demand for the crop and millet price has been much higher than other cereals in the past few years (Firoz *et al*., 2010). Interestingly, new food products made from millet are also becoming popular among younger people, including noodles, pasta, vermicelli, snacks, and different bakery products (Titonell *et al*., 2003). The crop is of higher nutritional value especially to pregnant women and weaning children and its seeds can be stored for more than five years due to low vulnerability to insect damage. It provides food security for poor farmers

(Rincon *et al*., 2008). The study is therefore carried out to determine the most effective inter and intra raw spacing and the best nutrient source for the production of millet in the study area.

MATERIALS AND METHODS

The experiment was conducted to study the effect of spacing and nutrient sources on the growth and yield of millet in Bidir village, Katagum local government area of Bauchi state during the rainy season of 2023. The Bidir village is located at 11^0 50'08" N 10^0 10'02" E. The treatments consisted of three spacing (50x75, 75x75 and 100x75cm), three nutrient sources (NPK, Poultry manure and Cow dung) and a control. These were factorially combined to give twelve treatments and laid out in a randomized complete block design (RCBD) with three replications. The millet seed (Super SOSAT Variety) was obtained from Bauchi state Agriculture Development program (BSADP) zonal office Azare in order to have a recommended and certified seed variety. Data on growth parameters were collected at bi-weekly interval, while that of yield parameters at harvest from five randomly tagged plants on: plant height, leaf area, 1000 grain weight and grain yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted in separation of the means.

RESULTS AND DISCUSSION

Plant Height

Table 1 presented result on the effects of spacing and nutrient sources on plant height of millet. The result as presented in table 1 revealed a significant ($P<0.05$) difference among the treatments used throughout the study period. The results further showed that, except at 2 and 4WAS where no significant ($P<0.05$) difference was observed, planting millet at a spacing of 100 x 75cm was found to produced statistically ($P<0.05$) the tallest plants than the other spacing used. The results further indicated that, growing millet with the application of poultry manure was found to significantly ($P<0.05$) produced taller plants than the other nutrients sources and all the nutrient sources were better than the control throughout the study period. The interaction between spacing and nutrient source on plant (Table 2) revealed that, growing millet at a spacing of 50 x 75cm and 75 x 75cm with the application of poultry manure produced significantly ($P<0.05$) the tallest plants than the other treatments combination used. The significant difference observed in this study indicated the importance of organic fertilizer in millet production. The increase in plant height as a result of poultry manure application could be due to availability of plant nutrients released by poultry manure. The results of this study is in agreement with the report of Agber *et al*. (2012) who reported that, fertilizer application increases the plant height of crop plants. The results of this findings also lend support from the report of Shuaibu *et al*. (2022) that, difference on plant height might be related to the effect of nitrogen which promotes vegetative growth of plant. On the various spacing used however, the results indicated that, growing millet at a spacing of 75 x 75 cm produced the tallest plants. The significant increase in plant height observed proved the influence of plant density on plant height of millet. The result of this findings corroborates the report of Bationo *et al*. (2010) who affirmed that, plant height and stem girth of millet shows a significant response to plant population. It is also in conformity with the result of Roy and Isah *et al*. (2020) who reported a similar trend while studying spacing in Groundnut production.

Leaf Area (cm)

Table 3 presented results on the effects of spacing and nutrient sources on leaf area of millet. The result revealed a significant ($P<0.05$) difference among the treatments used throughout the study period. The results further showed that, no significant ($P<0.05$) difference over planting millet at different spacing except at 2WAS were significant ($P<0.05$) difference was observed. The results further indicated that, growing millet with the application of poultry manure was found to significantly ($P<0.05$) produced wider leaves than the other nutrients sources and all the nutrient sources were better than the control throughout the study period. The interaction between spacing and nutrient source on leaf area (Table 4) revealed that, growing millet at a spacing of 75x75cm with the application of poultry manure produced significantly ($P<0.05$) the higher leaf area than the other treatments combinations used. Control plot on the other hand, irrespective of the spacing produced the narrow leaf area. The significant difference observed could be due to plants competition to absorb sunlight and the availability of nutrients. The results of this study is in conformity with that of Debiase *et al*. (2016) who reported that adequate soil nutrient enhances many aspects of plant physiology like fundamental process of photosynthesis, flowering, seed formation and maturation. It is also in support of the findings of Firoz *et al.* (2010) who found that phosphorus plays an important part in many physiological processes that occur within a developing and maturing plant, it is involved in enzymatic reactions in the plant and it also hastens the ripening of fruits.

1000 Grain Weight

Table 5 presented the results on the effects of spacing and nutrient sources on 1000 grain weight of millet. The results revealed a significant (P<0.05) difference among the treatments used.. The results indicated that, spacing had no significant (P<0.05) effect on grain weight of millet. The results of this study is not in conformity with the findings of Debiase *et al.* (2016) who reported that optimum plant density promotes grain weight. The results further indicated that, growing millet with the application of poultry manure and NPK was found to significantly (P<0.05) produced higher 1000 grain weight than the use of cow dung which was better than the control. This indicated the importance balanced nutrition to grain weight of millet. The results of this findings lend support from the report of Blanchet *et al*. (2016) who stated that application of fertilizer gradually increased plant height, stem diameter, number of leaves per plant, leaf area per plant and grain weight.

Grain Yield (kg/ha)

Table 5 presented the results on the effects of spacing and nutrient sources on grain yield of millet. The result revealed a significant (P<0.05) difference among the treatments. The results further indicated that, planting millet at a spacing of 75x75cm was found to produced significantly (P<0.05) the higher yield than the other spacing used. The significant difference observed could be due optimum population leading adequate nutrient absorption and adequate sunlight for photosynthesis. This corroborated with the findings of Agber *et al*. (2012) that plant population had a significant influence on grain yield of millet. The results also revealed that growing millet with the application of poultry manure and NPK fertilizer was found to significantly (P<0.05) produced higher grain yield than the use of cow dung which was better than the control throughout.. This proved the significance of poultry manure on millet production. The results of this study corroborates the findings of Shuaibu *et al*. (2018) who reported an increase on yield of sorghum due to application of poultry manure. It is also in line with the result of Shuaibu, *et al*. (2022) who stated that, poultry manure application increased fertility status of soil which in turn translated to increase in grain yield.

CONCLUSION AND RECOMMENDATION

Conclusively, it is evident that planting millet at a spacing of 75x75cm with the application of poultry manure at the rate of 5 t/ha have more effect on the growth and yield of millet than other treatments. Based on the result of this experiment, planting millet at a spacing of 75 x 75cm with the application of poultry manure gave the highest value in all the parameters observed and is therefore recommended for millet production. However, farmers who grow millet should adopt the use of 75x75cm intra and inter raw spacing with application of poultry manure at the rate of 5 t/ha for millet production in the study area.

REFERENCES

Agber, P.I., Ter, S. and Ayuba, S.A. (2012). Assessment of pearl millet performance to early and late planting opportunities and fertilizer application models in Makurdi, Nigeria. *African Journal of Agricultural Research*, **7**(4): 59 – 66.

Alkass, M.H., Ajwa, H. and Othman, M. (2010). Yield and postharvest quality of lettuce in response to nitrogen, phosphorus, and potassium fertilizers. *Hortscience*, **45**(10):139-144.

Basavaraj, G., Rao, P.P., Bhagavatula, S. and Ahmed, W. (2010). Availability and utilization of pearl millet in India. *SAT e-Journal*, **8**: 1-6.

Bationo, A., Ntare, B. R., Tarawali, S. and Tabo, R. (2010). Soil fertility management and cowpea production in the Semi-Arid tropics of West Africa. *African Crop Science Journal*, **6:** 342 – 352.

Blanchet, G., Gavazov, K., Bragazza, L. and Sinaj, S. (2016). Responses of soil properties and crop yields to different inorganic and organic amendments in a Swiss conventional farming system. *Agriculture, Ecosystems and Environment*, **23**: 116 – 126.

Chakraborty, S. and Newton, A.C. (2011). Climate change, plant diseases and food security: an overview. *Plant Pathology*, **60**: 2–14.

Debiase, G., Montemurro, F., Fiore, A., Rotolo, C., Farrag, K. and Miccolis, A. (2016). Organic amendment and minimum tillage in winter wheat grown in Mediterranean conditions: effects on yield performance, soil fertility and environmental impact. *European Journal of Agronomy*, **75:** 149 – 157.

Firoz, A.Z., Alam, M.S., Uddin, M.S. and Khatun, S.A. (2010). Effect of sowing time and spacing on lettuce seed production in Hilly region. *Bangladesh Journal of Agricultural Research*, **34**(3): 531-536.

Isah, Y., Sabo, M. U. and Shuaibu, Y. M. (2020). Influence of phosphorus fertilizer rates and plant spacing on growth and yield of groundnut (*Arachis hypogeae* L.) in Bauchi State, Nigeria. *International Journal of Agricultural Research and Food Production*, **5**(1): 1 – 18.

Mengistu, T. and Yamoah, C. (2012). Effect of sowing date and planting density on seed production of carrot *(Daucuscarota var. sativa)* in Ethiopia. *African Journal of Plant Science*, **4**(8): 270-279.

Rincon, L., Pellicer, C. and Saez, J. (2008). Effect of different nitrogen application rates on yield and nitrate concentration in lettuce crops. *Afrochemia*, **42**: 304-312.

Shuaibu, Y. M., Bala, R. A., Kawure, S. and Shuaibu, Z. (2018). Effect of organic and inorganic fertilizer on the growth and yield of sorghum (*Sorghum bicolor* (L.) Moench) in Bauchi state, Nigeria. *GSC Biological and Pharmaceutical Sciences,* **2**(1): 25 – 31.

Shuaibu, Y. M., Garba, A. A., Fagam, A. S., Voncir, N., 1Kawure, S., Bala, R. A., Sabo, M. U. and Nayaya, J. A. (2022). Effects of nutrient sources and agro-ecology on physical and chemical properties of soil in Bauchi State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology*, **2**(2): 140 – 147.

Titonell, P.A., de Grazia, J. and Chiesa, A. (2003). Nitrate and dry water concentration in leafy lettuce *(Lectuca sativa* L.*)*. Cultivar as affected by N fertilization and plant population *Agricultura Tropica and subtropica*, **36**: 82-87.

Table1: Effects of Spacing and Nutrient Sources on Plant height of Millet

Treatments	2	4	6	8	10
Spacing (S)					
50x75cm	9.31	26.17	76.72^{b}	182.39^{C}	202.95^{b}
75x75cm	9.00	27.74	79.12^{ab}	186.39^{b}	204.24^{b}
100x75cm	9.21	26.09	81.85^{a}	190.37^{a}	209.22^{a}
LS	NS	NS	**	**	*
SE ±	0.23	0.85	1.03	1.05	1.68
Nutrient Sources (N)					
Control	6.33^{c}	17.32^{c}	55.36^{d}	169.27^{d}	189.19^{c}
NPK	9.08^{b}	25.92^{b}	73.63^{c}	185.50^{c}	204.92^{b}
PM	11.70^{a}	34.94^{a}	102.48^{a}	200.70^{a}	220.94^{a}
CD	9.58^{b}	28.50^{b}	85.48^{b}	190.05^{b}	206.83^{b}
LS	**	**	**	**	**
SE ±	0.26	0.98	1.19	1.21	1.94
INTERACTION					
SxF	**	NS	NS	*	NS

Means followed by different letters(s) within a treatment group are significantly different by DMRT, LS = Level of significance, **Significant at 1% probability level, *Significant at 5% probability level, NS = Not significant.

Table 2: Interaction of Spacing and Nutrient Sources on Plant height of Millet at 2 and 8WAS.

	WAS					
	2			8		
Treatments	50x75	75x75	100x75	50x75	75x75	100x75
Control	5.36^{e}	5.28^{e}	8.35^{d}	168.06^{d}	170.05^{d}	169.71^{d}
NPK	7.99^{d}	8.07^{d}	11.17^{bc}	182.06^{c}	182.72^{c}	191.71^{b}
PM	12.76^{a}	12.17^{ab}	10.18^{c}	191.70^{b}	202.06^{a}	208.35^{a}
CD	11.12^{b}	10.49^{c}	7.13^{d}	187.73^{bc}	190.71^{b}	191.69^{b}
LS		**			*	
SE ±		0.46			2.10	

Means followed by different letters(s) within a treatment group are significantly different by DMRT, LS = Level of significance, **Significant at 1% probability level, *Significant at 5% probability level.

Table 3: Interaction of Spacing and Nutrient Sources on Leaf Area (cm^2) of Millet at 2WAS.

Treatments	50x75cm	75x75cm	100x75cm
Nutrient Sources			
Control	5.93^{f}	6.30^{f}	7.11^{f}
NPK	10.47^{d}	9.91^{d}	9.27^{e}
PM	14.88^{b}	16.87^{a}	14.91^{b}
CD	10.98^{d}	13.39^{c}	12.13^{cd}
LS		*	
SE ±		0.48	

Means followed by different letters(s) within a treatment group are significantly different DMRT, LS = Level of significance, *Significant at 5% probability level.

Table 4: Effects of Spacing and Nutrient Sources on 1000 Grain Weight and Grain Yield of Millet

Treatments	1000 Grain Weight (g)	Grain Yield (kg/ha)
Spacing (S)		
50x75cm	17.73	543.10^{b}
75x75cm	18.18	596.72^{a}
100x75cm	18.04	567.56^{ab}
LS	NS	*
SE ±	0.15	16.01
Nutrient Sources(F)		
Control	15.50^{c}	367.21^{c}
NPK	18.80^{ab}	635.27^{ab}
PM	19.20^{a}	668.55^{a}
CD	18.44^{b}	605.46^{b}
LS	**	**
SE ±	0.18	18.49
INTERACTION		
S*F	NS	NS

Means followed by different letters(s) within a treatment group are significantly different by DMRT, LS = Level of significance, **Significant at 1% probability level, * significant at 5% probability level, NS = Not significant.

EFFECT OF MULCH MATERIALS AND MULCHING RATES ON GROWTH AND RHIZOME YIELD OF TURMERIC (*Curcuma longa* L.) IN SOUTHERN GUINEA SAVANNAH ZONE OF NIGERIA

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ABSTRACT

Experiment was conducted at the Biotechnology Advanced Research Centre Farm, Garki-Abuja from June 2023 – February 2024 to assess the performance of mulch materials and mulching rates on a local variety of turmeric. The experiment was 3x3 factorial laid out in a Randomized Complete Block Design (RCBD), replicated three times. The treatments comprised of three mulching materials (rice husk, saw dust, soybean straw) and three mulching rates (0. 5 and 10 t/ha). Data were collected on plant height, number of leaves, leaf length, number of rhizome, rhizome length, rhizome weight and rhizome yield. Data collected were subjected to analysis of variance (ANOVA) and significant means were compared using Duncan Multiple Range Test (DMRT) at 5% probability level. Results revealed that the plants mulched with rice husk at 5 t/ha had the highest rhizome yield (3.74 t ha^{-1}) while the least mean value was obtained from saw dust (2.84 t ha^{-1}). Therefore, rice husk mulch material can be recommended for the production of turmeric for the farmers within southern guinea savannah zone of Nigeria.

Key words: turmeric, rhizome, mulch, rate, growth, yield

INTRODUCTION

Turmeric (*Curcuma longa* L.) is a rhizomatous herbaceous perennial plant of the family Zingiberaceae. It is native to Asia and India, and occupies about 6% of the total area under spices and condiment in India (Akter *et al*., 2019). Commercially, it is traded as a spice, dye, oleo-resin and source of industrial starch. Curcumin is the principal component of turmeric, which has anti-inflammatory, anti-cancer, anti-tumor, anti-bacterial, anti-oxidant, anti-fungi and anti-parasitic properties (Akter *et al*., 2019; Tomeh *et al*., 2019; Ahmad *et al*., 2020). Principally, turmeric has a wider range of values such as orange coloring powder in textile industry food industry, medicinal value flavor and for its oleoresin. Dry turmeric contains about 69.43% carbohydrate, 6.30% protein, 5.1% oil, 3.5% mineral and other important elements (Sidhu *et al*., 2016). It is an ancient, most valuable, sacred spice that contains appreciable quantities of protein (6.3%), lipids (5.1%), carbohydrates (69.45) and fiber (2.6%). Moreover, it is rich in minerals like phosphorus, calcium, iron and vitamin A. Curcumin as an active ingredient present in turmeric (3-5%) which is responsible for biological activity and acts as a coloring agent to food, fiber, wood and several preparations (Sidhu *et al*., 2016).

The production and productivity of turmeric crop is still low in Nigeria as compared to other major producing countries. This production gap is due to several factors among which are declining soil fertility, shortage of appropriate and adequate research information. Several studies reported that turmeric is a nutrient exhaustive crop; especially as it is a heavy feeder of N (Singh *et al*., 2001; Agere and Shiferaw, 2015). The high nutrient requirements of turmeric are due to their shallow rooting and potential to produce large amount of dry matter per unit area (Singh *et al*., 2001). In addition, the crop has a prolonged growing period of (8-9 months) therefore; the nutrient requirement period also becomes prolonged so as to promote rhizome yield.

The spices "turmeric" constitutes boiled, dried, cleared and polished rhizome which has underground swollen modified stem of plant (Shirish *et al*., 2013). Mulching is an important component in the management practices of turmeric. In the dry months, it conserves moisture in the soil and enhances soil temperature for proper germination of the rhizome (Kumar *et al*., 2022). In addition, physical properties of soil are enhanced and it also minimizes the fertility of the soil (Qin *et al*., 2014). Organic mulches are efficient in reduction of nitrates leaching, improvement of soil physical properties, prevention of erosion, improving nitrogen balances as well as enhancing soil biological activity (Bhardwaj, 2011, Iqbal *et al*., 2020). Natural mulches such as leaf, straw, saw dust, spent materials and crop residues have been used for centuries (Indulekha and Thomas, 2018). After decomposition, organic mulches return organic matter and plant nutrients to the soil and improve its physical, chemical and biological properties after decomposition, which in turn increases the crop yield (Thakur and Kumar, 2021). Furthermore, it prevents washing out of soil nutrient during heavy rains (Iqbal *et al*., 2020; Mohanty, 1991). Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuation, improves physical, chemical and biological properties of soil, which add nutrient to the soil and ultimately enhances the growth and yield of crops (Kumar *et al.*, 2010). Therefore, considering all these facts, the current study was undertaken to evaluate the effects of mulch materials and mulching rates on growth and yield of turmeric.

MATERIALS AND METHODS

Field trial was conducted at the Sheda Science and Technology Complex Garki-Abuja, Biotechnology Advanced Research Centre Farm, FCT, Nigeria in 2023-24 cropping season. Abuja is located at 8^{O}10'N and 7^{O} 10'N and the climate is cold and dry from November to March and then warm and moist from April to October. The maximum and minimum temperature is 35 and 27^{O}C, respectively. The humidity of the area is high (74%) all year round except in January when dry wind blows from the north. The average annual rainfall is over

1250 mm. The margina local variety of turmeric was planted at the spacing of 50 x 50 cm on the bed size of 2 x 2 m ($4m^2$). The experiment was 3 x 3 factorial laid out in a Randomized Complete Block Design (RCBD), replicated three times. The treatments comprised of three mulching materials (rice husk, saw dust, soybean straw) and three mulching rates (0. 5 and 10 t/ha). Weeding was done manually four times at 3, 6, 9 and 12 weeks after planting (WAP). Data were collected on plant height, number of leaves, leaf length, number of rhizomes, rhizome root length, rhizome weight (g) and rhizome yield (t/ha). Data collected were subjected to analysis of variance (ANOVA) and significant means were compared using Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS

Effect of mulch materials and mulching rates on plant height, number of leaves and leaf length of turmeric

Plant height, number of leaves and leaf length were not significantly ($P \geq 0.05$) influenced by mulch materials, mulching rates and the interaction between mulch materials and mulching rates except leaf length that was significantly influenced by mulching rates (Table 1)). Plants mulched with 10 t/ha significantly had the longest leaves which was statistically comparable with other rates of mulching.

Effect of mulch materials and mulching rates on number of root and root length of turmeric

The number of rhizome was significantly ($P \leq 0.05$) influenced by both mulch materials and mulching rates (Table 2). The application of rice husk mulch material significantly produced higher number of rhizomes although at par with other mulching types. Mulching at $5tha^{-1}$ (32.92) proved its superiority over other rates which were followed by plants mulched at the rate of 10 t ha^{-1} while the least mean value was recorded from the control plots. The interaction effect between mulch materials and mulching rates was significant ($P \leq 0.05$) as shown in Table 4. On the other hand, rhizome root length was not significantly ($P \geq 0.05$) affected by mulch materials, however it was affected by mulching rates, where plants mulched at the rates of 5 and 10 t ha^{-1} significantly ($P \leq 0.05$) gave longer rhizomes than the control. There was no significant interaction between mulch types and mulching rates on rhizome length.

Effect mulch materials and mulching rates on rhizome weight and rhizome yield of turmeric

Rhizome weight was not significantly ($P \geq 0.05$) influenced by mulch materials and mulching rates (Table 3). However, the interactive effect between mulch materials and mulching rates on rhizome weight was significant ($P \leq 0.05$). On the other hand, the rhizome yield was significantly influenced by mulching materials only while mulching rates and the interaction between mulch types and mulching rates was not significant. The application of rice husk mulch material produced the highest yield (3.74 t ha^{-1}) of turmeric while soybean straw and saw dust resulted in lower yield respectively (Table 3).

Interaction between mulch type and mulching rates on number of rhizomes and rhizome weight of turmeric

The interaction between mulch materials and mulching rates on number of rhizomes is significant (Table 4), where plants mulched with rice husk at the rate of 5 t/ha and soybean at the rate of 10 t/ha significantly produced higher number of rhizomes although at par with the remaining interactions. On the other hand, plants mulched with rice husk significantly produced the heaviest weight which was at par with soybean straw at 10 t/ha compared with the rest of the interactions (Table 4).

DISCUSSION

The increase in the growth parameter as the plant aged might be due to the increase in the plant cell number and size. The result from this study indicated that leaf length responded significantly to different mulching rates evaluated. Result from this study is in conformity with the findings of Li *et al* (2018) in potato, Shan Jahan *et al* (2018) in lettuce, Filipovic (2016) in bell pepper who reported that leaf length could further be developed and elongated under good nourishment with mulches. The results of the current study revealed that plants in which mulch materials and mulching rates were applied had better number of rhizome root growth than the unmulched plots. This is in agreement with the findings of (Thakur *et al*., 2019) who stated that plants mulched with rice husk, saw dust, dry leaves and straws usually have high soil moisture content and regulate temperature which result into nutrient availability and nutrient uptake for optimum rhizome root development. From this study, it became evident that there was appreciable rhizome root length growth which corroborates with the findings of Weraduwage *et al*. (2015) who reported that rhizome root of turmeric could further grow with a better means of mulch. They opined that a higher biomass accumulation could enhance more shooting and root growth. The current results are in support of Reddy *et al*. (2017), who discovered that maximum rhizome root and rhizome length is obtainable when the mulching materials are well utilized. From the current study, it was proven that the interaction effect between mulch materials and mulching rates had a significant influence on number of rhizome roots and rhizome weight. The finding concurred with those of Reddy *et al*. (2017) who conducted a trial on turmeric plant. Results from the present study, showed that rice husk mulch material recorded the highest rhizome yield of 3.74 t ha^{-1} over others. However, the yield obtained was much more lower compared to the yield of 42.99 t ha^{-1} gotten from the research conducted by (Srinivas and Mahender 2023). The wide gap might have arisen from environmental and edaphic factors governing the production areas.

CONCLUSION AND RECOMMENDATION

Based on the findings from the study it was discovered that rice husk gave the best growth and rhizome yield of turmeric than other mulch materials and mulching rates evaluated. Therefore, rice husk at 5 t/ha could be recommended for application by turmeric farmers within the study area. In the other hand, further field trial could be conducted to have better growth and rhizome yield of turmeric.

REFERENCES

Agere, L. and Shiferaw (2015). Determination of optimum rate of Nitrogen and Phosphorus fertilizers for the yield and components of turmeric (*Curcuma longa* L.) on Nitisols at Yaki Woreda Southwestern Ethiopia. *Academic Research Journal of Agricultural Science and Research*. 3(10): 289-295

Ahmad, S.A., Hussain, M.B., Sultan, M.T., Arshad, M.S., Waheed, M., Shariati, M.A., Plygun, S. and Hashempur, M.H. (2020). Biochemistry, Safety, Pharmacological Activities, and Clinical Applications of Turmeric: A Mechanistic Review. Evidence-Based Complementary and Alternative Medicine, 7656919. https://doi.org/10.1155/2020/7656919.

Akter, J., Hossain, M.A., Takara, K., Islam, M.Z. and Hou, D.X. (2019). Antioxidant activity of different species and varieties of turmeric (*Curcuma* spp): Isolation of active compounds. Comparative Biochemistry and Physiology Part-C: *Toxicology and Pharmacology* 215, 9–17.

Bhardwaj, R.L. (2011). Bench mark survey on effect of mulching material on crop production. Krishi Vigyan Kendra, Sirohi, MPUAT Udaipur, 12-15

Filipović, V., Romić, D., Romić, M., Borošić, J., Filipović, L., Mallmann, F. J. K. and Robinson, D.A. (2016). Plastic mulch and nitrogen fertigation in growing vegetables modify soil temperature, water and nitrate dynamics: Experimental results and a modelling study. *Agriculture Water Management.*, 176, 100–10

Indulekha, V.P. and Thomas, C.G. (2018). Utilization of water hyacinth as mulch in turmeric. *Journal of Tropical Agriculture* 56, 27–33

Iqbal, R., Raza, M.A.S., Valipour, M., Saleem, M.F., Zaheer, M.S., Ahmad, S., Toleikiene, M., Haider, I., Aslam, M.U. and Nazar, M.A. (2020). Potential agricultural and environmental benefits of mulches - a review. Bulletin of the Notational Research Centre 44, 75.

Kumar, B. and Gill, B.S. (2010). Growth, yield, quality of turmeric (*Curcuma longa* L.) as influenced by planting method, plant density and planting material. J*ournal of Spices and Aromatic Crops* 19(1&2), 42–49

Kumar, P., Lata, S., Swapnil, Sinha, A. and Singh, D. (2022). Effect of tillage and mulching on growth, yield and economics of maize crops. *International Journal of Bio-resource and Stress Management* 13(4), 332–338.

Li, Q., Li, H., Zhang, L., Zhang, S. and Chen, Y. (2018). Mulching improves yield and water-use efficiency of potato cropping in China: a meta-analysis. Forestry Crop Research, 221, 50–60.

Mohanty, D.C., Sharma, Y. and Panda, B.S. (1991). Influence of mulch materials and ground covers on the yield of turmeric under rainfed condition in Orissa. Indian Cocoa, *Arecanut and Spices Journal*, 14:97-99

P. Srinivas and B. Mahender (2023). Effect of different types of plastic mulches on growth and yield of turmeric (*Curcuma longa*. L.). *Biological Forum – An International Journal*, 15(5a): 506-509

Qin, S., Zhang, J., Dai, H., Wang, D. and Li, D. (2014). Effect of ridge-furrow and plastic-mulching planting patterns on yield formation and water movement of potato in a semi-arid area. *Agricultural Water Management* 131, 87–94.

Reddy, R.A., Tiwari, K.N. and Santosh, D.T. (2017). Yield response of turmeric (*Curcuma longa* L.) under drip fertigation and plastic mulch conditions. *International Journal of Pure and Applied Bioscience* 5, 1265–1269.

Shah Jahan, M., Sarkar, D. M., Chakraborty, R., Muhammad Solaiman, A. H., Akter, A., Shu, S. and Guo, S. (2018). Impacts of plastic filming on growth environment, yield parameters and quality attributes of lettuce. Not Science Biology., 10, 522–529.

Shirish, S.P., Tushar, S.K., and Sathish, A.B. (2013). Mulching: A soil and water conservation practice. *Research Journal of Agriculture and Forestry Sciences* 1(3), 26–29.

Sidhu, P.S., Dhillon, G.S., Brar, A.S. (2016). Effect of mulching, spacing and intercropping of green gram (Vigna radiate) on growth, yield and quality of turmeric (*Curcuma longa* L.). *International Journal of Agricultural Sciences* 12, 90–94

Singh, P., Srivastava, P., Sharma, A., Hore, D. and Panwar, B. (2001). Genetic variability and correlation in turmeric (*Curcuma longa* L.). *India Journal Hill Farm*., 14:24-28

Thakur, M., and Kumar, R. (2021). Mulching, boosting crop productivity and improving soil environment in herbal plants. *Journal of Applied Research on Medicinal and Aromatic Plants* 20, 100–287

Thakur, M., Bhatt, V., Kumar, R. (2019). Effect of shade level and mulch type on growth, yield and essential oil composition of damask rose (*Rosa damascena* Mill.) under mid hill conditions of Western Himalayas. *Plo One* 14(4), 1–14.

Tomeh, M.A., Hadianamrei, R. and Zhao, X. (2019). A review of curcumin and its derivatives as anticancer agents. Molecular Science 20, 1–26.

Weraduwage, S.M., Chen, J., Anozie, F.C., Morales, A., Weise, S.E., Sharkey, T.D. (2015). The relationship between leaf area growth and biomass accumulation in Arabidopsis thaliana. Frontiers in Plant Science 6.

Table 1: Effect of mulch materials and mulching rates on plant height, number of leaves and leaf length of turmeric during 2023/-24 cropping season

Treatment	Plant height (cm)	Number of leaves per plant	Leaf length (cm)
Mulch materials (MM)			
Rice husk	53.44	30.17	27.23
Soybean straw	47.70	31.93	27.18
Saw dust	48.84	27.05	28.72
Level of significance	NS	NS	NS
SE±	3.34	2.01	1.21
Mulching rate (t/ha) (MR)			
0	44.55	30.13	24.73b
5	52.30	29.18	27.45ab
10	53.12	29.84	30.95a
Level of significance	NS	NS	*
SE±	3.34	2.01	1.21
Interaction			
MMXMR	NS	NS	NS

Means followed by the same letter (s) within the same column are not significantly different at 5% level of probability,*significant at 5%, NS= Not significant

Table 2: Effect of mulch materials and mulching rates on number of root and root length of turmeric in 2023/-24 cropping season

Treatment	Number of rhizomes	Rhizomes length (cm)
Mulch materials (MM)		
Rice husk	32.73a	11.32
Soybean straw	26.33b	10.63
Saw dust	29.14ab	11.61
Level of significance	*	NS
SE±	1.48	0.46
Mulching rates (t/ha) (MR)		
0	26.86b	10.16b
5	32.92a	11.63a
10	28.43b	11.77a
Level of significance	*	*
SE±	1.48	0.46
Interaction		
MM X MR	*	NS

Means followed by the same letter (s) within the same column are not significantly different at 5% level of probability,*significant at 5%, NS= Not significant

Table 3: Effect of mulch materials and mulching rates on rhizome weight and rhizome yield of turmeric in 2023/-24 cropping season

Treatment	Rhizome weight (g)	Rhizome yield (t/ha)
Mulch materials (MM)		
Rice husk	91.11	3.74a
Soybean straw	90.02	2.91b
Saw dust	83.60	2.84b
Level of significance	NS	*
SE±	3.44	0.20
Mulching rates (t/ha) (MR)		
0	91.65	3.37
5	87.61	2.98
10	85.46	3.14
Level of significance	NS	NS
SE±	3.44	0.20
Interaction		
MM X MR	*	NS

Means followed by the same letter (s) within the same column are not significantly different at 5% level of probability,*significant at 5%, NS= Not significant

Table 4: Effect of mulch materials and mulching rates interaction on number of rhizomes and rhizome weight of turmeric in 2023/-24 cropping season

Mulch materials	Mulching rates	Number of rhizomes	Rhizome weight (g)
1	1	32. 15ab	105.27a
1	2	32.65ab	94.13ab
1	3	33.40a	73.94c
2	1	18.53c	84.07bc
2	2	33.69a	91.10abc
2	3	26.71ab	94.89ab
3	1	29.33ab	85.62bc
3	2	32.42ab	77.62bc
3	3	25.17bc	87.55abc
CV		15.10	11.70
SE±		2.57	5.95

CV-Coefficient variation, Means followed by the same letter (s) within the same column are not significantly different at 5% level of probability

INFLUENCE OF ROW ARRANGEMENT AND ORIENTATION ON GROWTH AND YIELD OF SORGHUM (*Sorghum bicolor* L. MOENCH)/GROUNDNUT (*Arachis hypogaea* L.) INTERCROP IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Poor crop yield obtained in traditional crop production systems might be attributable in part to improper crop arrangement with its attendant waste of essential environmental resources and special attention has been directed towards increasing crop productivity per unit area. A field study was conducted during the 2018 rainy season at BUK (Latitude 11^{0}58'N and Longitude 8^{0}25'E) and Wasai Minjibir (Latitude 12.1459^{0}N and Longitude 0.866'485^{0}E) to assess the sorghum-groundnut intercropping system as influenced by row orientation and arrangement in Sudan savannah ecology of Nigeria. The treatments consisted of east-west (E-W) and north-south (N-S) orientation with row arrangement of (1:1, 1:2, 2:1, 2:2, 3:3, 2:4 or 4:2). The treatments were laid out in a randomized complete block design with three replications. The sorghum variety samsorg-40 (ICSV 400) was sown simultaneously with groundnut variety Samnut 24. Data was collected on crop growth rate, relative growth rate and net assimilation rate of sorghum/groundnut, 1000 grain yield (g), grain yield (kgha^{-1}) and stover yield (kg/ha) of sorghum and 100 seed weight (g) and kernel yield (kgha^{-1}) of groundnut. Data generated were subjected to Analysis of Variance (ANOVA) using JMP Pro 13. Significantly different treatment means were separated using Student Newman Keuls (SNK). Results showed that N-S row orientated cropping pattern produced significantly higher sorghum-groundnut grain and kernel yield compared to E-W orientation. Row arrangements of 2:1 and 2:4 of sorghum and groundnut produced the highest yields (773.70 kg/ha and 338.20 kg/ha, respectively) and therefore recommended in the study area.

Key words:- Orientation, Arrangement, Intercrop, physiological growth traits, yield.

INTRODUCTION

Intercropping is the system of simultaneously growing two or more crops on the same land area with a definite row arrangement **(**Guleria and Kumar, 2016**)**. The practice of intercropping has actually been around since farming began. Intercropping is a popular farming system among farmers in Nigeria especially the small scale farmers. This is majorly practiced to increase the productivity per unit of land and ensure economic utilization of land, labour and capital resources (Idoko, 2018). However, it is very much important to ensure that component crops do not compete with each other for space, moisture, nutrients, and solar radiation (Jayanta *et al.*, 2017). It is a simple but inexpensive strategy and has been recognized as a potentially benefiting technology for increased crop production (Awal *et al*., 2006).

Row arrangement of intercrop is an important management practice that can improve radiation interception through higher productivity of intercrop. The resources of great concern and importance in crop mixture in Nigeria are solar radiation, especially the photo-synthetically active radiation (PAR) and soil nutrients. Plant positioning in rows causes inter- and intra-row shading, which affects the light (Ben, 2011).

Row orientation indirectly affects plant assimilation and respiration and in-turn influence photosynthetic activities. Orientation of rows, especially, E-W row is preferred to maximize light absorption, but this is not always possible. In many cases the topography that includes the shape, terrain and slope of the land, as well as the location of existing vegetation, road, irrigation lines, buildings and physical barriers, dictate the row orientation (Ben, 2011).

The challenge therefore is to identify crops capable of sustaining their potential yield when grown in specific row arrangements with other crops (Oseni, 2010). Inappropriate row direction may result to yield losses of crop for light, space and/or carbon dioxide. Bedry, 2007; El Naim and Ahmad, 2010). Cereal-legume intercropping is widely practiced in Africa as a means to increase efficiency of land use through optimum utilization of solar radiation, water and nutrients (Tamiru, 2014). The aims of this research is to identify the influence of row arrangement and orientation on growth and yield of the sorghum (*Sorghum bicolor* l. *moench*)/groundnut (*arachis hypogaea* l.) intercropping system.

MATERIALS AND METHODS

The experiment was conducted during the wet season of 2018 at two locations. Teaching and Research Farm, Bayero University, Kano (Latitude $11^0$58'N and Longitude $8^0$25'E) and Institute for Agricultural Research (IAR) Farm located at Wasai (Latitude 12.1459^0N and Longitude 0.866'485^0E), Minjibir Local Government Area of Kano State.

The experiment comprised of 18 treatments of two row directions (East-West and North-South) and seven (7) row arrangements (1:1, 1:2, 2:1, 2:2, 3:3, 2:4 and 4:2) with 4 plots where sole crops were allocated. This was laid out in randomized complete block design and replicated three times. The gross plot size was 13.5m x 4.0 m ($54m^2$) consisting of 18 rows. The discard between the plots was 1 ridge and between the replicates were 2 ridges. The net plot size varies as follows: 1:1 = 8 ridges = (8 x 0.75m x 3m = $18m^2$), 1:2 = 9 ridges = ($20.25m^2$), 2:1 = 9 ridges = ($20.25m^2$), 2:2 = 8 ridges = ($18m^2$), 3:3 = 6 ridges = ($13.5m^2$), 2:4 = 12 ridges = ($27m^2$), 4:2 = 12 ridges = ($27m^2$)

The treatments combinations were as follows: 1:1 Sorghum-Groundnut at East-West, 1:1 Sorghum-Groundnut at North-South, 1:2 Sorghum-Groundnut at East-West, 1:2 Sorghum-Groundnut at North-South, 2:1 Sorghum-Groundnut at East-West, 2:1 Sorghum-Groundnut at North-South, 2:2 Sorghum-Groundnut at East-West, 2:2 Sorghum-Groundnut at North-South, 3:3 Sorghum-Groundnut at East-West, 3:3 Sorghum-Groundnut at North-South, 2:4 Sorghum-Groundnut at East-West, 2:4 Sorghum-Groundnut at North-South, 4:2 Sorghum-Groundnut at East-West, 4:2 Sorghum-Groundnut at North-South, Sole Sorghum at East-West, Sole Sorghum at North-South, Sole Groundnut at East-West, Sole Groundnut at North-South.

SAMSORG - 40 (ICSV 400): Short season variety**,** early maturity period of 95-100 days, potential yield 2.5 - 3.5 ton/ha non-lodging**,** drought tolerant, good response to fertilizer, grain have good food and malting quality as well as adapted to Sudan savannah ecology. (Murty *et al*., 1996; Chukwuma *et al*., 2014)

SAMNUT-24: Early maturity between 80-95 days, good yield performance (2 t ha^{-1}), good fodder yield, rosette resistant and high oil content (53%) (Echekwu *et al*., 2011; Micheal *et al*., 2018).

Data were collected on crop growth rate, relative growth rate and net assimilation rate of sorghum/groundnut, 1000 grain yield (g), grain yield (kg/ha) and stover yield (kg/ha) of sorghum and 100 seed weight (g) and kernel yield ($kgha^{-1}$) of groundnut. Data generated were subjected to Analysis of Variance (ANOVA) using JMP Pro 13. Significantly treatment means were separated using Student Newman Keuls (SNK) at 5% probability level.

RESULTS AND DISCUSSION

Effect of Row arrangement and Orientation on Growth and Yield of Sorghum in Sorghum-Groundnut Intercropping System

The results indicated that row arrangement and orientation as well as their interactions had no significant effect on crop growth rate, relative growth rate and net assimilation rate in both locations but there was a significant effect on Net assimilation rate at Minjibir Table 1. This could be due to evenly distribution of solar energy at early period of plant growth which could lead to less competition with less shading effect during vegetative stage. (Huffaker, 1990) reported that suitable distribution could form a good canopy structure and improve micro-environment, such as light, temperature, humidity and carbon dioxide content, at Minjibir with East to West row orientation having higher NAR than North to South so also, 1:1 arrangement significantly recorded higher NAR which was statistically similar to other row arrangement except 2:4 that recorded the lowest NAR. The interactions between row arrangement and orientation had significant effect on NAR at Minjibir (Table 2). Treatment of 1:1 arrangement with East-West orientation had higher NAR which was statistically similar with all other combinations, but different from 1:2 and 2:4 arrangement with North-South orientation.

The influence of row arrangement and orientation on sorghum 1000 grain weight, grain yield and stover yield (kg/ha) is presented in Table 3. Row orientation had no significant effect on 1000 seed weight in both locations. Row arrangement significantly influenced 1000 seed weight only at BUK with no effect at Minjibir site. Arrangement of 1:2 had heavier 1000 seed weight which was statistically similar to 1:1, 2:1, 2:4 and 4:2 but different from 2:2 and 3:3 arrangements. This could be due to benefit the cereal drive from alternating planting between legumes for nitrogen and prevent against shading effect. These findings was not in conformity with Undie *et al.* (2012) who reported that intercropping had no significant effect on 100 seed weight of maize. The non-significant effect at Minjibir could be due to proper nutrient utilization. This was inconformity with Muoneke *et al*. (2007) and Hayder *et al*. (2003) which showed that there was no significant effect on 1000 grain weight of maize when intercropped with soyabean at any rate.

The influence of row orientation on grain yield at Minjibir was found to be significant where East-West recorded higher grain yield (kg/ha) than North-South while on row arrangement, the results indicated 2:1 and 4:2 arrangements produced higher grain yield in kg per hectare compared to other arrangements. The interactions was not significant at both locations. This could be attributed to the population of the sorghum in the intercropping which either increase inter-competition among the combining crops. This aligns with the findings of Atabo *et al.* (2015) who reported that significantly higher sorghum grain and panicle yields per hectare were recorded at 2 Sorghum: 1 Soybeans arrangements than the other crop row arrangements evaluated. Findings of Kadan and Braig (2008) was similar reported that sorghum grain yield was higher at 2:1 planting pattern than cowpea. The effect of row arrangement on harvest index was recorded significantly higher for 2:1 and 4:2 but different from all other arrangement combinations.

The effect of row orientation was not significant at BUK but it was significant at Minjibir where East-West orientation showed significantly higher stover yield than North-South. Row arrangement of 4:2 significantly recorded higher stover yield but statistically similar to all other arrangements except 1:2 and 2:4 which recorded the lowest yield in stover at BUK. However at Minjibir, 1:2, 2:1, 2:2 and 4:2 recorded higher stover yield which was statistically similar with 1:1 and 3:3 but different from 2:4 with less stover yield. The component mixture of crops requires higher population pressure to produce maximum stover yields. Higher stover weight in sorghum was recorded at 4:2 arrangement as presented in this research. Several research works reported that in intercropping plants density increased grain and stover yield as reported by (Dawadi and Sah, 2012) and (Muranyi, 2015).

Effect of Row arrangement and Orientation on Growth and Yield of Groundnut in Sorghum-Groundnut Intercropping System

The results showed that row orientation and arrangement have no significant effect on the three growth parameters (crop growth rate, relative growth rate and net assimilation rate) in both locations Table 4.. So also the interaction between row orientation and arrangement hads no effect in sorghum-groundnut intercropping system in both locations. This could be attributed to the proper and good management practice with distribution of precipitation which helps in good development during vegetative growth. Muhammed *et al*. (2009) reported that in the vegetative phase, better rainfall and good distribution would have improved plant growth only and thus dry matter accumulation.

Row orientation had no significant effect on 100 seed weight in both locations but significant on kernel yield in both locations were North-South significantly recorded higher kernel yield than East-West Table 5. Row arrangement significantly influenced 100 seed weight in BUK. 1:1 and 3:3 had heavier 100 seed weight which was statistically similar to 2:1, 2:2, 2:4 and 4:2 and different from 1:2 arrangement Which is in conformity with the investigation of Guddisa (2018) who reported that maximum groundnut 100 seed weight was obtained as a result of intercropping sorghum with cowpea at 1:1 from the treatment 2:2 with sorghum var. butana row arrangement. So also, the influence of row arrangement on kernel yield of groundnut was significant with 1:2 and 2:4 produced the highest kernel yield, followed by 1:1, 2:2 and 3:3 arrangements. This could be due to less inter-specific competition for growth resources thereby allowing the crops to exploit the environmental resources fully and enable it to produce more pods and branches.

CONCLUSION

Most of the physiological growth attributes from this research were not significantly affected by orientation and arrangement. However, the yield attributes such as the grain and kernel yield at Minjibir produced highest yields as a result of proper utilization of sunlight and partitioning of assimilates trough source to sink relationship. Regardless of planting pattern and row orientation, sorghum-groundnut intercropping at 1:2 had the yield advantages and exploitation of the environmental resources as opposed to other intercropping systems. Furthermore, the overall productivity of the system become effective due to good utilization of land and economic benefit of the intercrop.

REFERENCES

Awal M.A., Koshi. H, and Ikeda T. (2006). Radiation Interception and Use by Maize/Peanut Intercrop canopy. *Agriculture Forest Meteorology*. 139: 74-83.

Atabo, J. A., Ogunlela V. B., Olufajo O. O., and Lawal A. B. (2015). Productivity of Sorghum/Soyabean Intercrop as Influenced by Cultivar and Row Arrangement in the Northern Guinea Savanna Agro-ecology of Nigeria. *Journal of Biology, Agriculture and Healthcare*. 5(16): 124-136.

Bedry K. A. (2007). Effect of weeding regimes on faba bean (*Vicia faba* L.) yield in the Northern State of Sudan. *University of Khartoum Journal of Agricultural Science*, 15: 220-231.

Ben Duada (2011). The effect of abattoir effluent waste water on soils of Gandu area of Sokoto, Sokoto State, Nigeria. *International Journal of Tropical Agriculture and Food Systems* 5(3).

Dawaki, D. R and Sah, S.K. (2012). Growth and yield of hybride maize (*Zea mays* L.) in relation to planting density and nitrogen levels during winter season in Nepal. *Tropical Agricultural Research*, 23 (3): 218-227.

Echekwu C. A., B Ntare, U. Alhassan, S.G. Mohammed and Y.D. Ndiripaya (2011). Nigerian Seed Portal Initiative..towards boosting agricultural productivity. IAR, SAMARU/ICRISAT. http://www.nigerian seed portal initiative.

El- Naim, A. M. and Ahmed, S. E. (2010). Effect of weeding frequencies on growth and yield of two roselle (*Hibiscus sabdarifta* L.) Varieties under rain fed. *Australian Journal of Basic and Applied Sciences*, 4(9): 4250-4255.

Gudissa, B. (20218). Effect of Groundnut (*Arachis hypogea* L.) intercropping with different crops. *Journal of Biology, agriculture and Healthcare*. Vol.8. No. 13. 2224-3208.

Guleria, G., and Kumar, N. (2016). Sowing methods and varying seed rates of cowpea on production potential of sorghum, Sudan grass hybrid and cowpea. *Agricultural Reviews*, 37: 290-299.

Hayder G., Suhail S. M., Aslam K. and Sherin K. (2003). Maize and soybean intercropping under various levels of soybean seed rates. *Asian Journal of Plant Sciences*. 2 (3): 339-441. Doi: 10.3923//ajps.2003,339-341.

Huffaker R.C. (1990). Proteolytic Activity During Senescence of Plants. New phytologist 116(2): 199-231. https://doi.org/10.1111/j.1469-8137. 1990. tb04710.x

Idoko, J.A, Akaazua, B.W. and Aduwele, A.T. (2018). Effect of Sweet Potato Vine Planting Orientation on the Growth and Yield of Sweet Potato/Maize Intercropping System in Makurdi, Southern Guinea Savanna, Nigeria. *International Journal of Scientific Research and Management* (IJSRM), 6(4): 101-113

Jayanta L, Anup D., Tarik M., Chaitanyaprasad N., Ram S. M.,Gulab S. Y., Shivakumar, B. G., Sandeep K. and Rattan L. (2018). Cereal and Legume Intercropping: An Option for Improving Productivity and Sustaining Soil Health. Legumes for Soil Health and Sustainable Management pp 347-386. Springer, Singapore.

Kadan. G.L and Braig, I.A. (2008). Studies on different planting pattern of sorghum/soyabean Intercropping System. *International Journal of Agricultural Science* 4(1): 181-187.

Khatiwada, P.P. (2000). Intercropping cauliflower under maize: an approach to extend the cauliflower product in season for subsistence farmers. *Kasetsart Journal Nautral Sci*ence, 32: 72-80.

Micheal B. V., Sadiq Abubakar S., Amina M., Aminu S., Hippolyte A., Hakeem A. A. and Abba A. K. (2018). Pattern and drivers of the adoption of improved groundnut technologies in North-Western Nigeria. International Crop Research Institute for the Semi Arid Tropics (ICRISAT); Nigeria. *African Journal of Agriculture*, 6(1): 01-16.

Muhammad W. Riaz M., Muhammad S. Ibni Z. and Shahid I. (2009). Impact of Phosphorus Levels and Different Tillage Systems on Yield and Economics of Mungbean (*Vigna radiata* L.). *Greener Journal of Agronomy, Forestry and Horticulture*. 2(4): 073-078.

Muoneke, C., Ogwuche, M., Kalu, B. A. (2007). Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agroecosystem. *African Journal of Agricultural Research*. 2(12): 667-667.

Muranyi, E. (2015). Effect of planting density and row spacing on maize (*Zea mays* L.) grain yield in different crop year. *Journal of Agricultural and Environmental Sciences*, 2(1): 57-63.

Mutsaers H.J.W. (1980). The effect of row orientation, date and latitute on light absorption by row crops. *The Journal of Agricultural Science*, 95: 381-386.

Oseni (2010). Effect of row arrangements on sorghum-cowpea intercrops in the semi arid savannah of Nigeria. *Journal of Agriculture and Biology Pakistan*. 12: 137-140

Surve, V. H., Arvadia, M.K. and Tandel, B. B. (2012). Effect of row ratio in cereal-legume fodder under intercropping systems on biomass production and economics. *International Journal of Agriculture, Research and Review*, 2: 32-34.

Tamiru H. (2014). Effect of intercrop row arrangement on maize and haricot bean productivity and the residual soil. *World Journal of Agricultural Sciences*, (4): 069-077.

Undie, U., Uwah D.F., Attoe E. E. (2012). Effect of intercropping and crop arrangement on yield and productivity of late season maize/soybean mixtures in the humid environment of southern Nigeria. *Journal of Agriculture Science*. 4(4).

Table 1: Crop growth rate ($g.wk^{-1}$), relative growth rate ($mg.\ wk^{-1}$) and net assimilation rate $g.cm^{-2}wk^{-1}$ of sorghum as influenced by row orientation and arrangement in sorghum-groundnut inter-cropping system at BUK and Minjibir in 2018 raining season

Treatments	BUK			MINJIBIR		
	CGR ($g.wk^{-1}$)	RGR ($mg.\ wk^{-1}$)	NAR ($gcm^{-2}wk^{-1}$)	CGR ($g.wk^{-1}$)	RGR ($mg.\ wk^{-1}$)	NAR ($gcm^{2}wk^{-1}$)
Row orientation (RO)						
East-West	4.45	1.09	0.31	1.99	2.09	0.36a
North-South	3.46	0.79	0.34	1.81	2.10	0.33b
P value	0.758	0.099	0.201	0.494	0.688	0.051
SE±	0.498	0.173	0.030	0.248	0.020	0.016
Row arrangement (RA)						
1:1	2.95	0.85	0.32	1.70	2.07	0.39a
1:2	3.63	0.96	0.29	2.03	2.11	0.31ab
2:1	4.48	0.95	0.28	2.03	2.08	0.39a
2:2	3.61	0.68	0.34	1.40	2.10	0.35ab
3:3	5.28	1.35	0.35	2.28	2.08	0.34ab
2:4	4.70	1.63	0.30	1.87	2.11	0.30b
4:2	2.78	0.60	0.36	1.98	2.11	0.35ab
P value	0.324	0.259	0.062	0.622	0.966	0.025
SE±	0.899	0.311	0.057	0.465	0.038	0.030
Interaction						
RO x RA	1.255	0.354	0.081	4.978	0.078	0.043

Means followed by the same letters in a column are not significantly different at 5% level of probability using SNK
WAS = Week After Sowing

Table 2: Interaction of row orientation and arrangement on net assimilation rate of sorghum at Minjibir in sorghum-groundnut intercropping system.

	Row Orientation	
	East-West	North-South
Row arrangements		
1:1	0.44a	0.35ab
1:2	0.35ab	0.27b
2:1	0.36ab	0.42a
2:2	0.35ab	0.35ab
3:3	0.37ab	0.31ab
2:4	0.34ab	0.26b
4:2	0.34ab	0.35ab
SE±	0.042	

Means followed by the same letters in a column are not significantly different at 5% level of probability using SNK.

Table 3: 1000 grain yield (g), grain yield (kg/ha) and stover yield (kg/ha) of sorghum as influenced by row orientation and arrangement in sorghum-groundnut intercropping system at BUK and Minjibir in 2018 raining season

Treatments	BUK 1000 Grain Weight (g)	BUK Grain Yield (kg/ha)	BUK Stover Yield (kg/ha)	MINJIBIR 1000Grain Weight (g)	MINJIBIR Grain Yield (kg/ha)	MINJIBIR Stover yield (kg/ha)
Row orientation (RO)						
East-West	28.72	412.70	2384	28.43	525.10a	3389a
North-South	27.98	425.00	2507	30.08	432.10b	3030b
P value	0.252	0.511	0.992	0.233	<.001	0.003
SE±	0.700	18.520	120.000	0.953	17.260	106.6
Row arrangement(RA)						
1:1	27.85ab	398.10b	2410abc	26.44	486.10b	3292ab
1:2	32.15a	189.30c	1862cd	29.71	193.30c	3306a
2:1	29.36ab	699.60a	3015ab	30.73	773.70a	3310a
2:2	25.95bc	398.10b	2456abc	32.75	481.50b	3426a
3:3	23.15c	382.70b	2479abc	26.61	481.50b	3051ab
2:4	29.21ab	179.00c	1877c	31.48	185.20c	2670b
4:2	31.18ab	685.20a	3027a	27.06	753.10a	3401a
P value	<.001	<.001	0.008	0.094	<.001	0.010
SE±	1.263	34.660	224.6	1.783	32.280	199.4
Interaction						
RO x RA	2.409	49.01	317.6	3.567	45.65	230.1

Means followed by the same letters in a column are not significantly different at 5% level of probability using SNK.

Table 4: Crop growth rate ($g.wk^{-1}$), relative growth rate ($mg. wk^{-1}$) and net assimilation rate ($gcm^{-2}wk^{-1}$) of groundnut as influenced by row orientation and arrangement in sorghum-groundnut intercropping system at BUK and Minjibir in 2018 raining season.

Treatments	BUK CGR ($g.wk^{-1}$)	BUK RGR ($mg. wk^{-1}$)	BUK NAR ($gcm^{-2}wk^{-1}$)	MINJIBIR CGR (g/wk)	MINJIBIR RGR ($mg. wk^{-1}$)	MINJIBIR NAR ($gcm^{2}wk^{-1}$)
Row orientation(RO)						
East-West	2.90	1.35	0.45	1.83	1.72	0.41
North-South	2.64	1.33	0.49	1.74	1.75	0.51
P value	0.454	0.874	0.663	0.433	0.397	0.121
SE±	0.250	0.084	0.051	0.073	0.030	0.045
Row arrangement(RA)						
1:1	2.90	1.28	0.51	1.98	1.72	0.58
1:2	3.01	1.66	0.41	1.48	1.75	0.36
2:1	2.92	1.35	0.57	1.92	1.75	0.43
2:2	3.26	1.25	0.43	1.90	1.70	0.49
3:3	2.10	1.35	0.54	1.82	1.76	0.45
2:4	2.39	1.30	0.47	1.78	1.78	0.41
4:2	2.82	1.20	0.37	1.63	1.70	0.52
P value	0.641	0.487	0.763	0.174	0.917	0.624
SE±	0.468	0.157	0.095	0.136	0.057	0.084
Interaction						
RO x RA	0.937	0.315	0.192	0.274	0.114	0.169

Means followed by the same letters in a column are not significantly different at 5% level of probability using SNK.

Table 5: 100 seed weight (g) and kernel yield (kgha^{-1}) of groundnut as influenced by row orientation and arrangement in sorghum-groundnut intercropping system at BUK and Minjibir in 2018 raining season.

Treatments	BUK		MINJIBIR	
	100 seed weight (g)	Kernel yield(kg/ha)	100 seed weight (g)	Kernel yield(kg/ha)
Row orientation(RO)				
East-West	31.31	172.30b	27.50	239.60b
North-South	31.22	256.90a	27.30	264.40a
P value	0.615	<.001	0.662	0.015
SE±	0.132	10.170	0.335	7.040
Row arrangement(RA)				
1:1	31.63a	185.20bc	28.31	261.70b
1:2	30.50b	329.20a	27.11	324.10a
2:1	30.85ab	148.10cde	27.93	163.70c
2:2	31.33ab	181.40bcd	26.35	264.90b
3:3	31.81a	209.90b	27.51	257.60b
2:4	31.51ab	308.60a	26.60	338.20a
4:2	31.25ab	135.80cde	28.00	154.00c
P value	0.012	<.001	0.249	<.001
SE±	0.247	19.030	0.627	13.170
Interaction				
RO x RA	0.495	26.910	0.342	24.020

Means followed by the same letters in a column are not significantly different at 5% level of probability using SNK.

ASSESSMENT OF THE EFFECT OF SOWING DATES ON DRY MATTER ACCUMULATION AND GRAIN YIELD OF SOYBEAN VARIETIES [*Glycine max* (L.) MERR] IN THE NIGERIAN SAVANNAS

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ABSTRACT

The study evaluated the impact of sowting dates on soybean [*Glycine max* (L.) Merr.] performance in two agroecological zones (AEZs) of Nigeria. Experimental treatments involved six sowing dates (15 June, 22 June, 29 June, 6 July, 13 July, and 20 July) and three soybean (TGX-1835-10E, TGX-1951-3F, TGX-1904-6F) varieties. These were laid in a split plot design with three replications. Results showed that variety and sowing dates significantly influenced growth and yield parameters in both locations. At BUK, optimal yields (>1500 kg ha^{-1}) were achieved when TGX-1835-10E and TGX-1951-3F were sown from 15 to 29 June and TGX-1904-6F on 15 June. Sowing beyond 29 June reduce yields by 12–55% for TGX-1835-10E and 27–63% for TGX-1951-3F. For TGX-1904-6F, sowing after 15 June reduces yields by 27–90%. At Zaria however, optimal yields (>1500 kg ha^{-1}) were obtained when TGX-1835-10E and TGX-1951-3F were sown from 15 June to 6 July, and TGX-1904-6F between 15 to 29 June. Delaying of sowing beyond these dates significantly reduced yields by 18–31% for TGX-1835-10E and 12–20% for TGX-1951-3F and 10–41% for TGX-1904-6F.

INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] is increasingly important in Nigerian agriculture due to its high-quality protein and vegetable oil content (Akande *et al*., 2007). It is widely cultivated for food, oil, and feed, offering higher protein content than other sources (Samuel *et al*., 2022; Dugje *et al*., 2009). Nigeria and South Africa are the leading producers in Africa, contributing 29% and 40% of total production, respectively (Gbegbelegbe *et al*., 2019). However, Nigerian soybean yields average less than 1 t/ha, significantly lower than the 2 to 3.38 t/ha achieved in top-producing countries like the USA, Brazil, and Argentina (FAO, 2018). Factors contributing to these low yields include poor soil fertility, agronomic practices, diseases, irregular rainfall, high temperatures, and drought (Khojely *et al*., 2018).

Soybean is mainly grown in Nigeria's Guinea and Sudan savannas, where rainfall is generally sufficient for its growth (Ugbabe *et al*., 2017). However, increasing climate variability, including delayed rainy seasons and dry spells, threatens rain-fed agriculture (Tofa *et al*., 2020; Bebeley *et al*., 2022; Kamara *et al*., 2023). The Sudan savanna is particularly vulnerable to drought due to unreliable rainfall (Umar *et al*., 2021), with the duration of the growing season highly influenced by the timing of the first rainfall (Kamara *et al*., 2023). Sowing drought-tolerant and early-maturing soybean varieties during optimal windows can help address these climate challenges.

The International Institute of Tropical Agriculture (IITA) and national research bodies have developed high-yielding, drought-tolerant soybean varieties that are resistant to diseases and poor soil conditions. Timely sowing is essential for maximizing yields, as it affects growth stages due to variations in photoperiod, temperature, and rainfall (Han *et al*., 2006). Studies indicate that early sowing enables farmers to take advantage of the first rains (Weber *et al*., 1995), but improper timing either too early or too late can hinder yield due to poor crop establishment or shortened grain-filling periods (Bastidas *et al*., 2008). Drought during critical stages like seedling or flowering can cause significant yield instability, making recovery impossible for farmers (Bebeley *et al*., 2022).

The sowing date is a crucial factor influencing soybean yield (Calvino *et al*., 2003). Research in Nigeria and Sudan has shown that inappropriate sowing dates adversely affect grain yield and its components (Ibrahim *et al*., 2012; Yagoub *et al*., 2013). For instance, Omoloye *et al.* (2015) found that early-planted soybeans in Nigeria experienced fewer infestations and less seed damage. Adetayo *et al.* (2022) confirmed that delayed sowing negatively impacted plant height, pod number, and grain yield, with optimal yields requiring sowing before mid-August

Adjusting sowing dates and selecting appropriate soybean varieties can enhance yield and resilience against climate variability (Battisti *et al*., 2018). However, further research is needed to identify optimal sowing dates for different soybean varieties in major producing zones of the Nigerian savannas. This study aims to establish the best management practices for soybean production in these regions.

MATERIALS AND METHODS

Study Areas

This experiment was conducted during the 2021 and 2022 cropping seasons at two sites: IITA's experimental station in Samaru Zaria (Northern Guinea savanna, NGS) and Bayero University Research Farm in Kano (Sudan savanna, SS). These locations differ in climatic and soil conditions. The Sudan savanna has a dry season with high temperatures (28-32°C), low rainfall (600-800 mm), and a short growing season (90-110 days), with soils classified as Alfisols (Dawaki *et al*., 2013). In contrast, the Northern Guinea savanna experiences a longer growing period (151-180 days), with annual rainfall of 900-1000 mm and maximum temperatures up to 40°C (Atehnkeng *et al*., 2008). Its soils are ferruginous tropical with high clay content (Aminu *et al.*, 2015).

Weather and Soil characteristics of the Study Areas

Weather conditions, including rainfall, temperature, and solar radiation, were monitored using a Watch-Dog weather station. Soil samples were collected and analyzed for texture, pH, and nutrients. The soils in Samaru Zaria are loamy with low nitrogen and phosphorus levels, while those in Kano are sandy loam with similarly low nutrient content.

Treatments and Experimental Design

The experiment was a split-plot factorial design, with six sowing dates (June 15-July 20) and three soybean varieties (TGX-1835-10E, TGX-1951-3F, and TGX-1904-6F). These were replicated three times. Sowing dates were assigned to the main plots while the varieties occupies the sub plots.

Cultural Practices

Each plot consisted of four rows, and seeds were sown with specific spacing and thinning protocols. After harvesting, plants were dried, weighed, and the final grain yield was adjusted to 12% moisture content.

Data Collection and Analysis

Data were collected on total dry matter and grain yield. These were analyzed using ANOVA in SAS, treating year and replication as random effects, and sowing date and variety as fixed effects. Differences among treatments were evaluated using LSD tests at a 5% significance level.

RESULTS

The impact of year on total dry matter (TDM) was significant at both BUK-Kano and Samaru Zaria, with TDM being 23% and 19% higher in 2022 than in 2021, respectively. The variety TGX-1951-3F produced higher TDM at Samaru Zaria, while no significant difference was found among varieties at BUK-Kano. Sowing dates significantly affected TDM, with a decline of 8-51% at BUK-Kano and 7-46% at Samaru Zaria as sowing dates were delayed from June 15 to July 20. The TGX-1904-6F variety experienced the greatest decline, and TGX-1951-3F the least, with delayed sowing.

Grain yield was 31% higher in 2022 than in 2021 at BUK-Kano and 5% higher at Samaru Zaria. Grain yield also varied across sowing dates and varieties, with TGX-1835-10E producing the highest yield (1448.8 kg ha^{-1}) at BUK-Kano, while TGX-1951-3F had the highest yield (1743 kg ha^{-1}) at Samaru Zaria. Delayed sowing led to grain yield decreases of 9-75% at BUK-Kano and 9-51% at Samaru Zaria for all varieties. Early sowing between June 15 and June 22 (PD1-PD2) favored higher yields, with significant declines observed beyond June 22 for all varieties at both locations. TGX-1951-3F was particularly sensitive to sowing delays at BUK-Kano, while at Samaru Zaria, TGX-1904-6F performed best with early sowing.

DISCUSSION

The results of the investigation demonstrated a significant decline in total dry matter (TDM) across varieties at both locations when sowing was delayed beyond June 22. Delayed sowing shortens the vegetative phase due to a reduced growing season, limiting vegetative growth and biomass accumulation. This is consistent with findings by Ennin *et al.* (2006) in Ghana.

Additionally, optimal sowing dates varied by location and variety. In the Sudan Savanna (SS) agro-ecological zone (AEZ), sowing early maturing soybean varieties TGX-1835-10E and TGX-1951-3F between June 15-29 can yield over 1500 kg ha^{-1}. However, delaying sowing beyond June 29 reduced yields of TGX-1835-10E by 27-63%, TGX-1951-3F by 12-55%, and TGX-1904-6F by 27-90%. Bebeley *et al.* (2022) reported similar results, showing yield reductions of 11-70% and 8-69% when sowing TGX-1835-10E and TGX-1951-3F beyond June 21. Due to the short sowing window and unpredictable rainfall, sowing TGX-1904-6F in the SS AEZ is not advisable.

In Samaru Zaria (Northern Guinea Savanna, NGS AEZ), yields of over 1500 kg ha^{-1} can be achieved when TGX-1835-10E and TGX-1951-3F are planted between June 15-July 6, and TGX-1904-6F between June 15-29. Delaying sowing beyond July 6 results in a 18-31% yield reduction for TGX-1835-10E and 12-20% for TGX-1951-3F. Sowing TGX-1904-6F beyond June 29 reduces yield by 10-41%. The moderate rainfall and longer growing season in Samaru Zaria led to less yield reduction compared to the SS AEZ. Samaru Zaria's favorable growing season and soil conditions, including higher organic matter and clay content, improve water retention and nutrient availability, enhancing soybean production.

The reduction in yield when sowing beyond the optimum date may be caused by drought stress due to insufficient moisture before the crop completes its life cycle in October. In the Nigerian savannas, late-season rainfall is unpredictable (Tofa *et al.*, 2020) and may cease in September or October before the crops mature, resulting in significant yield losses (Kamara *et al.*, 2023). While this study provides insights into optimal sowing dates, results are location-specific and not applicable to other areas of the Nigerian savannas due to soil and climate variability. Long-term simulation studies incorporating biophysical data and multi-year weather information are recommended.

CONCLUSION

Our study shows that soybean performance was influenced by year, agro-ecological zone (AEZ), variety, and sowing dates. Growth and yield were better in 2022 than in 2021 due to improved rainfall distribution. Soybean varieties generally performed better in the Northern Guinea Savanna (NGS) AEZ compared to the Sudan Savanna (SS) AEZ, owing to better soil fertility, higher rainfall, and longer growing seasons. TGX-1951-3F consistently outperformed TGX-1904-6F and TGX-1835-10E and was suitable for both AEZs, while TGX-1835-10E is better suited for the SS AEZ. TGX-1904-6F, a medium-maturing variety, is not recommended for the SS AEZ. Farmers should plant TGX-1835-10E and TGX-1951-3F between June 15-29 in the SS AEZ and June 15-July 6 in the NGS AEZ. TGX-1904-6F should be planted in the NGS AEZ between June 15-29 to avoid significant yield reductions. Due to unpredictable rainfall and the limited scope of short-term results, long-term simulation studies are needed to identify optimal sowing windows for broader areas in Northern Nigeria under changing climate.

REFERENCES

Adetayo, A. A. (2022). Effects of sowing date on growth and yield of some two varieties of soybean (*Glycine max*) in the forest-savannah agro-ecology of Nigeria. *Asian Journal of Plant Science Research, 12*(4), 302–308.

Akande, S. R., Owolade, O. F., & Ayanwole, J. A. (2007). Field evaluation of soybean varieties at Ilorin in the Southern Guinea Savanna ecology of Nigeria. *African Journal of Agricultural Research*, *2*(8), 356–359. https://doi.org/10.5897/AJAR.9000349

Aminu, Z., & Jaiyeoba, I. A. (2015). An assessment of soil degradation in Samaru Zaria area, Kaduna State, Nigeria. *IFE Research Publications in Geography, 13*(1), 27–37.

Atehnkeng, J., Ojiambo, P. S., Donner, M., Ikotun, T., Sikora, R. A., Cotty, P. J., & Bandyopadhyay, R. (2008). Distribution and toxigenicity of *Aspergillus* species isolated from maize kernels from three agro-ecological zones in Nigeria. *International Journal of Food Microbiology, 122*(1), 74–84. https://doi.org/10.1016/j.ijfoodmicro.2007.11.062.

Bastidas, A. M., Setiyono, T. D., Dobermann, A., Cassman, K. G., Elmore, R. W., Graef, G. L., & Specht, J. E. (2008). Soybean sowing date: The vegetative, reproductive, and agronomic impacts. *Crop Science, 48*(2), 727–740. http://dx.doi.org/10.2135/cropsci2006.05.0292

Battisti, R., Sentelhas, P. C., Parker, P. S., Nendel, C., Camara, G. M. S., Farias, J. R. B., & Basso, C. J. (2018). Assessment of crop-management strategies to improve soybean resilience to climate change in southern Brazil. *Crop and Pasture Science, 69*(2), 154–162. http://dx.doi.org/10.1071/CP

Bebeley, J. F., Kamara, A. Y., Jibrin, J. M., Akinseye, F. M., Tofa, A. I., Adam, A. M., Kamai, N., & Solomon, R. (2022). Evaluation and application of the CROPGRO-Soybean model for determining optimum sowing windows of soybean in the Nigeria savannas. *Scientific Reports, 12*(1), 6747. https://doi.org/10.1038/s41598-022-10505-4

Calvino, P. A., Sadras, V. O., & Andrade, F. H. (2003). Development, growth and yield of late-sown soybean in the southern Pampas. *European Journal of Agronomy, 19*(2), 265–275. http://dx.doi.org/10.1016/S1161-0301(02)00050-3

Dawaki, U. M., Dikko, A. U., Noma, S. S., & Aliyu, U. (2013). Heavy metals and physicochemical properties of soils in Kano urban agricultural lands. *Nigerian Journal of Basic and Applied Sciences, 21*(3), 239–246. http://dx.doi.org/10.4314/njbas.v21i3.9

Dugje, I. Y., Omoigui, L. O., Ekeleme, F., Kamara, A. Y., & Ajeigbe, H. (2009). *Farmers' guide to cowpea production in West Africa* (p. 19). International Institute of Tropical Agriculture (IITA).

Ennin, S. A., Asafu-Agyei, J. N., Dapaah, K., & Asafo-Adjei, B. (2006). Relative time of planting and spatial arrangement for soybean/maize intercropping. *Ghana Journal of Agricultural Science, 38*(2), 47–54. https://doi.org/10.4314/gjas.v38i2.2106

FAO. (2018). *Food and Agriculture Organization database*. Rome, Italy: FAO. http://fao.org/faostat/en/data/QC

Gbegbelegbe, S., Alene, A., Kamara, A., Wiebe, K., Manyong, V., Abdoulaye, T., & Mkandawire, P. (2019). Ex-ante evaluation of promising soybean innovations for Sub-Saharan Africa. *Food and Energy Security, 8*(1), 1–16. https://doi.org/10.1002/fes3.172

Han, T., Wu, C., Tong, Z., Mentreddy, R. S., Tan, K., & Gai, J. (2006). Post-flowering photoperiod regulates vegetative growth and reproductive development of soybean. *Environmental and Experimental Botany, 55*(1-2), 120–129. http://dx.doi.org/10.1016/j.envexpbot.2004.10.006

Ibrahim, S. E. (2012). Agronomic studies on irrigated soybeans in Central Sudan. II. Effect of planting date on grain yield and yield components. *International Journal of Agricultural Sciences, 2*(7), 766–773.

Kamara, A. Y., Bebeley, J. F., Aliyu, K. T., Tofa, A. I., Omoigui, L., Solomon, R., & Akinseye, F. M. (2023). Simulating potential yield of rainfed soybean in northeast Nigeria. *European Journal of Agronomy, 142*, 126683. https://doi.org/10.1016/j.eja.2022.126683

Khojely, D. M., Ibrahim, S. E., Sapey, E., & Han, T. (2018). History, current status and prospects of soybean production and research in Sub-Saharan Africa. *Crop Journal, 6*(5), 393–405. http://dx.doi.org/10.1016/j.cj.2018.03.006

Omoloye, A., Joda, A., & Tobih, F. O. (2015). Effects of planting dates and intra-row spacing on field infestation and damage by Hemipteran sucking bugs on soybean in Ibadan, Southwest Nigeria. *Journal of Agricultural and Environmental Sciences, 4*(1), 134–137. http://dx.doi.org/10.15640/jaes.v4n1a17

Samuel, A. F., Ji-min, K., & Sungtaeg, K. (2022). Current status of soybean production in Nigeria: Constraint and prospect. *Journal of Korean Society of International Agriculture, 34*(2), 149–156. https://doi.org/10.12719/KSIA.2022.34.2.149

Tofa, A. I., Chiezey, U. F., Babaji, B. A., Kamara, A. Y., Adnan, A. A., Beah, A., & Adam, A. M. (2020). Modeling sowing-date effects on intermediate-maturing maize in 193 contrasting environments in the Nigerian Savanna: An application of DSSAT model. *Agronomy, 10*(6), 871. https://doi.org/10.3390/agronomy10060871

Ugbabe, O. O., Abdoulaye, T., Kamara, A. Y., Mbava, J., & Oyinbo, O. (2017). Profitability and technical efficiency of soybean production in northern Nigeria. *Tropicultura, 35*(3), 203–214.

Umar, A., Wali, S., & Dankani, I. (2021). Characterization of monsoonal rainfall in the Sudano-Sahelian zone of Northwestern Nigeria. *Indonesian Journal of Earth Sciences, 1*(2), 123–135. http://dx.doi.org/10.52562/injoes.v1i2.261

Weber, G., Elemo, K., Lagoke, S. T. O., & Oiken, S. (1995). Population dynamics and determinants of *Striga hermonthica* on maize and sorghum in savanna farming systems. *Crop Protection, 14*(4), 283–290. https://doi.org/10.1016/0261-2194(94)00004-R

Yagoub, S. O., & Hamed, M. H. A. (2013). Effect of planting date on two genotypes of soybean (*Glycine max* Merrill.) grown under semi-desert region. *Universal Journal of Agricultural Research, 1*(3), 59–64. http://dx.doi.org/10.13189/ujar.2013.010303

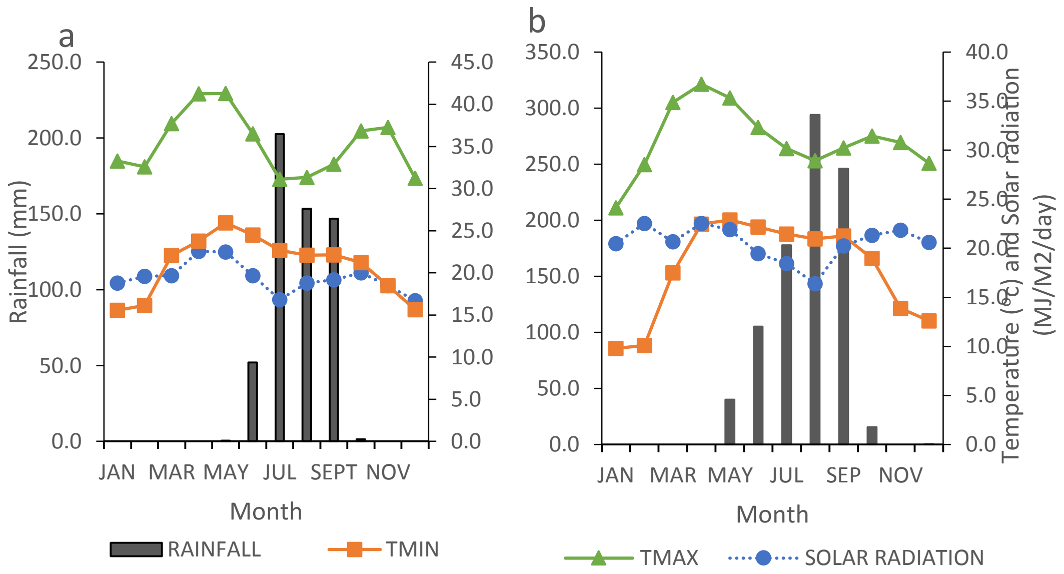

Figure 1. Monthly rainfall, Minimum and Maximum temperature (TMin and TMax in °C) and Solar radiation (SRAD) at BUK-KANO for (a) 2021 and (b) 2022 experimental years.

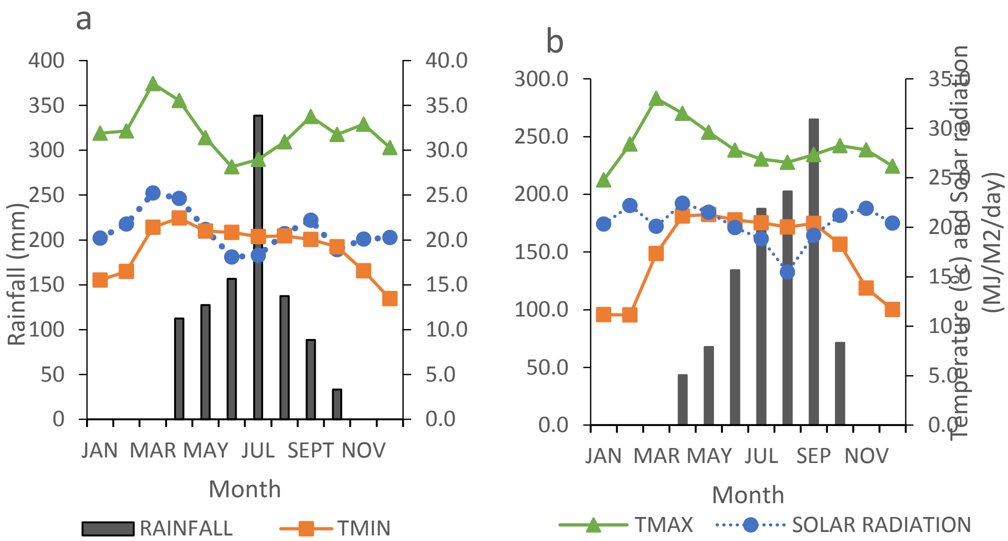

Figure 2. Monthly rainfall, Minimum and Maximum temperature (TMin and TMax in °C) and Solar radiation (SRAD) at Samaru Zaria for (a) 2021 and (b) 2022 experimental years.

Table 1. Interactive effects of variety and sowing dates on total dry matter of soybeans at two locations in the Sudan and northern Guinea savannas of Nigeria.

	Bayero University BUK-Kano				Samaru Zaria			
	Total Dry Matter (kg ha^{-1})							
Pdate	TGX-1835-10E	TGX-1904-6F	TGX-1951-3F	Mean	TGX-1835-10E	TGX-1904-6F	TGX-1951-3F	Mean
PD1	5870.1	6977.9	6453.4	6433.8	6042.4	7073	7133.5	6749.6
PD2	5582.8	5895.3	6260.3	5912.8	5675.9	6612	6537	6275
PD3	5245.3	5406.8	5449.3	5367.1	4885.9	5806.9	5588	5426.9
PD4	4648.7	4072.4	4605.2	4442.1	4433.9	4761.8	5021	4738.9
PD5	3795.8	3370.9	3706.5	3624.4	3768.7	4118.7	4457.4	4114.9
PD6	2837	3021.7	3531.6	3130.1	3393.5	3625.1	3847.3	3622
Mean	4663.3	4790.8	5001.1		4700.1	5332.9	5430.7	
LSD(5%)pd	410.26 **				318.28 **			
LSD(5%)var	290.11 ns				229.24 **			

PD1 = 15 June, PD2 = 22 June, PD3 = 29 June, PD4 = 6 July, PD5 = 13 July, PD6 = 22 June. ** = Highly significant at 5% level probability, * = Significant at 5% probability, ns = not significant.

Table 2. Interactive effects of variety and sowing dates on grain yield of soybeans at two locations in the Sudan and northern Guinea savannas of Nigeria

	Bayero University BUK-Kano				Samaru Zaria			
	Grain Yield (kg ha^{-1})							
Pdate	TGX-1835-10E	TGX-1904-6F	TGX-1951-3F	Mean	TGX-1835-10E	TGX-1904-6F	TGX-1951-3F	Mean
PD1	1938.9	1838.9	2041.8	1939.9	1947.2	2378.4	2351.5	2225.7
PD2	1996	1341.9	2084.3	1807.4	1885.2	2054.9	2145.6	2028.6
PD3	1626.2	1113.3	1539.8	1426.5	1787.9	1599.9	1880.2	1756
PD4	1423.6	877	1127.2	1142.6	1609.2	1446.1	1525.3	1526.9
PD5	971.5	325.8	662.9	653.4	1312.2	1176.2	1334.3	1274.2
PD6	736.5	172.3	565.5	491.4	1103.8	943.1	1218.5	1088.5
Mean	1448.8	944.9	1336.9		1607.6	1599.8	1742.6	
LSD(5%)pd	84.63 **				93.50 **			
LSD(5%)var	62.95 **				68.97 **			
LSD(5%)pdxvar	141.29 **				157.12 **			

PD1 = 15 June, PD2 = 22 June, PD3 = 29 June, PD4 = 6 July, PD5 = 13 July, PD6 = 22 June. ** = Highly significant at 5% level probability, * = Significant at 5% probability, ns = not significant.

EFFECT OF SULFURIC ACID AND HOT WATER TREATMENT ON GERMINATION OF TAMARIND (*T. indica*) IN DUTSE METROPOLIS

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ABSTRACT

This study investigated the effects of sulfuric acid and hot water treatments on the germination percentage and seedling growth of *Tamarindus indica* in Dutse metropolis. A total of thirty (30) seeds of T. indica were used, with each seed planted in a separate pot containing a mixture of sand and animal manure in a 2:1 ratio. The seeds were divided into three groups: ten (10) seeds treated with sulfuric acid, ten (10) seeds treated with hot water, and ten (10) seeds serving as a control group, all sown at a depth of 2 cm. The parameters measured included seedling height, number of leaves, and germination percentage.The highest germination percentage (80%) was observed in seeds treated with 50% sulfuric acid for a 30-minute soaking period. In comparison, seeds treated with hot water showed a germination percentage of (50%) after fifteen days. Seedlings from the sulfuric acid treatment reached an average height of 6.8 cm, while those from the hot water treatment reached 2.9 cm additionally, the average number of leaves was 5 for the sulfuric acid treatment and 3 for the hot water treatment. Given that concentrated sulfuric acid demonstrated the highest effectiveness in breaking seed dormancy, it is recommended to use this treatment for enhancing germination rates of Tamarind seeds, ensuring that the concentration and soaking duration are precisely controlled to maximize germination without damaging the seeds.

Key words: *Tamarindus indica*, sulfuric acid, hot water, soaking and germination

INTRODUCTION

Tamarindus indica, commonly known as tamarind, is a crucial tropical tree species renowned for its diverse applications in culinary, medicinal, and industrial fields. Widely cultivated across tropical regions, tamarind thrives in Nigeria's varied climates and soil types, where it is valued for its tangy fruit used in traditional dishes and beverages, as well as for its contributions to local medicine and agriculture. The tree's adaptability and economic importance make it a key species in Nigerian agroforestry, contributing to food security, economic development, and sustainable land management practices (Akinmoladun, 2020).

The fruit's pulp is a popular ingredient in many cuisines, while other parts of the tree are utilized in pharmaceuticals, textiles, and as fodder (Fenner *et al.*, 2019). Seed germination is a critical stage in the lifecycle of tamarind, influencing both the quality and quantity of subsequent crop yields. However, tamarind seeds often exhibit dormancy, a physiological state that prevents germination even under favorable conditions. This dormancy is an adaptive mechanism that ensures seeds germinate only when environmental conditions are optimal for seedling survival (Baskin & Baskin, 2018).

Overcoming seed dormancy is essential for successful cultivation and effective regeneration of tamarind trees, particularly in regions like Dutse, Jigawa State, where agricultural practices must adapt to local environmental challenges. Various seed treatments have been employed to break seed dormancy and enhance germination rates. These treatments include chemical, mechanical, and physical methods designed to weaken or alter the seed coat, making it more permeable to water and nutrients. Concentrated sulfuric acid, hot water, and other methods are commonly used to improve germination outcomes (Fenner *et al.,* 2019; Meyer & Poljakoff-Mayber, 2018).

This study investigates the effect of different seed treatments on the germination of Tamarindus indica in Dutse, Jigawa State. By evaluating the impact of chemical treatments, such as sulfuric acid and hot water, as well as the efficacy of various potting mixtures, the research aims to identify the most effective methods for breaking seed dormancy and promoting successful germination. The findings of this study are expected to provide valuable insights for improving tamarind cultivation practices and optimizing seedling production in the region.

METHODOLOGY

MATERIALS

Distilled water, Tamarind seeds, Sulphuric acid, Poly pots, Centimetre ruler, petri dish, masking tape, and Beakers.

SEED COLLECTION

The seeds of *Tamarindus indica* were collected using a random sampling technique from three different locations in Dutse, {Federal University Dutse; (Dutse main campus), Dutse Ultra-Modern Market and Jigawa State Agricultural Supply Company (JASCO)}. After dehulling the fruits, equal samples of seeds were combined to give one bulk population samples from which sub-samples were taken for each treatment method (hot water and sulphuric acid) and untreated (control), which gives a total number of 30 samples seeds for the research.

EXPERIMENTAL TREATMENTS:

- **T1:** Control (untreated seeds, soaked in distilled water)
- **T2:** Seeds treated with sulfuric acid (50%) for 30 minutes
- **T3:** Seeds soaked in hot water (100^0C) for 30 minutes

SEED VIABILITY TEST

Floatation technique was used for testing empty seeds or non-viable seeds that sink or settle down to the bottom of the container. In this experiment, 50 seeds of *T. indica* were soaked into a 200ml beaker containing water and observed for 10 minutes to identify the viable seeds.

FIELD EXPERIMENT

Field experiments were conducted at the biological garden of Federal University Dutse (FUD), Jigawa.

SOWING OF SEEDS AND GERMINATION COUNT

Ten seeds of *T. indica* were sown in poly pots containing sterilized soil and animal manure in the ratio 2:1 at 2cm depth. The seeds were covered with soil and soil saturated with water. Watering is carried out once in a day (early morning) and twice in a day after complete germination (i.e., early morning and late evening).

DATA COLLECTION

During early growth assessment, data on seedling height, leaf number were and germinating percentage of the treatments was collected at 5- days interval after complete germination.

LABORATORY INVESTIGATION

The following experiments were carried out in the Biology laboratory of the department of Biological Sciences Federal University Dutse, Jigawa state.

CHEMICAL SEED SCARIFICATION

Ten (10) samples of seeds were treated with concentrated sulphuric acid (H_2SO_4) contained in a beaker. The seeds were put in the sulphuric acid, having a concentration of fifty (50) percent for a period of thirty minutes (30 mins) as treatment time which is accompanied by stirring in order to ensure equal treatments of the seeds. The treatments were then washed thoroughly with distilled water and transferred to petri dishes and then taken to the field for germination assessment.

DATA ANALYSIS

Germination percentage was calculated for each treatment. Data was analyzed using ANOVA to determine significant differences between treatments.

RESULTS AND DISCUSSION

AVERAGE SEEDLING HEIGHT

Table 1 shows the average seedling height demonstrates that tamarind seeds treated with sulfuric acid and hot water showed the highest average seedling height compared to the untreated seeds (control). This corroborates with the work of Girma and Biruk (2022) who speculated that pre-germination treatments have a significant effect on germination and growth performance (height, stem diameter and number of leaves) of Tamarindus indica. Also with that of Ebeid *et al.* (2022) who stated that; the highest values of the growth parameters were obtained from applying concentrated sulphuric acid for 20 and 10 min., respectively. The study recommended sulphuric acid for 20 minutes for the best seed germination and seedling growth

AVERAGE LEAF NUMBER

Figure 2 presents the average leaf number of young tamarind seedlings that were subjected to different methods of breaking dormancy in which direct method was used to count the number of leaves during data collection at the intervals of five (5) days after the young seedling emerged. Treatment with sulphuric acid showed highest average leaf number, hot water treatment and control were at par. Results from Mane *et al.* (2020**)** indicated that sulfuric acid is more effective in promoting leaf development compared to other treatments. Tamarind seeds treated with sulfuric acid and hot water can lead to higher average seedling height compared to untreated seeds.

GERMINATION PERCENTAGE

Figure 3 shows the number of seeds that germinate after fifteen (15) days, and germination percentage of both the treatments. The table also shows that Conc. Sulphuric acid is the most effective mean of breaking the dormancy of tamarind seeds with 80% of germination rate. This is in line with studies conducted by Kumar *et al.* (2021), who reported that concentrated sulfuric acid treatment effectively breaks dormancy and achieves high germination rates, supporting its use in tamarind cultivation.

ANALYSIS OF VARIANCE

Table 1, shows the Analysis of variance (ANOVA) between the treatments administered i.e. Conc. Sulphuric acid (50%) and Hot water (100°C) on germination percentage. Significant differences between the treatments were observed at 0.5 (5%) level of significance. Fcal (33.36) > Ftab (3.49): The calculated F-value is significantly higher than the tabulated F-value, indicating that there is a statistically significant difference between the treatments at the chosen significance level. This suggests that the different treatments have a real effect on the the germination of tamarind seeds.

CONCLUSION

The research demonstrates that concentrated sulfuric acid treatment is the most effective method for overcoming seed dormancy in *Tamarindus indica*, achieving the highest germination rate compared to hot water treatments. This effectiveness is due to sulfuric acid's ability to significantly soften the seed coat, increasing its permeability to water and nutrients, and thus accelerating the germination process. Among the treatments, sulfuric acid proved to be more effective, promoting quicker and more uniform germination. These findings suggest that pre-treatment of tamarind seeds with sulfuric acid could be a viable method to improve germination success, potentially aiding in the cultivation and propagation of Tamarind in the region.

REFERENCES

Akinmoladun, F. (2020). Economic and Agroforestry Potential of Tamarindus indica in Nigeria. *African Journal of Plant Science and Biotechnology*, 14(2), 65-72.

Baskin, C. C., & Baskin, J. M. (2018). *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination* (2nd ed.). Academic Press. ISBN: 978-0128098711.

Baskin, C.and Baskin, J: (2018). Seed dormancy and how is related to germination. Retrieved from http://www.seedbilogy.com/seed/ac.

Ebeid, A. F. A Amr, M. M. Mahmoud, and Mona, M. A. Mostafa (2022): Effect of some pre-sowing treatments on seed germination and seedling growth of Melia azedarach l. and Tamarindus indica l. trees. *Journal of Sohag Agriscience* (JSAS) 2022, 7(1):100-1 07.

Fenner, M., & Thompson, K. (2019). *The Ecology of Seeds*. Cambridge University Press. ISBN: 978-0521875134.

Girma, M., & Biruk, A. (2022). *Effectiveness of Seed Treatments on Breaking Dormancy and Enhancing Germination of Tamarindus indica L. Journal of Agricultural and Environmental Sciences*, 12(3), 102-113.

Kumar, S., Sharma, S., & Chauhan, R. (2021). *Effect of Pre-Treatment Methods on Germination and Seedling Growth of Tamarindus indica L. Journal of Agricultural Sciences*, 13(4), 235-245.

Mane, A. K., & Chavan, D. S. (2020). *Comparative Effects of Seed Treatments on Germination and Seedling Growth of Tamarindus indica L. International Journal of Plant Research*, 10(2), 151-158.

Pugalenthi, M., Gopalakrishnan, S., & Kumar, S. (2018). Tamarind (Tamarindus indica L.): A Comprehensive Review of its Cultivation, Uses, and Nutritional Benefits. *Journal of Agriculture and Food Research*, 14(3), 110-125.

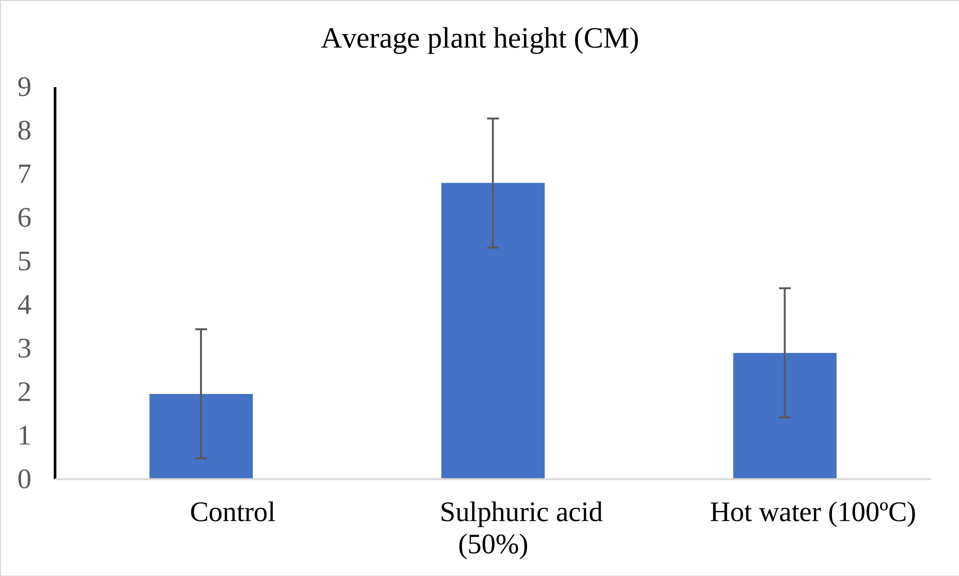

FIGURE 1. Average Seedling height (cm)

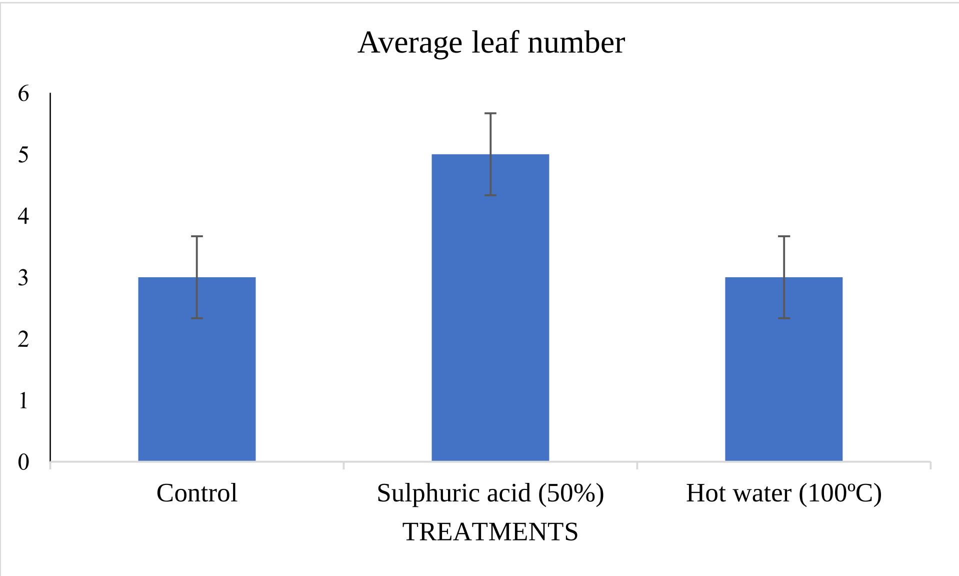

FIGURE 2: Germination percentage rate (%)

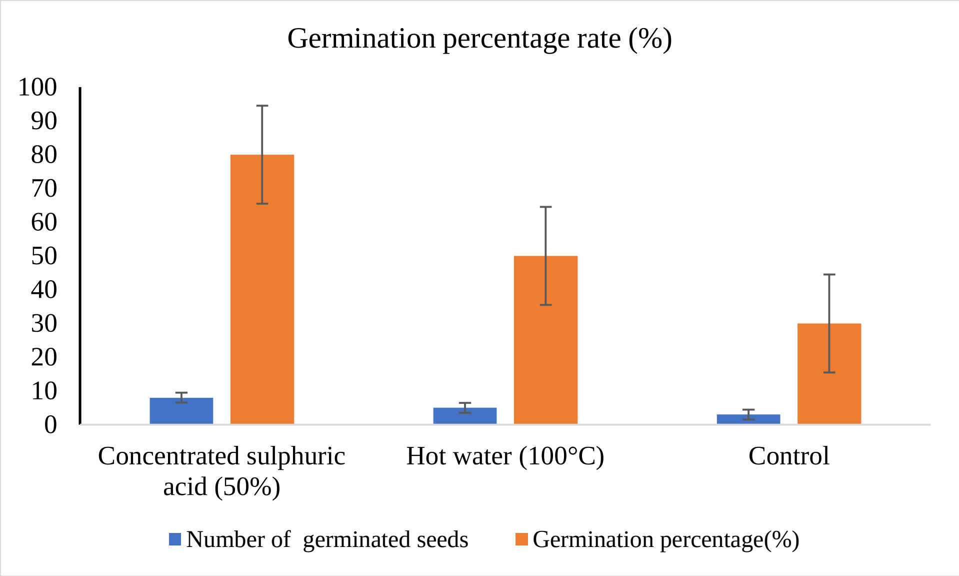

FIGURE 3. Average leaf number

Table 1: ANOVA Table showing the significant differences observed

S V	Df	SS	MS	Fcal	Ftab
Treatments	2	144.12	72.06	33.36	3.49
Error	20	43.1	2.16		
Total	22				

KEY: α = 0.5 (5%), Coefficient of variation (CV) = 13.7%, DFF=degree of freedom, SS=Sum of Squares, MS= Mean separation, Fcal=F value calculated, Ftab=F value tabulated.

AMELIORATING THE MOISTURE STRESS OF GRAIN AMARANTH (*Amaranthus cruentus* L.) THROUGH THE APPLICATION OF FISH GUANO AND ABSCISIC ACID

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ABSTRACT

Understanding how organic fertilizer and growth inhibitors impact plants in different environmental conditions is crucial for improving sustainable and efficient crop production in a changing climate scenario. Field trials were conducted during 2021/2022 dry seasons to determine the effects of fish guano (FG) and abscisic acid (ABA) on growth and yield of grain amaranth under moisture stress conditions. The trials were conducted at Bayero University Kano and AlikoDangote University of Science and Technology, Wudil research and Teaching farms. Treatments consisted of induced moisture stress at vegetative, flowering and grain filling; 0, 0.1 and 0.2kg of fish guano fertilizer and 0, 20 and 50µmolL^{-1} of ABA whichwas laid out in a split-plot design and replicated three times. Moisture stress was assigned to the main plots while FG and ABAwere factorially combined and assigned in the subplots. Data were collected on plant height, crop growth rate (CGR), fresh weight and dry weight and were subjected to analysis of variance (ANOVA) using Genstat 17th edition. Significant treatments were compared using the Student Newman Keuls Test (SNK). The results showed that moisture stress had no significant influence on the Plant height, CGR, fresh and dry weight. There was significant difference of FG at 0.2kg and ABA at 20 and 50 µmolL^{-1} on plant height (83.5kg/ha).On the other hand, ABA had a highly significant influence on the plant height ($p<.001$), CGR ($p=0.042$), fresh and dry weight ($p<.001$) with 0.2kg/ha FG and 50µmolL^{-1}performing the best on the growth characters. This could be recommended for production of grain amaranth in regions of low or deficit rainfall.

Key words: Moisture Stress, Grain Amaranth, Fish Guano and Abscisic Acid

INTRODUCTION

The genus *Amaranthus*, also referred to as amaranth, is a diverse group of seasonal or close to the end perennials with about 60 species. Consequently, amaranth is a promising food source that can enhance well-being and lower the incidence of metabolic diseases(Moazma *et al*.,2024).It contains more protein than other crops like corn and rice and essential amino acids (Soriano-García*et al*., 2018).Fish guano is rich in nutritional values through the maintenance and development of the micro-fauna and micro-flora of the soil Abscisic acid regulates various physiological processes, including stomatal opening, protein storage and provides adaptation to plants' stresses (Sah *et al*., 2016).The production and consumption of grain amaranth remains low (World Vegetable Centre, 2019)as it is mostly consumed by resource-poor farmers to supplement and complement the starchy staple meals (Gerrano *et al*., 2015).There is limited information on the role of increased fertilization rate and abscisic acid concentrations in mediating plant responses to moisture stress in grain amaranth. Application of fish guano can provide readily available nutrients to support the plant's physiological processes under moisture stress conditions, when the uptake of nutrients is challenging due to reduced root activity. Application of ABA can enhance the plant's ability to cope with moisture stress by triggering various physiological and biochemical changes that will improve the plant's resilience and growth under moisture stress conditions. This study was carried out to examine the effects of FG and ABA on growth and yield of grain amaranth under moisture stress.

MATERIALS AND METHODS

Treatments and Experimental Design

Treatments consisted of stress at vegetative, flowering and grain filling, Fish guano at 0, 0.1 and 0.2kg and ABA concentration 0, 20 and 50µmolL^{-1}which were laid out in a split plot design with three replications. The imposed moisture stress was assigned to the main plot while FG and ABA were combined and assigned to the sub plot. Both trials were conducted at Bayero University Kano and Aliko Dangote University of Science and Technology, Wudil Wudil during the dry season of 2021 and 2022.

Preparation of Stock Solutions

Fish guano powder was suspended in 4L of distilled water, mixed thoroughly and diluted to the prescribed rates and sprayed across seedlings using the handheld watering can (Angibaud, 2016). A stock solution of ABA was prepared by mixing 100mg ABA powder in 1ml ethanol. A weighed quantity of ABA was added in a graduated cylinder and 1L was made in a volumetric flask by adding distilled water. (PhytoTechnology, Laboratories, 2016).

Cultural practices

The experimental sites were cleared, ploughed and harrowed to obtain a fine tilt soil and divided into plots of 3 x 4.5 m (13.5 m^2) of 6 rows each. Ten seedlings were transplanted on each of the 6 rows at a depth of 2cm with a spacing of 75cm x 30cm between stands. Weeding was done three times using hoe. Garlic extracts were applied at each moisture stress stage to control leaf miner.

Data collection

Plant height (Cm)

Five randomly selected plants were measured using a meter scale tape in each of the net plots at 4, 8 and 12WAT on 5 tagged plants.

Crop growth rate (Kg/Ha): $CGR = \frac{W_2 - W_1}{P(T_2 - T_1)}$

P= Ground areaW_1= initial dry weight of plant/m^2 recorded at time t_1, W_2= final dry weight of plant/m^2 recorded at time $t_2$$T_1$ and T_2 will be the interval of time.

Fresh and dry weight (Kg/Ha^{-1})

Fresh plant samples were measured at harvest using a weighing scale balance and then oven dried. The means were collected and the average was recorded.

Data analysis

Data collected was subjected to analysis of variance (ANOVA) using Genstat 17th edition. Significant treatment means were separated using Student Newman-Keuls at P<0.05.

RESULTS AND DISCUSSION

Plant height

The results revealed no significant ($P \leq 0.05$) effect of moisture stress on plant height at all sampling periods in 2021 and 2022 at both locations (Table 1). The FG had significant (p<0.05) effect on plant height of grain amaranth at 8 and 12WAT at BUK in 2022 season as well as 12WAT in 2022 at Wudil. There was linear and progressive increase in plant height with increasing rates of fish guano at 8WAT in 2022 at BUK. A similar trend was observed at 12WAT in 2022 at both locations. This agrees with the assertions of Davies (2009) who stated that FG is a high-quality organic fertilizer that contain natural ingredients that have the ability to promote vigorous growth for outdoor vegetables. Similar findings have been reported by Jamil *et al*. (2014) and Nurhasliyana *et al.* (2022).The ABA concentration showed significant (p<0.05) effect on plant height of grain amaranth except at 4WAT at BUK in 2021.Plant height increased with increasing ABA concentrations across the seasons and locations(**Table 1**).The result also showed significant interaction (p>0.05) of FG x ABA at 12 WAT in 2022 with 0.2kg FG x 50µm ABA (102.3cm) recording the tallest plant while 0kg FG × 0µm ABA recorded the shortest plant (42.0cm**) (Figure 1)**.This corroborates with the findings of Skineh *et al*.,(2023) who reported that ABA concentrations combined with organic manure at different irrigation management is an effective strategy to improve the growth and yield of crops by alleviating the adverse effects of drought stress on crops.

Crop growth rate (CGR)

Moisture stress stages had significant (p<0.05) effect on CGR only at 4WAT at BUK in 2022 season while no significant effect was observed in other sampling periods and locations (**Table 2**) Stress imposed at flowering stage significantly recorded higher crop growth rate than when stress was imposed at vegetative and grain filling stages. This is in line with the findings of

Ardakani *et al*. (2005), who reported that water deficit stress, at, vegetative or at flower initiation stages of sunflower reduced CGR. According to (Hussain *et al.,* 2012), water deficit decreased mitosis, cell expansion and elongation which causes decrease in CGR. The FG rate had no significant influence on CGR at all sampling periods in both season and locations. The ABA had significant ($p<0.05$) effect on CGR only at 8WAT in 2022 at Wudil while non-significant effect was observed in other sampling periods and location. The CGR increases significantly with increasing ABA concentration at 8WAT in 2022 at Wudil. This corroborates the findings of Unyayar *et al.,* (2004) who reported that application of ABA increased CGR of sunflower. The interaction of stress and FG on CGR of grain amaranth was highest (0.51) at vegetative x 0.2kg FG followed by vegetative x 0kg FG (0.50) and the least recorded at grain filled x 0.2kg FG (0.22) (**Figure 2**).

Fresh weight (FW) and dry weight (DW)

Imposed moisture stress stages and FG rates had no significant ($p>0.05$) effect on FW and DW of grain amaranth at all sampling periods in both seasons at both locations(Table 2). However, ABA had significant ($p<0.05$) effect on FW and DW of grain amaranth in both seasons at BUK as well as in 2022 season at Wudil. The FW and DW increased significantly with increasing ABA concentrations at both seasons at BUK as well as 2022 season at Wudil. This agrees with the findings of Hussain *et al.* (2012) who reported that exogenous application of ABA increased dry weight of sunflower leaves which ultimately increased crop growth rate. The result also showed significant interaction of Stress x FG on FW and DW in 2021 at Wudil with 0.1kg FG with stress at flowering stage (5.16kg/ha and 2.58kg/ha) recorded the highest and 0.2kg FG at vegetative stress stage (2.57kg/ha and 1.17kg/ha) recorded the least FW and DW respectively **(Figures 3 and 4**).

Conclusion

Based on the findings obtained from this study, it can be concluded that the application of fish guano at 0.2kg significantly contributes to the provision of essential nutrients for promoting plant growth. Additionally, 50µMabscisic acid helps regulate plant responses to water stress at different stages. Therefore, applying 0.2kg/ha of fish guano fertilizer and a 50µM abscisic acid concentration can potentially improve grain amaranth growth during drought conditions.

References

Angibaud,Derome& Specialties (2016). https://www.angibaud.fr/en/ ISO 9001

Ardakani, M. R., Rad, A. H. S., Habibi, D. and Jahed, S. (2005). Effect of drought stress on quantitative and qualitative characteristics of oilseed rape (*Brassica napus* L.).

Interdrought-II,the second international conference on integrated approaches to sustain and improve plant production under drought stress; Rome, Italy, September, pp 132

Davies, Z. G., Fuller, R. A., Loram, A., Irvine, K. N., Sims, V. and Gaston, K. J. (2009).A national scale inventory of resource provision for biodiversity within domestic gardens. *Biological Conservation*, 142(4): 761-771.

Gerrano,A.S., Jansen-Van-Rensburg, W.S. and Adebola, P.O.(2015).Genetic diversity of *Amaranthus species* in South Africa. *South African Journal of Plant Soil*, 32:39-46

Hussain,S., Ali, A., Ibrahim, M., Saleem, Bukhsh, M. F. and M. A.(2012).Exogenous Application of Abscisic Acid for Drought Tolerance in Sunflower (*Helianthus annuus* L.). *The Journal of Animal and Plant Sciences*, 22(3): 806-826. ISSN: 1018-7081.

Jamil, A., Widowati, L.R. and Hartatik, W.(2014).Soil fertility management and fertilizer innovation to support the organic farming agriculture. Proceedings of the National Organic Agriculture.18-19 June 2014. Pp.: 1-14.

Moazma Sattar, Farhan Saeed, Muhammad Afzaa, Amara Rasheed, Aliha Asif, Sadia Sharif, Muzzamal Hussain, Hafiz Asad Ur Rehman, Muhammad Ahtisham Raza, Haroon Munir & Entessar Al Jbawi.(2024).An overview of the nutritional and therapeutic properties of amaranth. *International journal of food properties*, 27:1,263-272, DOI:10.1080/10942912.2024.2304266

Nurhasliyana, R., Nik, M. and Syahmi, S.(2022).Effects of Guano manure on height growth and foliar nutrient concentrations of Selasih. *Science Heritage Journal*, 6: 27-30. 10.26480/gws.01.2022.27.30.

Phytotech Lab (2016). https://phytotechlab.com/biochemicals.html. Accessed on 3/4/2020

Sah, K.R., Reddy, S.K. and Li, J.(2016).Abscisic acid and abiotic stress tolerance in crop plants.*Frontiers in Plant Science.* 7:571. DOI: 10.3389/fpls.2016.00571.

Sakineh Darini, Syed Mehdi Naser Alaviabd Jalal Ghanbari. (2024).The effect of abscisic acid application on improving yield, yield components and water use efficiency of sesame(Sesamum indicum L.) under water-limited conditions. *Journal of crop science research in arid regions* Volume 6, issue 1- pg 229-244

Soriano-García, M., Arias-Olguín, I. I., Montes, J. P. C.,Ramírez, D. G. R., Figueroa, J. S. M., Flores-Valverde, E. andValladares-Rodríguez, M. R.(2018). Nutritional functional value and therapeutic utilization of Amaranth.*Journal of Analytical and Pharmaceutical Research*, 7(5):596–600. DOI: 10.15406/japlr.2018.07.00288.

Unyayar, S., Keles, Y. and Unal, E.(2004).Proline and ABA levels in two sunflower genotypes subjected to water stress. *Bulgaria Journal of Plant Physiology*, 30(3-4): 34-47.

World Vegetable Centre.(2019).The Asian Vegetable Research and Development Center. Tainan, Taiwan.v2.

Table 1: Effect of Fish guano and Abscisic acid concentrations on plant height (cm) of Grain amaranth under Moisture deficit conditions at BUK and Wudil during the 2021 and 2022 dry seasons

	BUK						Wudil					
	2021			2022			2021			2022		
	Weeks after transplanting (WAT)											
Treatments	4	8	12	4	8	12	4	8	12	4	8	12
Moisture deficit (MD)												
Vegetative	21.77	41.35	70.19	22.57	43.06	83.1	31.14	69.1	95.5	28.97	45.3	71.0
Flowering	22.06	42.75	69.32	22.66	46.70	79.4	29.82	67.9	93.1	28.37	46.5	68.4
Grain Filling	26.75	43.14	66.93	22.83	46.63	75.0	30.59	69.7	90.9	27.79	46.7	70.8
p-value	0.196	0.744	0.501	0.944	0.196	0.069	0.913	0.798	0.131	0.540	0.864	0.789
SE±	1.76	1.67	1.85	0.55	1.31	1.72	2.17	1.82	1.22	0.69	1.90	2.93
Fish guano (F) (kg)												
0	22.91	42.35	67.75	22.19	42.52b	74.8b	29.98	64.9	90.5	27.50	44.2	66.0b
0.1	24.12	41.46	71.66	23.75	46.44a	79.3ab	29.59	68.7	89.6	27.80	47.4	68.8b
0.2	23.55	43.43	67.03	22.11	47.42a	83.5a	31.98	73.1	99.4	29.83	46.9	75.3a
p-value	0.626	0.598	0.118	0.195	0.017	0.025	0.221	0.285	0.089	0.154	0.446	0.014
SE±	0.88	1.37	1.66	0.70	1.23	2.19	1.02	3.61	3.40	0.90	1.92	2.22
ABA (A) (µM)												
0	22.11	27.93c	37.93c	21.31b	41.97b	55.9c	25.24c	48.0c	66.8c	25.04b	36.0c	45.0c
20	24.13	44.49b	76.31b	22.17b	43.34b	81.4b	29.45b	72.8b	99.2b	28.97a	48.0b	76.9b
50	24.34	54.83a	92.19a	24.57a	51.07a	100.3a	36.86a	86.0a	113.5a	31.12a	54.6a	88.3a
p-value	0.153	<.001	<.001	0.006	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE±	0.88	1.37	1.66	0.70	1.23	2.19	1.02	3.61	3.40	0.90	1.92	2.22
Interaction												
S*F	0.182	0.218	0.937	0.980	0.192	0.782	0.422	0.497	0.638	0.237	0.417	0.222
S*A	0.088	0.655	0.790	0.560	0.506	0.854	0.053	0.662	0.843	0.431	0.199	0.661
F*A	0.292	0.670	0.559	0.556	0.594	0.562	0.390	0.731	0.565	0.434	0.790	0.022
S*F*A	0.583	0.203	0.014	0.607	0.675	0.703	0.383	0.187	0.008	0.908	0.613	0.572

Means followed by the same superscript (s) in a column within a treatment group are not significantly different at a 5% level probability using SNK

Table 1: Effect of Fish guano and Abscisic acid concentrations on Crop growth rate ($kgha^{-1}$), fresh and dry weight ($kgha^{-1}$) of Grain amaranth under Moisture deficit conditions at BUK and Wudil during the 2021 and 2022 dry seasons

	BUK								Wudil							
	2021				2022				2021				2022			
Treatments	CGR		FW	DW	CGR		FW	DW	CGR		FW	DW	CGR		FW	DW
	4 WAT		8WAT		4 WAT		8WAT		4 WAT		8WAT		4 WAT		8WAT	
Moisture deficit(MS)																
Vegetative	0.47	0.29	1.08	0.65	0.42ab	0.24	1.08	0.65	0.45	0.55	3.20	1.49	0.29	0.39	1.08	0.65
Flowering	0.42	0.33	0.99	0.52	0.48a	0.32	1.00	0.52	0.64	0.42	3.87	1.85	0.43	0.37	0.99	0.52
Grain Filling	0.33	0.34	1.17	0.68	0.34b	0.32	1.17	0.69	0.60	0.28	3.37	1.65	0.25	0.34	1.17	0.69
p-value	0.077	0.553	0.165	0.274	0.028	0.240	0.208	0.274	0.643	0.130	0.213	0.272	0.248	0.685	0.165	0.278
SE±	0.03	0.03	0.05	0.06	0.02	0.03	0.23	0.10	0.14	0.07	0.22	0.13	0.06	0.03	0.05	0.06
Fish guano (F) (kg)																
0	0.42	0.29	1.00	0.54	0.456	0.29	0.96	0.54	0.50	0.40	3.39	1.59	0.33	0.34	1.00	0.54
0.1	0.41	0.32	1.14	0.67	0.34	0.24	1.14	0.66	0.65	0.44	3.75	1.80	0.28	0.38	1.13	0.67
0.2	0.39	0.35	1.12	0.65	0.45	0.35	1.12	0.65	0.55	0.40	3.30	1.60	0.37	0.38	1.12	0.65
p-value	0.849	0.467	0.352	0.266	0.151	0.187	0.348	0.261	0.203	0.838	0.587	0.677	0.245	0.679	0.355	0.263
SE±	0.03	0.03	0.07	0.05	0.04	0.03	0.05	0.05	0.05	0.05	0.32	0.18	0.04	0.04	0.07	0.05
ABA (A) (µM)																
0	0.43	0.03	0.73c	0.39c	0.49	0.25	0.73c	0.40c	0.57	0.34	3.80	1.87	0.333	0.30b	0.74a	0.04c
20	0.39	0.28	1.12b	0.64b	0.37	0.27	1.13b	0.64b	0.53	0.45	3.51	1.67	0.30	0.36ab	1.11b	0.64b
50	0.40	0.34	1.39a	0.82a	0.39	0.36	1.39a	0.82a	0.60	0.45	3.13	1.45	0.34	0.44a	1.39a	0.82a
p-value	0.523	0.307	<.001	<.001	0.199	0.095	<.001	<.001	0.701	0.330	0.356	0.299	0.774	0.042	<.001	<.001
SE±	0.03	0.03	0.07	0.05	0.04	0.03	0.05	0.05	0.05	0.05	0.32	0.18	0.04	0.04	0.07	0.05
Interaction																
S*F	0.036	0.833	0.140	0.074	0.182	0.222	0.169	0.078	0.363	0.805	0.032	0.022	0.357	0.121	0.144	0.079

S*A	0.059	0.696	0.822	0.732	0.962	0.995	0.790	0.812	0.326	0.904	0.172	0.260	0.415	0.467	0.824	0.815
F*A	0.629	0.883	0.640	0.788	0.304	0.269	0.693	0.792	0.282	0.657	0.225	0.321	0.024	0.124	0.644	0.791
S*F*A	0.619	0.991	0.133	0.402	0.303	0.991	0.159	0.404	0.847	0.271	0.711	0.392	0.967	0.489	0.136	0.404

Means followed by the same superscript(s) in a column within a treatment group are not significantly different at a 5% level probability using SNK. CGR = crop growth rate, FW = fresh weight, DW = dry weight, WT = weeks after transplanting

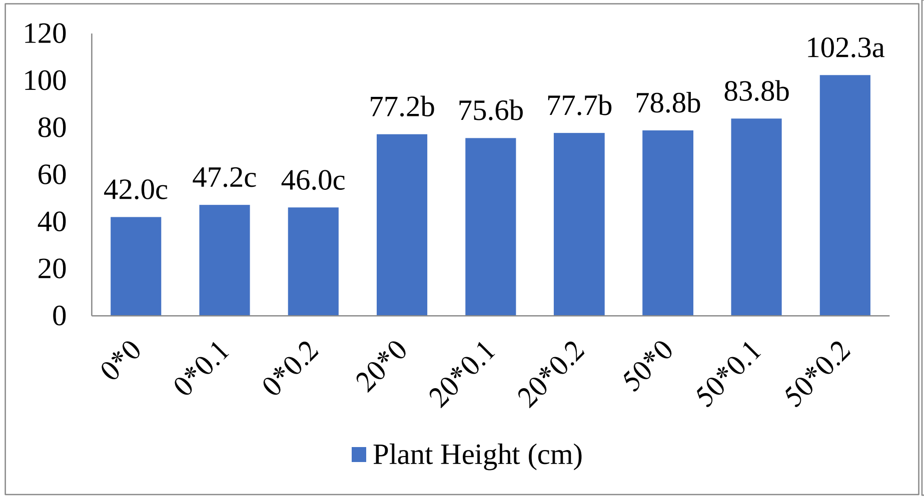

Figure 1: Fish Guano x Abscisic acid interaction on Plant height at 12WAT during 2022 dry season at Wudil

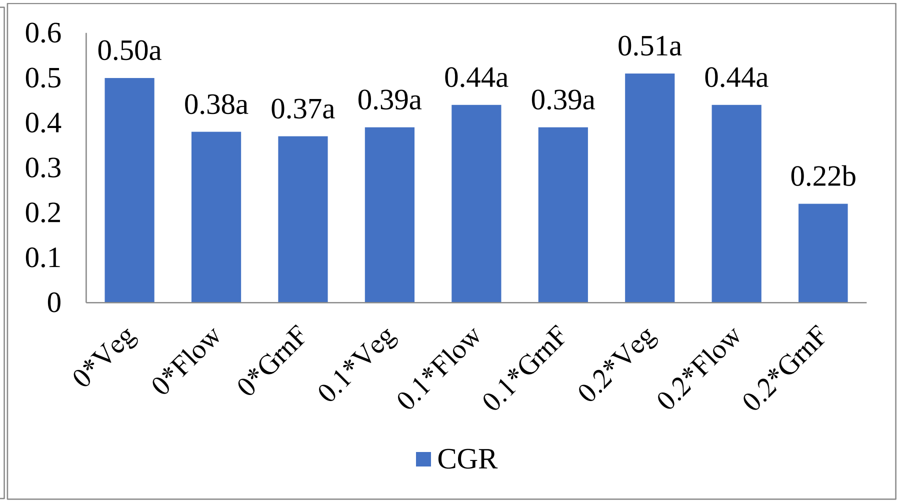

Figure 2: Stress x Fish guano interaction on Crop growth rate (kg/ha) of grain amaranth at 4WAT at BUK during 2021 dry season

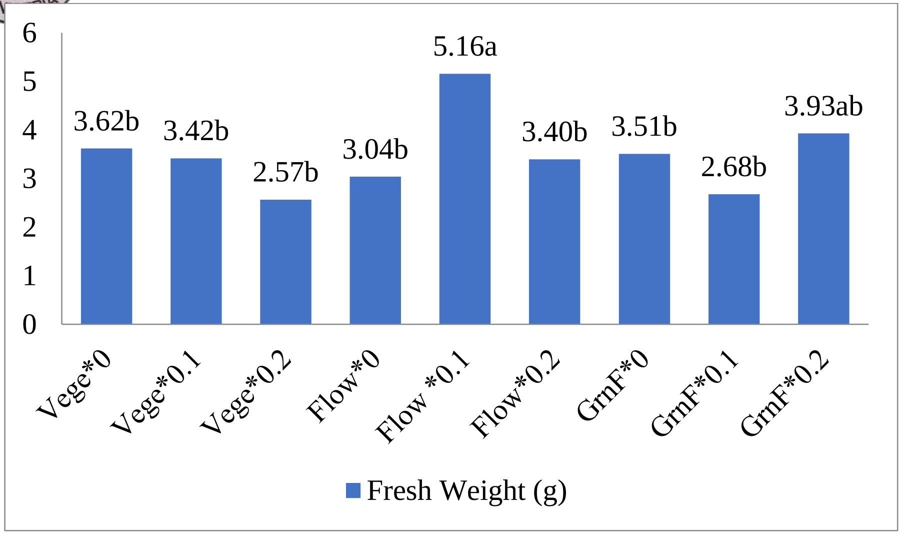

Figure 3: Stress x Fish guano interaction on fresh weight (kg/ha) of grain amaranth at Wudil during 2021 dry season

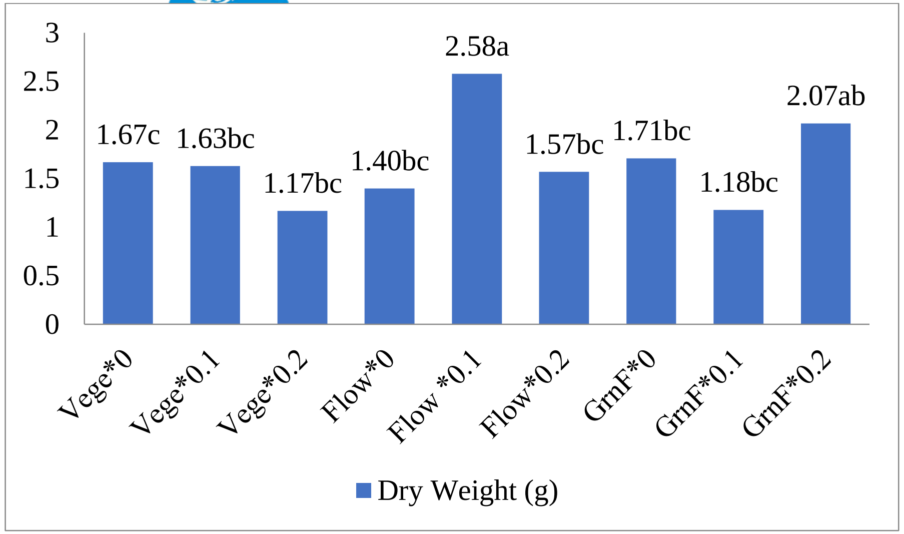

Figure 4: Stress x Fish guano interaction on dry weight (kg/ha) of grain amaranth at Wudil during 2021 dry season

EVALUATION OF CUCUMBER GENOTYPES FOR GROWTH AND YIELD ATTRIBUTES IN SOUTH-EAST NIGERIA

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ABSTRACT

Field experiment was conducted in 2020 in Calabar, Nigeria. To evaluate five genotypes of cucumber for growth and yield attributes. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Five genotypes of cucumber (Murano 2, Marketer, Poinsett, Poinsett + and local) were used for this experiment. The results showed that cucumber genotypes varied significantly across all the characters ($p<0.05$) except establishment count, number of leaves at 4WAS, 5WAS, 7WAS, vine length at 6WAS and 8WAS, number of fruits at 3rd harvest 6th harvest, fruit length at 3rd harvest and fruit weight at 3rd and 6th harvest ($p>0.05$).. Murano 2 and Poinsett + significantly performed better in the studied traits than all the other genotypes. They are therefore recommended for cultivation in this agro-ecology.

Key words: Genotypes, evaluation, yield, growth and performance

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to the family Cucurbitaceae. This family is made up of 118 genera and 825 species (Wang, *et al.,* 2007). Members of this family are distributed in tropical and sub-tropical regions of the world (Wang, *et al.*, 2007). It. is the fourth most important vegetable worldwide (Zhang *et al.*, 2002). According to (FAO, 2006), the most economically important cucurbits according to world total creation are water melon (*Citrullus lanatus*), Cucumber (*Cucumis sativus*) and melon (*Cucumis melo*). Cucumber has been cultivated for at least 3000 years (Ullah *et al.,* 2012) it is an important fruit with great nutritional, medicinal and economic potential. Cucumber is grown for its tender fruits, which are consumed either raw as salad, cooked as vegetable or as pickling in its immature stage (Khan *et al*., 2015)

Genetics of cucumber is an effective way to obtain greater variation and response to selection. Large variability ensures better chances of producing new forms of varieties. In Nigeria, the use of local unimproved varieties for production has resulted in very low cucumber yields (Ene-Obong, 2001) Non-accessibility of varieties well suited for specific production zones is one of the constraints to cucumber production in Nigeria. The solution to this problem is to select high yielding genotypes adapted to a particular agro-ecological zone.

This has necessitated this research work with the following objective. To evaluate five genotypes of cucumber for growth and yield attributes in humid tropical agro-ecology.

MATERIALS AND METHODS

The research work was carried out in Cross River State Agricultural Development Project (CADP), Calabar , Nigeria. from May-June , 2020 early cropping season. Calabar is located in the South Eastern zone of Nigeria with latitude (4.9757^{o}N, and longitude 8.3417^{o}E).

Treatments and Experimental Design

Five genotypes of cucumber (4 exotic and 1local landrace) were used for this research. The exotic genotypes; poinsett , murano 2, marketer and poinsett + were obtained from Technism Seed Company Calabar and local genotype was sourced from local farmers . A plot of land measuring 12.5m x 8m (100m$^{2)}$ was manually cleared using cutlass. The experiment was laid out in a Randomized Complete Block Design RCBD with 3 replications.

Cultural Practices

Two seeds each of the cucumber genotypes were sown per hole with a planting depth of 2cm. Each experimental unit measured 2m x 2m with an alley way of 0.5m. The planting distance was 50cm by 50cm giving a plant population of 80,000 plants per hectare, 400 plants in the entire field and 16 plants per plot.

Data Collection and Analysis

Data was collected on the following traits; emergence percentage (%), establishment count (%) number of leaves per plant, number of branches, vine length (cm), number of days to 50% flowering, days to male flower initiation, days to female flower initiation, days to fruit initiation, days to first fruits maturity. number of fruits per plant, fruit length (cm) and fruit weight (g). These were subjected to analysis of variance. Significant treatment means were separated using DMRT at 5% level of probability.

RESULTS

The results of the growth traits of the cucumber genotypes are presented in tables 1a and 1b. These showed that the percentage emergence, number of leaves, vine length and number of branches, were significantly different ($p<0.05$). Murano 2 had the longest vines across all the weeks. While poinsett+ had the shortest vines. The local had the highest number of branches across the weeks while marketer had the least number of branches.

The results of the flowering traits of 5 genotypes of cucumber are presented in Table 2. The flowering traits were all significantly different from each other (p< 0.05). The mean days to male flower initiation was (24 days). Local took longer days to initiate male flowers (30.00 days), followed by Poinsett (26.00 days), marketer took (22 days) Murano 2 and Poinsett + took (21.00 days) each. The mean days to female flower initiation was 28 days. Local took longer days to initiate female flower (34.00) followed by marketer 27, Poinsett + (27days), Poinsett (27days) and Murano 2 (24 days). It took local 34 days to 50% flowering, while marketer, Murano 2, Poinsett + and Poinsett took 26.00 days each to 50% flowering. It took local 37 days to initiate fruits. Marketer, Poinsett + and Poinsett took 31 days each to fruit initiation while Murano 2 took (25 days). Days to first fruit maturity ranged from 42 days in marketer to 48 days in local.

The results of the yield traits of the (5) five genotypes of cucumber is presented in Table 3a and 3b. The number of fruits per plant was significant (p<0.05) except at third and sixth harvest (p>0.05). There was significant difference in fruit length of the 5 genotypes of cucumber across all the harvest (P<0.05), except in the third harvest (p>0.05). The fruit weight of the five genotypes of cucumber differs significantly from each other (p<0.05) except in third and sixth harvest (p>0.05).

DISCUSSION

The significant variations in the growth traits of cucumber genotypes may be due to inherent genetic makeup of the genotypes. The variation in emergence, number of leaves, vine length and number of branches is due to varietal differences in vegetative growth. It was observed that murano 2 and local had better performance in the number of leaves, vine length, number of branches compared to marketer, poinsett and poinsett+. Highest number of branches tends to increase the femaleness of cucurbits and thereby results in increased yield. Similar estimation for this character in different cucumber genotypes were reported by (Pal *et al.,* 2017; Ranjian *et al.*, 2015). The higher number of leaves in the local genotype did not result to higher yields. This result is in agreement to the findings of (Pal *et al.*, 2017; Adinde, *et al.*, 2016; Ranjian *et al.*, 2015. The variation in the number of days to the reproductive traits might be due to genetic nature of the different genotypes as the environmental conditions were same for all the cucumber genotypes. Similar estimation was reported by (Adinde *et al.*, 2016).

The result of the yield traits of the five genotypes of cucumber showed that number of fruit per plant differed significantly among the five genotypes. Murano 2 and poinsett + had the highest number of fruits per plant compared to local, poinsett and marketer. (Adinde *et al.*, 2016, Mukhtar and Kayani, (2019) also reported that number of fruit per plant varied significantly among cucumber genotypes. The genotypes murano 2 and poinsett + had the longest fruits compared to local, poinsett and marketer. Longer fruits generally have greater contributions to the final yield. This result agreed with the results obtained by (Khan *et al.*, 2015, Mukhtar and Kayani, 2019).

Conclusion

The study showed that significant genotype variations in growth and yield traits exist among the cucumber genotypes. Murano 2 gave better performance for vine length, number of leaves, number of branches, it also had the highest number of fruits and produced the longest fruits with respect to fruit length. Murano 2 and poinsett + were early maturing and had better performances in the studied traits , these genotypes (Murano 2 and Poinsett +) are therefore recommended for further evaluation as high yielding and early maturing genotypes for cultivation in this agro-ecology.

References

Adinde, J. O., Anieke, U. B., Uche, O. J., Aniakor, A. C., Isani, L. C. and Nwagboso A. A. (2016). Assessment of performance of four cucumber (*Cucumis sativus* L.) cultivars in Iwollo, South-Eastern Nigeria. *International Journal of Current Research in Biosciences and Plant Biology*. 3(10): 136-143.

Adhikan , B. N ,Pokhrel ,B. B ,and Shresyha, J (2018). Evaluation and development of finger millet (*Elevsine coracana* .L) Genotypes for cultivation in high hills of Nepal. Farming and management 3(1): 37-46..

Eno-Obong, H. N. (2001). Eating right, University of Calabar, Press, Calabar, Nigeria. Pp. 161.

FAO (2006) Food and Agricultural Organization . Cucumber production in Pakistan.

Harian, J. R. (1975). Crops and man, Madison: American Society of Agronomy.

Hector, V., Randall, T. and Steve, F. (2005). Field cucumber production guidelines. Hawaii Cooperative Extension Agent, Pp. 1-7.

Khan, Z., Shah, A. H., Gul, R., Majid, A., Khan, U. and Ahmad H. (2015). Morpho-agronomic characterization of cucumber germplasm for yield and yield associated traits. *International Journal of Agronomy and Agricultural Research (IJAAR).* ISSN: 2223-7054. 6(1):11-6.

Mukhtar, T. and Kayani, M. Z. (2019). Growth and yield responses of fifteen cucumber cultivars to root-Kurt Nematode (*Moloidogyne incognita*). *Acta Sci. Pol. Hortorum Cultus.* 18(8):45-52.

Pal, Saheb. Hem Rahj, and Sharma Neha Yadav (2017). Evaluation of cucumber genotypes for yield and quality traits. *Journal of Hul Agriculture.* 8(2):144-150.

Ullah, M. Z., Hasan, M.J., Chowdhury, A. Z., Saki, A. I. and Rahman, A. H. M. A. (2012). Genetic variability and correlation in exotic cucumber (*Cucumis sativus*) varieties. *Bangladesh Journals*, 25(1): 13 - 21.

Wang, Y. H., Joobeur, T., Dean, R. A. and Staub, J. E. (2007). Genome mapping and molecular breeding in cucurbits. In: *Plant Breeding Reviews* 27:213-244.

Zhang, F., Wshi, Z Jin, Shen, Z. (2002). Response of antioxidance enzymes in cucumber chlororoplast to condmium toxicity. *Journal of Plant Nutrition*, 26(9):. 1779-1788.

Table 1a: Mean Values of Growth Traits Performance of 5 Genotypes of Cucumber

			Number of leaves					**Vine Length**				
Genotype	Emergence (%)	Establishment count (%)	4WAS	5WAS	6WAS	7WAS	8WAS	4WAS	5WAS	6WAS	7WAS	8WAS
Local	77.8^{a}	83.3	28.0	43.7	107.0^{a}	138.8	127.1^{a}	67.2_{ab}	81.9_{ab}	129.6	171.6^{ab}	169.4
Marketer	63.9^{ab}	75.0	20.1	33.2	64.3^{b}	68.4	54.7^{b}	55.3_{bc}	73.2_{abc}	109.3	110.3_{c}	101.0
Murano 2	69.9^{ab}	80.6	24.3	40.8	76.8^{b}	90.7	48.3^{b}	80.4_{a}	93.0_{a}	140.8	173.9_{a}	153.8
Poinsett	50.0^{b}	86.6	20.3	28.3	55.9^{b}	70.8	85.4^{ab}	52.1_{bc}	66.0_{bc}	78.0	123.1_{bc}	111.2
Poinsett+	80.6^{a}	86.1	23.6	36.4	59.1^{b}	56.5	87.7^{b}	42.5_{c}	54.6_{c}	88.7	100.5_{c}	93.6
		NS	NS	NS		NS				NS		NS
□	68.3	81.1	23.2	36.5	72.6	85.0	74.6	59.5	73.7	109.3	135.9	125.8

Keys: 4WAS – four weeks after sowing
5WAS – five weeks after sowing
6WAS – six weeks after sowing
7WAS – seven weeks after sowing
8WAS – eight weeks after sowing

Table 1b: Mean Values of Growth Traits Performance of 5 Genotypes of Cucumber

Genotype	Number of branches			
	5WAS	6WAS	7WAS	8WAS
Local	3.67_{a}	3.888_{a}	3.89_{a}	3.89_{a}
Marketer	2.72_{b}	2.833_{c}	2.83_{b}	2.83_{b}
Murano 2	3.61_{a}	3.611_{ab}	3.61_{ab}	3.61_{ab}
Poinsett	3.44_{ab}	3.500_{abc}	3.78_{a}	3.78_{a}
Poinsett +	2.89_{ab}	2.944_{bc}	2.94_{b}	2.94_{b}
□	3.27	3.555	3.41	3.41

Keys: 5WAS – five weeks after sowing
6WAS – six weeks after sowing
7WAS – seven weeks after sowing
8WAS – eight weeks after sowing

Table 2: Mean Values of Flowering Traits of 5 Genotypes of Cucumber

Genotype	Flowering Traits				
	Days to male flower initiation	Days to female flower initiation	Number of days to 50% flowering	Days to first fruit initiation	Days to first fruit maturity
Local	30.00_{a}	34.00_{a}	34.00_{a}	37.000^{a}	48.00_{a}
Marketer	22.67_{c}	27.67_{b}	26.00_{b}	31.000_{b}	42.00_{b}
Murano 2	21.00_{c}	24.00_{c}	26.00_{b}	25.333_{c}	35.67_{c}
Poinsett	26.00_{b}	27.33_{b}	26.00_{b}	31.000_{b}	41.67_{b}
Poinsett +	21.00_{c}	27.67_{b}	26.00_{b}	31.000_{b}	37.00_{bc}
□	24.13	28.13	27.60	31.067	40.87

Table 3a: Mean values of Yield Traits of 5 Genotypes of Cucumber

	Numbers of fruit per plant						Fruit length					
Genotype	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	6th harvest	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	6th harvest
Local	0.000_b	0.000_b	0.00	0.00_b	2.000_a	1.67	0.0_b	0.0_b	0.0	0.06_b	15.47_{bc}	14.67_b
Marketer	0.000_b	0.00_b	1.67	1.33_{ab}	2.000_a	1.33	0.0_b	0.0_b	17.5	13.8_a	17.22_a	15.30_b
Murano 2	0.667_a	1.67_a	1.33	1.67_a	1.667_b	1.33	15.2_a	19.5_a	15.5	18.9_a	17.09_{ab}	20.13_a
Poinsett	0.000_b	0.67_{ab}	0.33	2.00_a	1.000_b	1.00	0.0_b	5.2_b	5.8	19.2_a	14.48_{cd}	15.56_b
Poinsett+	0.000_b	1.33_a	1.00	1.33_{ab}	1.000_b	1.67	0.0_b	15.1_a	10.4	18.9_a	13.66_d	15.60_b
			NS			NS			NS			
□	0.133	0.73	0.87	1.27	1.533	1.40	3.0	8.0	9.8	14.2	15.58	16.25

Key:
NOFP 1 – Number of fruit per plant at 1st harvest
NOFP 2 – Number of fruit per plant at 2nd harvest
NOFP 3 – Number of fruit per plant at 3rd harvest
NOFP 4 – Number of fruit per plant at 4th harvest
NOFP 5 – Number of fruit per plant at 5th harvest
NOFP 6 – Number of fruit per plant at 6th harvest

FHL 1 – Fruit length at 1st harvest
FHL 2 – Fruit length at 2nd harvest
FHL 3 – Fruit length at 3rd harvest
FHL 4 – Fruit length at 4th harvest
FHL 5 – Fruit length at 5th harvest
FHL 6 – Fruit length at 6th harvest

Table 3b: Mean values of Yield Traits of 5 Genotypes of Cucumber

			Fruit weight			
Genotype	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	6th harvest
Local	0.000_b	0.000_c	0.000	0.000_b	0.453_a	0.487
Marketer	0.000_b	0.000_c	0.340	0.353_a	0.373_a	0.340
Murano 2	0.240_a	0.490_a	0.400	0.440_a	0.353_{ab}	0.497
Poinsett	0.000_b	0.017_c	0.100	0.420_a	0.243_c	0.307
Poinsett+	0.000_b	0.343_b	0.247	0.440_a	0.250_{bc}	0.497
			NS			NS
□	0.048	0.288	0.217	0.331	0.335	0.425

Key: FHW 1 – Fruit weight at 1st harvest

FHW 2 – Fruit weight at 2nd harvest

HW 3 – Fruit weight at 3rd harvest

FHW 4 – Fruit weight at 4th harvest

FHW 5 – Fruit weight at 5th harvest

FHW 6 – Fruit weight at 6th harvest

INFLUENCE ORGANIC AMENDMENTS ON THE PERFORMANCE OF VEGETABLE AMARANTHS (*Amaranthus cruentus* L.*)* IN DUTSIN-MA LOCAL GOVERNMENT AREA, KATSINA STATE

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ABSTRACT
This study was carried out to evaluate the performance of vegetable Amaranth (*Amaranthus cruentus* L.) as influenced by different sources of organic amendments in Dutsin-ma local government area, Katsina state. The experiment comprised of four organic amendments (Biochar 5tonha$^{-1,}$, goat litter 5tonha^{-1}, cow dung 5tonha^{-1}, and poultry manure 5tonha^{-1}) and untreated plot as control. These were laid out in a Randomized Complete Block Design (RCBD) with three replications. The result of the experiment showed that there were significant differences (p<0.05) in number of leaves, plant height, stem diameter, leave area, total fresh weight and total dry matter of amaranth. Application of goat litter and poultry manure produce the highest value at 2, 3, and 4WAS while at long run Biochar 5tonha^{-1} produce the higher value at 5 and 6WAS. Goat litter and poultry manure produce the highest fresh weight and dry weight15tonha^{-1} at 2, 3, and 4WAS while at 6WAS Biochar produce the highest tons of fresh weight and dry weight. Application of Biochar 5tonha^{-1} produced the highest value of all the parameters compared with no application of organic amendment. Biochar is recommended for improved and sustainable production of vegetable amaranth in the study area.

Key words: Amaranths, amendments, biochar, poultry manure.

INTRODUCTION

Amaranths is a leafy vegetable produced in almost all the states in Nigeria especially in the urban and peri-urban centers of the country (Shu`aib, 2017). It is an annual, herbaceous plant that is produced all the year round, depending on the availability of water, and is produced and consumed all over Nigeria to supplement the nutritional requirements of Nigerian households. In terms of origin, Amaranth originated from South America (Muhammaed *et al.*, 2017). It is one of the leafy vegetables often relied upon as cheap and affordable source of protein, vitamin A and minerals to combat the menace of malnutrition and maintenance of good health and prevention of diseases (Abdullahi, 2017). Furthermore, amaranth is one of the common indigenous vegetables produced and consumed in Africa as it serves as a cheap source of vitamins and proteins to both the rural and urban dwellers.

In Nigeria, Amaranth is commonly cultivated for its leafy vegetable and the grain receives little or no attention for consumption. This could be because of its low crop productivity and little awareness of the importance of the crop as most people refer to the grain as a minor crop. In Nigeria, it is called ‘tete’ in Yoruba, ‘alaiyaho’ in Hausa and ‘imne’ in Igbo (These are the major tribes in Nigeria). (Ogundare *et al.*, 2022). Schippers (2000) reported that Amaranthus accessions gave good yields when high levels of nitrogen were applied and it responded well to organic matter. Amaranths cultivation has emerged as an important field not only for enhancing nutritional levels especially of Indian diets, but also as a diversified profession for higher earnings. In order to make it competitive and profitable, it is important and necessary to introduce modern production technology. Timeliness of operations and judicious, efficient use of critical inputs is the key to achieve higher levels of quality and productivity. Vegetable seedlings are one of the most important and costly input in the modern vegetable crops production. Precision in the application of this input is vital in realizing the crop potential and returns. The exclusive use of inorganic nitrogenous fertilizer to improve crop production most of the time has a negative effect on semi-arid tropical soils as this increases soil acidity, which has been well reported by several researchers (Adefolaju *et al.*, 2016)

Decline in soil fertility has been identified as a major biophysical root cause for the declining per capital food availability from small holder farms in the tropical Africa (Adekiya *et al.*, 2018). In tropical soils, the use of synthetic fertilizer has not been sustainable due to its induced soil acidity, nutrient imbalance (Adekiya *et al*., 2018). Soil organic matter have significant effect on soil physio-chemical health, sequestration of carbon, controlling land erosion and protecting land from degradation (Adekiya *et al.,* 2018). Biochar application to soils in combination with either organic or inorganic fertilizer has been reported to have a pronounced effect on plant growth and yield (Simeon *et al*., 2018). Biochar can effectively retain NH_3, NH_4^+, and NO_3^- in animal manure (Adekiya *et al*., 2018). Recent studies demonstrated that bulking manure with Biochar reduced N loss while simultaneously enhancing humification, and producing mature manure with a high fertilizer value (Ishizaki and Okazaki 2018), thereby increasing the yield of crops. No field studies have been conducted in Nigeria to determine the effects of Biochar in combination with organic or inorganic fertilizer on crop yield.

The rising amounts of inorganic fertilizers and its negative effect on human health, soil structure and texture and environment insisted the farmer to apply integrated plant nutrient that increase the fertility of soil and yield of crops (Jilani *et al.*, 2021). Biochar application to soils in combination with either organic or inorganic fertilizer has been reported to have a pronounced effect on plant growth and yield (Dunsin *et al* 2018). Organic manure is an important agronomic option for sustainable soil management and crop production in the tropics. PM is a good nutrient source for both subsistence and commercial crop producers. Its use reduces inputs thereby increasing profit (Iyiola *et al.,* 2016). Nutrients, especially N and P are higher in PM compared with other animal manures (O. Dunsin *et al.,* 2016). Application of PM to amaranth may influence yield and quality including mineral and proximate compositions. Although PM has a positive effect on physical, chemical and biological soil properties in repeated application, or application above the required rate, may be a source of contaminants and may affect crop quality (Charity Aremu *et al.,* 2016).

The objective of the study was to determine the effect of organic amendment on the performance of amaranths and to describe their effect on fertility of the soil in Dutsin-MA Local Government Area (LGA) of Katsina state.

MATERIALS AND METHODS

Study Area

The study was conducted in Dutsin-Ma, Katsina State, Nigeria, in the Sudan savanna zone during the dry season.

Treatments and Experimental Design

The experimental treatments comprised of four organic amendments (Biochar 5tonha$^{-1,}$, goat litter 5tonha^{-1}, cow dung 5tonha^{-1}, and poultry manure 5tonha^{-1}) and untreated plot as control. These were laid out in a Randomized Complete Block Design (RCBD) with three replication.

Biochar Production

Biochar was produced by burning organic residues, including rice bran and sorghum leaves, in a pit for 24 hours.

Cultural Practices

The land was prepared using a tractor, and Amaranth seeds were sown with 10cm by 20cm spacing. Organic manure was applied according to treatment groups. Irrigation was carried out every two days, thinning was done a week after sowing, and manual weeding was performed regularly. Pests and diseases were managed using cypermethrin and pestox powder.

Data Collection and Analysis

Data on plant height, number of leaves, number of branches, leaf area, stem diameter, fresh and dry weights per hectare were recorded at 2, 4, 6, and 8 weeks after sowing (WAS). These were subjected to analysis of variance using SPSS version 26.0 AS as described in Rao (2007). Where means were found to have statistical difference, the treatments were compared using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1 shows the plant height of vegetable amaranth under the influence of different organic amendments. This shows that there is significant difference ($p<0.05$) in the height of amaranth at 2WAS with control (12.13cm) being the least and goat litter (20.83cm) with highest value obtained, Biochar and cow dung are statistically similar (15.53cm) and significantly higher than control and lower than goat litter and poultry manure. At 3WAS, greater increase in plant height of amaranths was recorded on plant treated with different 5ton/ha of organic amendment in which goat litter has the highest value (41.40cm) while poultry manure and cow dung are statistically similar with (32.53cm) and (31.10cm) respectively. Control (0ton/ha) produces the shortest plant (21.67cm). At 4WAS, significantly increase in plant height of amaranths was recoded on plant treated 5ton/ha of organic amendment in which biochar and poultry manure are the highest value obtain (51.43cm) and (50.57cm) respectively while plant treated with control 0ton/ha produces the shortest plant (31.15cm).

There is significant increase in plant height of amaranths at 5 and 6 weeks in which Biochar is the highest value obtained at both 5 and 6WAS (71.50cm) and (89.63cm) respectively because it serve as a conditioner in the soil and it also have higher carbon sequestration potential that is why it has lower height at 2, 3, and 4WAS than goat litters and poultry manure and has higher value obtained in 5 and 6WAS, While plant treated with control 0ton/ha produces the shortest plant (44.80cm) and (66.06cm) respectively.

Table 2 shows the number of leaves of vegetable amaranth under the influence of different organic amendment. The data were collected at 2, 3, 4, 5 and 6WAS. From the table it shows that there is significant difference ($p<0.05$) in the number of leaves of amaranth at 2WAS with control (7.667cm) being the least in which Biochar, goat litter, poultry manure and cow dung are statistically similar (10.000cm), (9.667cm), (10.333cm) and (10.333cm) respectively, and significantly higher than control. At 3WAS, table 2 shows there is significantly increase in number of leaves were recorded on plant treated with different 5ton/ha of organic amendment in which Biochar is the highest value obtained (13.67cm), there is not significant differences between goat litter and poultry manure at 3WAS but there is significant differences between Biochar and poultry manure. While plant treated with 0ton/ha control and cow with 5ton/ha produces the shortest plant (10.67cm) and (11.00cm) respectively.

This happen due to the very slow decay of cow dung in in the soil. At 4, 5, and 6WAS, Table 2 further revealed a significant increase in number of leaves were recorded on plant treated with different 5ton/ha of organic amendment in which Biochar is highest value obtained at 4, 5, and 6WAS. This happen due to the higher carbon sequestration potential of Biochar. While plant treated with 0ton/ha control and cow with 5ton/ha produces the shortest plant at 4, 5, and 6WAS.

Table 3 shows the leaf area of vegetable amaranth under the influence of different organic amendment. This shows that there is no significant difference in the diameter of amaranth at 2WAS. At 3WAS, it shows that there is significantly increase in leaf area from 2WAS to 3WAS in which Biochar is highest value obtained (41.18cm) while the remaining treatment are statistically similar. At 4WAS, significantly increase of amaranths was recoded on plant treated 5ton/ha of organic amendment in which Biochar and goat litter is the highest value obtained (63.43cm), Followed by poultry manure (53.78cm) and cow dung (43.11cm). While plant treated with 0ton/ha control produces the shortest plant (31.96). At 5 and 6WAS, greater increase in leaf area of amaranths was recorded on plant treated with different 5ton/ha of organic amendment in which Biochar is the highest value obtain at both 5 and 6 WAS (84.22cm) and (123.0cm) respectively. While goat litter and poultry manure are statistically similar at both 5 and 6WAS. Plant treated with 0ton/ha control produces the shortest plant at both 5WAS.

Table 5 shows the dry weight of vegetable amaranth under the influence of different organic amendment. This shows that there is significant difference ($p<0.05$) in the fresh weight of amaranth at 3WAS with control (0.1333ton/ha) being the least in which goat litter is the highest value (0.9333ton/ha) while the rest are statistically similar. At 4WAS, greater increase in dry weight of amaranths was recorded on plant treated with different 5ton/ha of organic amendment in which Biochar is highest value (2.900ton/ha), followed by poultry manure (2.633ton/ha), goat litter (2.033ton/ha) and control (0.867ton/ha) being the least. Significant increase in dry weight of amaranths was recoded at 6 WAS on plant treated 5ton/ha of organic amendment in which biochar is the value (4.667ton/ha) with control (1.733ton/ha) being the least while goat litter and cow dung are statistically similar.

CONCLUSION

From the results obtained in this study, it can be concluded that the application of biochar, goat litter and poultry manure has the initial potential to improve the performance of vegetables amaranth, however, at long run Biochar has the highest potential than all other amendments. Biochar is recommended for improved and sustainable production of vegetable amaranth in the study area. Application of goat litter and poultry manure produce the highest value at 2, 3, and 4WAS while at long run biochar 5tonha-1 produce the higher value at 5 and 6WAS. Goat litter and poultry manure produce the highest fresh weight and dry weight15tonha^{-1} at 2, 3, and 4WAS while at 6WAS Biochar produce the highest tons of fresh weight and dry weight. Based on this research Biochar is recommend for improved and sustainable production of vegetable amaranth in the study area and it can be repeated during dry season and raining season.

REFERENCES

A.O. Adekiya, T.M. Agbede, C.M. Aboyeji, O. Dunsin & V.T. Simeon (2018): Biochar and

Adekiya, A. O., Agbede, T.M., Ojeniyi, S.O. (2016). The effect of three years of tillage and poultry manure application on soil and plant nutrient composition, growth and yield of cocoyam. *Exp. Agric.* 52(3), 466–476.

Agbede, T. M., Adekiya, A. O., Eifediyi, E. K. (2017). Impact of poultry manure and NPK fertilizer on soil physical properties and growth and yield of carrot. *J. Hortic. Res.* 25(1), 81–88.

Akinrinde, E. A., Obigbesan, G. O. (2000). Evaluation of the fertility status of selected soils for crop production in five ecological zones of Nigeria. Proceedings of the 26th Annual Conference of Soil Science Society of Nigeria 279–288.

Alburquerque, J. A., Calero, J. M., Barrón, V., Torrent, J., del Campillo, M. C., Gallardo, A.,Villar, R. (2014). Effects of biochars produced from different feedstocks on soil properties and sunflower growth. *J. Plant Nutr. Soil Sci.* 177, 16–25.

Arif, M., Ali, A., Umair, M., Munsif, F., Ali, K., Inamullah, Saleem, M., Ayub, G. (2012). Effect of biochar, FYM and mineral nitrogen alone and in combination on yield and yield components of maize. *Sarhad J. Agric.* 28 (2), 191–195.

Baldock J. A, Smernik, R J. (2002). Chemical composition and bioavailability of thermally altered (Red pine) wood. *Org Geochem.* 33:1093–1109.

Beaton, J. D, Peterson, H. B, Bauer, N. (1960). Some aspects of phosphate adsorption by charcoal. *Soil Sci Soc Am J.* 24 (5):340–346.

Bessho T, Bell L. C. (1992). Soil solid and solution phase changes and mung bean response during amelioration of aluminium toxicity with organic matter. *Plant Soil.* 140:183–196.

Chintala, R, Schumacher, T. E, Kumar S, Malo, D. D, Rice, J. A, Bleakley B, Chilom G, Clay DE, Julson JL, Papiernik SK. (2014). Molecular characterization of biochars and their influence on microbiological properties of soil. *J Hazard Mater*. 279:244–256.

Dou L, Komatsuzaki M, Nakagawa M. (2012). Effects of Biochar, Mokusakueki and Bokashi application on soil nutrients, yields and qualities of sweet potato. *Int Res J Agric Sci Soil Sci.* 2(8):318–327.

Downie A, Crosky A, Munroe P. (2009). Physical properties of biochar. In: Lehmann J, Joseph S, editors. Biochar for environmental management: science and technology. London: UK: Earthscan; p. 13–32.

Fagbenro, J. A, Onawumi, O. A. (2013). The relevance of biochar technology to sustain soil productivity and crop production in organic farming systems. *Nigerian J Soil Sci.* 23(1):27–31.

Larney, F. J, Olson, B. M, Janzen, H. H, Lindall, C. N. (2000). Impart of topsoil removal and soil amendments on crop productivity. *Swedish Journal of Agronomy*. ; 92: 948-956.

Lehmann J, Gaunt J, Rondon M (2006). Biochar Sequestration in Terrestrial Ecosystems - A Review. Mitig Adapt Strateg Glob Chang 11: 403-427.

Rehman, H. A and Razzaq, R. (2017). Benefits of Biochar on the Agriculture and Environment – A Review. *J Environ Anal Chem* 4: 207. doi:10.41722380- 2391.1000207

Rondon, M. A, Molina, D, Hurtado, M, Ramirez J, Lehmann J. (2006) Enhancing the Productivity of Crops and Grasses while Reducing Greenhouse Gas Emissions through Biochar, pp. 138-168.

Sohi, S. P, Krull, E, Lopez-Capel E, Bol, R. (2010). A Review of Biochar and Its Use and Function in *Soil. Adv Agron* 105: 47-82.

Yanai Y, Toyota, K, Okazaki, M. (2007). Effects of Charcoal Addition on N2O Emissions from Soil Resulting from Rewetting Air Dried Soil in Short Term Laboratory Experiments. *Soil Sci Plant Nutr* 53: 181-188.

Table 1: Influence of organic fertilizers on plant height on the performance of amaranths

Amendment	2WAS	3WAS	4WAS	5WAS	6WAS
CR	12.13a	21.67a	31.15a	44.80a	66.07a
BCH	15.33b	34.63c	51.43c	71.50d	89.63d
CD	15.53b	31.10b	45.03b	57.73b	78.77b
GD	20.83c	41.40d	48.67c	68.17c	84.03c
PM	18.77c	32.53b	50.57c	69.10c	83.10c
SED	1.325	0.682	1.318	0.649	0.579

Keys: CR=Control, BCH=Biochar, CD=Cow Dung, GD=Goat Dropping, and PM=Poultry Manure.

Table 2: Influence of organic fertilizers on number of leaves on the performance of amaranths

Organic Fertilizer	2WAS	3WAS	4WAS	5WAS	6WAS
CR	7.667a	10.67a	17.00a	18.67a	24.33a
BCH	10.000b	13.67c	27.00d	40.67e	60.67e
CD	10.333b	11.00a	18.00ab	22.00b	40.67b
GD	9.667b	12.67b	19.33bc	31.67d	51.67d
PM	10.333b	11.67ab	21.00c	25.67c	45.00c
SED	0.624	0.641	0.738	0.641	0.691

Keys: CR=Control, BCH=Biochar, CD=Cow Dung, GD=Goat litter, and PM=Poultry Manure.

Table 3: Influence of organic fertilizers on leaf area on the performance of amaranths

Organic Fertilizer	2WAS	3WAS	4WAS	5WAS	6WAS
CR	7.93	29.73a	31.96a	46.08a	66.5a
BCH	12.80	47.18b	63.40d	84.22d	123.0d
CD	11.35	37.11a	43.11b	64.45b	90.9b
GD	10.01	35.02a	63.00d	81.42c	110.5c
PM	15.07	33.87a	53.78c	80.72c	111.6c
SED	3.17	3.90	0.888	0.985	2.318

Keys: CR=Control, BCH=Biochar, CD=Cow Dung, GD=Goat litter, and PM=Poultry Manure.

Table 4: Influence of organic fertilizers on fresh weight on the performance of amaranths

Organic Fertilizer	3WAS	4WAS	6WAS
CR	6.333a	10.30a	16.87a
BCH	9.400c	24.50c	36.00c
CD	8.000b	14.97b	25.97b
GD	7.900b	14.97b	33.43bc
PM	8.400b	24.60c	32.20bc
SED	0.3143	0.1183	3.67

Keys: CR=Control, BCH=Biochar, CD=Cow Dung, GD=Goat litter, and PM=Poultry Manure.

Table 5: Influence of organic fertilizers on dry weight on the performance of amaranths

Organic Fertilizer	3WAS	4WAS	6WAS
CR	0.1333a	0.867a	1.733a
BCH	0.4333b	2.900e	4.667d
CD	0.5333b	1.467b	2.633b
GD	0.9333c	2.033c	2.800b
PM	0.6000b	2.633d	3.737c
SED	0.0955	0.1011	0.1738

Keys: CR=Control, BCH=Biochar, CD=Cow Dung, GD=Goat litter, and PM=Poultry Manure.

EFFECT OF PLANT GROWTH REGULATORS ON THE YIELD AND GROWTH OF CARROT (*Daucus carota* L.) AS INFLUENCE BY VARIETIES AND IRRIGATION SYSTEMS

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ABSTRACT

Field experiment was conducted during the dry season of 2019/2020 and 2020/2021 at the Teaching and Research Farm of Bayero University Kano within latitude 12^0 58' N and longitude 8^0 25'E at an altitude of 458m, situated in Sudan Savanna Agro-ecological zone of Nigeria, to study the productivity of Carrot (*Daucus carota* L.) varieties as affected by gibberellic acid and water management strategy. Four (4) irrigation regimes (I_1 Farmer practice: 5 days at early vegetative stage, 7 days at juvenile to pre-flowering stage and 9 days at post-flowering to maturity stage) I_2 All irrigation at 5 days interval, I_3 All irrigation at 7 days interval, I_4 All irrigation at 9 days interval as control) was used as main-plot treatment, two (2) Varieties (V1 improved and V2 farmers variety) was used as sub plot, and four application period of GA^3 (G1: 100 ppm at vegetative stage, 100 ppm at flowering stage and 100 ppm at rooting stage, G2: 100 ppm at vegetative and 100 ppm at flowering stage and G3: 100 ppm at vegetative stage and G4: 0 ppm as control) was used as sub sub-plot treatments. These was combined and laid in a split- split plot design with three replications. The results from the analyzed data revealed that Farmer practice, had produced statistically better yield. The results also revealed that application of gibberellic acid 100 ppm increased significantly all growth characters as well as yield components, biochemical parameters were all increased with the increasing level gibberellic acid 100 ppm up to three times. Touchon mega variety had a varying and consistent results across. However, significant interactions in respect of gibberellic acid concentration and varieties, gibberellic acid concentrations and irrigation intervals as well as irrigation intervals and varieties were also recorded on growth and yield characters.

Key words: Carrot, Varieties, Irrigation Interval, Gibberellic acid

INTRODUCTION

The carrot (*Daucus carota L.*) belongs to the family Umbelliferae. It is related to celery, celeriac, coriander, fennel, parsnip and parsley, which are all members of this family. The carrot originated in Asia. Initially the roots were long and thin, and either purple or yellow in colors. These colors, as well as white and orange, still exist, with the orange or orange-red colors being by far the most popular today (Abbas, 2011). many shapes of roots also exist, from rather long and thin roots to short and thick. Roots may be cylindrical, conical, or even spherical in shape (Abbas, 2011).

Carrot roots are used as vegetables, and is an excellent source of carotene (1890 mg/100 g fresh weight) and precursor of vitamin A and fiber (Ali, *et, al.* 2014). It is an aromatic herb with diuretic and digestive properties, useful to stimulate uterus with anti-cancer properties and it increases the flow of urine, improves eyesight as well as skin health due to its rich source of beta-carotene (Algarra, *et al.*, 2014). Carrot is an important root vegetable because of its large yield per unit area and is consumed all over the world. It is grown mainly for its edible, swollen and fleshy tap root. The fleshy roots are eaten raw in salads boiled or steamed in vegetable dishes and is also used with other vegetable in the preparation of food (Khadijah, 2014). Carrots are particularly rich in carotene (pro-vitamin A), B1, C and essential oil, rich in vitamin E. Carrots also have large amount of carbohydrates and are low in protein and lipids. They are consumed either fresh, as a salad crop, or cooked. Large quantities are also processed, either alone or in mixtures with other vegetables, by canning, freezing or dehydration (Agnes, *et, al.2013*). and (Ahmed, 1998).

Carrot roots are valued as food mainly for its high carotene content. (Abbas, 2011). reported that, the nutrient content of carrot per 100g edible portion is: water (85%), energy (57 calories), protein (1.2g), calcium (27mg), vitamin A (10520 I.U), thiamine (0.04mg), riboflavin (0.05mg), and total mineral (0.9g). It is well known that smoking is hazardous to health, particularly by increasing the risk of cancer. But recent studies in medical sciences reported that smoker who consumes carrots daily have little risk of cancer (Khadijah, 2014). A carrot is an important vegetable for its high nutritive values and possible diversified use in making different palatable dishes and long storage life. Moreover, it has some important medicinal values (Kabir, *et, al.*2013). Carrot roots play an important role to protect the blindness in children providing vitamin A. Carrot is an excellent source of beta–carotene (red-orange pigment found in plants), our bodies turn beta–carotene into vitamin A, vitamin is important for good health, especially for good bones, teeth, vision and skin. Carrots are good source of fiber, vitamin C and potassium as well as Vitamin B6, folate and several minerals including calcium and magnesium (Khadijah, 2014).

The roots have been used in Traditional Chinese Medicine for the treatment of an ancylostomiasis dropsy chronic kidney disease and bladder afflictions, due to a wide range ofreported pharmacological effects, including antibacterial, antifungal, anthelmintic, hepatoprotective and cytotoxic activities (Fu, Hong-Wei, *et al* 2009). Most gardeners grow carrots for munching, salads, or juicing.

MATERIALS AND METHODS

Study area

The experiment was conducted during the dry season of 2019/2020 and 2020/2021 at the Teaching and Research Farm of Bayero University Kano within latitude 12^0 58' N and longitude 8^0 25'E at an altitude of 458m, situated in Sudan Savanna Agro-ecological zone of Nigeria,

Soil sampling and analysis

Soil of the experimental sites were collected at the depth of 0-30cm prior to planting. They were bulk analyzed for physicochemical properties using standard procedures as described by (Black, 1965). The soils were characterized as sandy loam with high pH, low organic carbon and very low nitrogen content medium available phosphorus and low cation exchange capacity

Treatments and Experimental Design

Four (4) irrigation regimes I_1 (Farmer practice, 5 days at early vegetative stage, 7 days at juvenile to pre-flowering stage and 9 days at post-flowering to maturity stage) I_2 All irrigation at 5 days interval, I_3 All irrigation at 7 days interval, I_4 All irrigation at 9 days interval as control) was used as main-plot treatment, Two (2) Varieties (V1 improved and V2 farmers variety) was used as sub plot, and four application period of GA^3 (G1: 100 ppm at vegetative stage, 100 ppm at flowering stage and 100 ppm at rooting stage, G2 100 ppm at vegetative and 100 ppm at flowering stage and G3 100 ppm at flowering stage and G4 0 ppm as control) was used as sub sub-plot treatments. These were combined and laid in a split- split plot design with three replications.

Data were collected on growth, yield components and root yield of carrot evaluated. These were subjected to analysis of variance (ANOVA) using GenStat 17th edition. Significant treatment means were separated using the Student Newman-Keuls test (SNK) at 5% level of probability.

RESULTS AND DISCUSSION

The results show that the more plant height affected significantly by the 100-ppm three times concentration of GA3 in comparison to the other concentrations frequency of application**.** The increase in plant height may be due to the effect of GA3 on the cell division and cell enlargement, and also GA3 stimulated the growth and expansion of cells through increasing the wall plasticity of cells (Salam *et al,* 2004). Significant variation was found in plant height due to the application of different concentration of plant growth regulators. The highest plant height at this stage was observed in GA3 100 ppm three times treatment which was statistically different to

GA3 100 ppm two times and GA3 100 ppm one-time treatments. The lowest plant height was recorded in control treatment. The 100 ppm three times concentration and frequency of gibberellic acid that resulted in a significant increase in the plant height, compared with other concentrations was due to the effect of the gibberellic acid which enhances the lateral buds, breaking apical dominance and vegetative growth and these results are in agreement with (Davis, 2000), which say the foliar application increases the shoot system such as plant high, number of leaf lateral buds, number of branch and number of flowers.

Root length was significantly influenced by any of the treatments in both seasons. In 2019/2020, the longest roots were obtained where 100 ppm three times GA3 was applied and in varieties where Touchon mega was used. It is generally assumed that root length is achieved 50 days after germination; temperatures between 20 and 24 °C favour early root growth (length) (Rubatzky *et al*. 1999). The average temperature during the first 50 days after sowing did not differ significantly from each other between 2019/2020 and 2020/2021 and were 24.77 and 24.25 °C, respectively, favourable for carrot root growth. In addition, the farmer practice irrigation intervals did not result in shorter roots compared to roots produced in 9-days irrigation intervals. The results obtained, showed significantly longer roots, however, when 100 ppm GA3 applied three times was combined with farmers practices irrigation intervals and Touchon mega.

The response of fresh yield and yield components of carrot on irrigation, variety and GA3 showed that whole-plant biomass, fresh leave weight, fresh root weight, harvest index and yield per hectare significantly ($p<0.05$) varied among the GA3 rates. The application of either 100 ppm three times or 100 ppm two times and 100 ppm one-time significantly increased the whole plant biomass defending on the frequency of application. With the variety, yield of Touchon mega significantly out growth Griffaton, the farmer irrigation intervals had impact on yield and its components. However, the variety Touchon which received 100 ppm three times GA3 gave the highest yield and in the whole plant biomass yield when compared with, farmer practice irrigation intervals which received no GA3 had the lowest root yield. Although, the lowest harvest index was found on Griffaton plots which received no GA3.

Carotene content increased significantly with increasing GA3 level at both 2019/2020 and 2020/2021 during sampling periods. Carotene content increased in response to farmer practice days irrigation intervals, irrigation intervals at 5 days interval, 7 days intervals and 9 days intervals respectively. The application of 100 ppm three times produced similar and significantly higher carotene content at both locations compared with the control treatment. Touchon mega significantly increased carotene content throughout the sampling periods at both 2019/2020 and 2020/2021 experiment.

Chlorophyll content of carrot, increased significantly with increasing GA3 level at both 2019/2020 and 2020/2021 during sampling periods. Carotene content increased in response to farmer practice days irrigation intervals, irrigation intervals at 5 days interval, 7 days intervals and 9 days intervals respectively. The application of 100 ppm three times produced similar and significantly higher carotene content at both locations compared with the control treatment. Touchon mega significantly increased carotene content throughout the sampling periods at both 2019/2020 and 2020/2021 experiment.

CONCLUSION

Carrot require adequate irrigation, the right amount of GA3, and variety. Carrots can grow in the environment and can be planted in a field, according to the results of the experiment. However, plot produced higher yields. The carrot variety (Touchon mega) were found to have adapted to the Kano environment, although the Griffaton variety is recommended for commercial carrot cultivation in the area. Within the limits of this study, it can be said that carrot plants can thrive with varying irrigation intervals. 100 ppm three times GA3 is the most economic plant growth hormones for the cultivation of carrots.

REFERENCES

Abbas. (2011). Effect of GA3 on Growth and Some Physiological Characterizes in Carrot Plant (*Daucus carota* L.) (2011), jjournal for pure & app. *Journal for Pure & Appl. Sci.*, 24 (3)

Abdul, K. S. (1987). Plants Growth Regulations. 1st and 2nd Edition. Ministry of higher education – Salahaden University – Iraq. (from Arabic)

Agnes, J., Joseph, N., and Mwanarussi, S. (2013). Improving Carrot yield through the use of bioslury manure. *Sustainable Agricultural Research*, 2(1): 164-172.

Ahmed, Z. A. (1998). The effect of nitrogen levels on phosphurus on the yield and yield attribute of carrot (Daucus carota L.) . *18th HORTSON* (pp. 160-165). IAR/ABU Zaria: Hortson.

Black, C. (1965). *Method of soil analysis II.* (C. a. Propertie, Ed.) Madison Wisconsin: American Society of Agronomy.

Davis, R. M. and Nunez, (2000). Influence of Gibberellic Acid on Carrot Growth and Severity of Alternaria Leaf Blight. University of California. Plant Disease 84:555-558

Fu, H.-W. Z.-K. (2009). A New of Daucus carota L. Molecules, .

Kabir, A., Ali, A., Waliullah, M. H., Mohay, & Rahman, M. M. (2013). Effect of spacing and sowing time on growth and yield of carrot (Daucus carrota L.). *Int. J. Sustain. Agric.,*, 5(1): 29-36.

Khadijah, A. (2014). *Growth, Yield and Quality Parameters of Carrots (Doucus Carrota) L. As Affected by Oganic Fertilizer and Gibberellic Acic (GA3).* Kano,, Gombe State,, Nigeria: Unpublished Project.

Kowal, J. M., & Knabe, D. (1972). *An Agro-climatologyAtlas of the Northern states of Nigeria.*

Matlub, A. N., Al–Lus, H. F., Mustafa, M. and Al – Hafez, M. (1984). Effect of some treatments of GA3 on Potato's Dormancy and its effect on autumn yield. *Zanko Journal* 3(2):49 – 69.

Michel-Wolwertz, M.-R. and Sironval, C. (1963). Inhibition of growth and accumulation of β-carotene in carrot roots by gibberellic acid. *Phytochemistry Journal*, 2(2): 183-187

Nieuwhof, M. (1984). Effect of gibberellic acid on bolting and flowering of carrot (Daucus carota L.). *Journal of Science Direct, Elsevier B.V.* 24 (3-4): 211-219

Salam, M.A., H.C. Mohanta., A.Q.M. Qamruzzaman., S.R. Saha and M.T. Rahman. (2004). Seed Yield of Cauliflower as Influenced by Plant Growth Regulators. *Journal of Sub-tropical Agriculture Res. Dev.* 2(2): 30-33.

Saleh, M. M.S. (1990). Physiology of plants growth hormones. 1st edition. Ministry of higher education – Salahaden University – Iraq. (From Arabic).

Santos, P., & Nunez, J. J. (2000). Influence of gibberellic acid on carrot growth and severity of Alternaria leaf blight. *Plant Dis.*, 84(4): 555-558.

Snedecor, G. a. (1967). *Statistical Method 6th Edition* . USA: lowa State University press.

Yahaya, S. U. (2011). *Effect of Gibberellic Acid concentration,Timing of application and Irrigation Interval on the Growth and Yield of Garlic (Allium sativum* L.). Kano: Unpublished Ph. D Thesis.

Table 1: Plant Height (cm) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (A3) at BUK during the 2019/2020 and 2020/2021 Dry Seasons.

Treatment	BUK 2019/2020				BUK 2020/2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Control	10.30b	28.76a	42.31a	55.84a	9.55b	26.78a	41.66a	51.09a
5 days	12.01a	26.59b	39.15b	48.96b	12.99a	24.30bb	34.74b	42.55b
7 days	9.16c	18.21c	29.25c	37.85c	7.01c	12.19c	17.51c	19.94c
9 days	5.76d	8.43d	11.10d	13.49d	6.25d	9.43d	12.58d	15.98d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.014	0.410	0.274	0.457	0.007	0.205	0.137	0.229
Variety (V)								
Touchon Mega	9.96a	22.79a	34.14a	42.86a	10.07a	20.66a	30.78a	37.29a
Griffaton	8.66b	18.20b	26.76b	35.21b	7.83b	15.20b	22.47b	27.49b
P-value	<.001	<.001	0.003	0.009	<.001	<.001	<.001	<.001
SE (±)	0.098	0.643	1.255	1.566	0.137	0.473	0.797	1.129
Gibrelic Acid (GA3)								
100ppm x3	11.42a	30.30a	42.18a	53.24a	11.75	27.05	39.29	48.25
100ppmx2	9.96b	24.47b	35.71b	44.70b	9.75	20.02	29.34	35.95
100ppmx1	8.97c	16.49c	29.23c	39.50c	7.71	13.83	23.81	28.78
Control	6.89d	10.73d	14.70d	18.70d	6.59	10.81	14.05	16.58
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.060	0.456	0.438	0.749	0.053	0.273	0.231	0.408
Interaction								
I × V	<.001	0.018	0.205	0.297	<.001	0.104	0.029	0.051
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	0.071	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	1.166	<.001	<.001	<.001	<.001	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance

Table 2: Root Length per plant (cm) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) BUK during the 2019/2020 and 2020/2021Dry Seasons

Treatment	BUK 2019/2020				BUK 2020/2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Farmer practice	4.12a	8.58a	14.17a	20.76a	4.31a	7.96a	14.10a	20.30a
5 days	3.70b	6.55b	11.45b	18.20b	4.00b	6.60b	12.51b	20.93a
7 days	2.93c	5.34c	8.19c	11.95c	3.22c	5.54c	9.18c	14.45b
9 days	1.99d	2.70d	7.14d	6.05d	2.68d	3.60d	5.79d	7.51c
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.041	0.019	0.078	0.106	0.007	0.205	0.137	0.229
Touchon Mega	3.55a	6.51a	10.73a	17.07a	3.84a	6.71a	11.81a	17.96a
Griffaton	2.97b	5.07b	9.74b	11.41b	3.26b	5.14b	8.97b	13.64b
P-value	0.002	0.008	0.004	<.001	<.001	0.010	0.011	0.011
SE (±)	0.09	0.292	0.179	0.682	0.035	0.168	0.601	0.925
Gibrelic Acid								
100ppm x3	4.03a	7.21a	15.23a	19.05a	4.67a	7.73a	14.74a	22.25a
100ppmx2	3.61b	6.55b	10.61b	16.33b	3.98b	6.81b	11.80b	18.21b
100ppmx1	3.10c	5.54c	9.08c	13.59c	3.26c	5.54c	9.63c	14.64c
Control	2.29d	3.88d	6.04d	8.00d	2.29d	3.60d	5.41d	8.09d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.051	0.058	0.098	0.270	0.008	0.041	0.056	0.081
Interaction								
I × V	0.037	0.633	<.001	0.082	<.001	<.001	0.371	0.519
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance.

Table 3: Carrot Yield (t ha^{-1}) as Affected by Variety, Irrigation, Gibberellic Acid (GA3) at BUK during the 2019/2020 and 2020/2021 Dry Seasons

Treatment	2BUK 019/2020	BUK 2019/2020
Irrigation (I)		
Farmer Practice	16.19a	13.83a
5 days	14.63b	13.36b
7 days	9.89c	7.79c
9 days	5.89d	5.32d
P-value	<.001	<.001
SE (±)	19.4	2.513
Variety (v)		
Touchon Mega	12.95a	11.85a
Griffaton	10.34b	8.33b
P-value	0.019	<.001
SE (±)	633.1	1.00
Gibrelic Acid		
100ppm x3	15.54a	13.98a
100ppmx2	13.53b	10.79b
100ppmx1	10.56c	8.97c
Control	6.96d	6.57d
P-value	<.001	<.001
SE (±)	136.6	35.0
Interaction		
I × V	0.934	<.001

I × GA3	<.001	<.001
V × GA3	<.001	<.001
I×V × GA3	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance

Table 4: Carotene content of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) at BUK during the 2019/2020 and 2020/2021 Dry Seasons

Treatment	BUK	
	2019/200	2020/2021
Irrigation (I)		
Control	4.15a	4.07a
5days	4.01b	4.05b
7days	3.03c	3.45c
9days	2.56d	3.26d
P-value	0.00	<.001
SE (±)	0.000	0.008
VARIETY (V)		
Touchon Mega	3.62a	3.85a
Griffaton	3.26b	3.60b
P-value	0.004	<.001
SE (±)	0.064	0.022
Gibrelic Acid (GA3)		
100ppm x3	4.01a	4.29a
100ppmx2	3.64b	3.99b
100ppmx1	3.39c	3.52c
Control	2.71d	3.04d
P-value	<.001	<.001
SE (±)	0.011	0.017
Interaction		
I × V	0.171	0.007
I × GA3	<.001	<.001
V × GA3	0.671	<.001
I×V × GA3	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance.

Table 5: Leaf Chlorophyll Content (umolm^{-2}) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) at BUK during the 2019/2020 and 2020/2021 Dry Seasons

Treatment	BUK 2019/2020				BUK 2020/2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Control	20.59a	22.92a	25.69a	28.91a	23.21a	27.22a	30.24a	32.35a
5 days	19.72b	21.05b	21.58b	23.87b	22.39b	22.92b	25.49b	7.72c
7 days	18.16c	19.28c	20.46c	21.09c	20.46c	21.00c	22.31c	3.53d
9 days	19.03d	19.79d	19.29d	19.65d	13.56d	17.66d	19.02d	19.97b
P-value	.00	0.00	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.000	0.000	0.765	0.000	0.253	0.047	0.000	0.232
VARIETY (V)								
Touchon Mega	19.65a	21.42a	22.74a	24.18a	20.57a	23.75a	25.81a	27.45a
Griffaton	19.09b	20.10b	20.79b	22.58b	19.24b	20.65b	22.72b	24.34b
P-value	<.001	0.014	<.001	<.001	<.001	<.001	<.001	0.003
SE (±)	0.027	0.301	0.000	0.111	0.181	0.107	0.027	0.509
Gibrelic Acid (GA3)								
100ppm x3	21.27a	22.31a	23.43a	25.45a	21.03a	25.40a	27.77a	29.08a
100ppmx2	20.22b	21.11b	22.29b	24.09b	20.25b	25.05b	25.88b	7.89c
100ppmx1	20.04b	20.31c	21.52c	23.17c	19.74c	21.55c	22.47c	4.68d
Control	15.98c	19.31d	19.80d	20.81d	18.62d	17.77d	20.94d	21.92b
P-value	<.001	<.001	<.001	0.00	<.001	<.001	<.001	<.001
SE (±)	0.084	0.236	1.165	0.053	0.264	0.076	0.084	0.270
Interaction								
I × V	<.001	0.299	<.001	<.001	<.001	<.001	<.001	0.014
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.035
V × GA3	<.001	0.082	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	0.002	<.001	<.001	<.001	<.001	<.001	0.003

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance.

GROWTH AND YIELD OF ONION (*Allium cepa* L.) AS AFFECTED BY INTRA ROW SPACING, VARIETY AND NITROGEN AT DADINKOWA GOMBE STATE NIGERIA

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ABSTRACT

To address the negative impact of variation in row spacing and nitrogen application rates in the management practice that affects output and profit margin of Onion farmers in Dadinkowa Gombe State Nigeria, field trials were conducted to evaluate the "effect of row spacing, variety and nitrogen fertilizer rates on the leaf dry weight and bulb diameter of onion during 2021, 2022 and 2023 rainy seasons at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa in Gombe State with the aim of determining the most suitable combination. Three row spacing (10, 15 and 20 cm) were used as main-plot, two varieties `Yar Rumi and Zobo, as sub plot and four rates of nitrogen fertilizer (0, 80, 100, and 120kg/ha^{1} were placed as sub-sub plot factors laid in a Split-split Plot Design and replicated thrice. The result showed that favorable interactions were obtained with a combination of Zobo with 120kg/N ha^{-1} in the 2021 trial with 42.67, V1 and V2 were statistically at par at the spacing of 30 x15 cm and 30 x 20 cm where 120kg/ha recorded 33.76, the same value recorded by V2 at 30 x10 cm at 100kg/ha for the second trial and V1 at 100kg/ha in 30 x 10 cm with 39.56, V2 in combination with 120kg/ha at 30 x 15 cm recorded 40.83 while at 30 x 15 cm varieties were statistically at par with favourable interactions witnessed at 100kg/ha and 120kg/ha with similar values for the 2023 trial. Based on this result, 30 x 15 cm spacing, variety Zobo and 120kg/ha N are recommended for significant interaction.

Key Words: Dadinkowa, Nitrogen Rates, Onion, Row Spacing, Variety

INTRODUCTION

The onion (*Allium cepa* L.) is a vegetable crop grown for its pungent bulbs and flavourful leaves. It belongs to the genus *Allium* of the family Alliaceae or Amaryllidaceae (Welbaum, 2015; Boukary *et al*,. 2012). Onion is one of the most important vegetable crops commercially grown in the world. It probably originated from Central Asia between Turkmenistan and Afghanistan where some of its relatives still grow in the wild. Onion from Central Asia, the supposed onion ancestor had probably migrated to the Near East (Bagali *et al.*, 2012). The crop is believed to be more intensively consumed than any other vegetable crops (Joosten, *et al.*, 2011). Moreover, the onion contributes to the commercialization of the rural economy and creates jobs opportunities for young people in the country (Nikus and Mulugeta, 2010); George *et al*., (2007) stated that it is a biennial crop which forms bulbs from seeds in the first season of growth and flowers in the second season to form seeds.

Griffiths *et al*., (2002) evaluated the health benefits from onions and reported them to include antithrombotic activity, antiasthmatic and antibiotic effects. Onion cultivation in Nigeria is confined to the Sudan Savanna zones especially Kano, Gombe, Sokoto, Kaduna, Plateau and Bornu States. Soils of these areas are mostly low in nutrient, due to low organic matter content. The rain forest zone of South-West Nigeria (Oyo, Ogun, Osun, Ondo, Ekiti) and South-South (Edo and Delta) of Nigeria depend solely on the ever-ready onion supply from the northern part of the country. This is attributed to the ignorance of resource-poor farmers on the possibility of onion cultivation in the rain forest agro-ecological zone of Nigeria. Although onion has been grown in Nigeria for a long time, the yield is still low compared to other region of the world. The reason for this is because improved production practices based on research findings have not been tried by generality of farmers. Fertilizer application and spacing are important factors that influence onion productivity.

The production of the crop in Northern Guinea Savannah is low when compared to the land area under cultivation by Onion farmers in the area. This could be due poor management practices that has high impact on the crop performance especially selection of varieties with laudable performance, Fertilizer application (forms, rates of application, time of application) and spacing which determine the plant population and quantity of inputs needed (seeds, fertilizer, pesticides), key determinants of cost of production. There is no definite spacing adopted by onion farmers in the study area and this affects the number of stands per given area which is directly related to yield of onion. Similarly, fertilizer application rate particularly nitrogen varies between one farm land and another farm in the same area. These affects cost of production, leads to unnecessary expenses and affect profit return. The study was conducted to measure the interaction between spacing, variety and nitrogen rates on the Leaf Dry Weight and Bulb Diameter of Onion and to determine the most suitable combination of the three factors that gives best result.

MATERIALS AND METHOD

Experimental Site

Field trials were conducted during 2021, 2022 and 2023 rainy seasons at the Research and Training Farm of Federal College of Horticulture Dadinkowa in Yamlatu Deba local government area of Gombe state located at latitude 11^o to 30 “N and longitude 10^o to 20 “E with altitude of 240 meters above the sea level and annual rainfall of 760 to 1100mm. Annual temperature range between 24^oC to 48^oC and the soil type of the area is predominantly loamy. (UBRBDA 2015)

Treatments and Experimental Design:

Three intra-row spacing (10, 15 and 20 cm) were used as main-plot treatment. Two varieties (`*Yar rumi* and *Zobo* variety) were use as sub plot, and four (4) levels of Nitrogen fertilizer application (0, 80, 100, and 120kg/ha^{-1}) were used as sub-sub plot treatments combined and laid in a Split-split Plot Design with three replications of 24 plots each. Gross plots size was 2 x 2 m (4 m^2) with 1m space between the replications and 0.5m between plots. The total number of plots was 72.

Fertilizer application

-NPK 15:15:15 was used to source the 40% of all the three nutrients (106.8g/4m^2)

-Nitrogen was sourced from Urea fertilizer at the rates of 40, 60 and 80kg and added to the 40% NPK 15:15:15 to make up the 80, 100 and 120kg/ha (34.8, 52 and 69.6g/4m^2 respectively)

-Phosphorous was obtained from Single Super Phosphate fertilizer at the rate of 28kg and added to the NPK 15:15:15 to make up the 68kg/ha (22.4g/4m^2)

The fertilizer was applied in two equal split doses with first application at 2 weeks after transplanting (WAT) while the second application was at 4 weeks after first application.

Data Collection

Data were collected from the five randomly sampled and tagged plants within the net plot at 2 weeks intervals on the Leaf Dry Weight using weighing balance (QE PASSED METTLER 600g) and Bulb Diameter at harvest by the use of Vanier caliper.

RESULTS

Interaction of Spacing, Variety and Nitrogen on the Leaf Dry Weight of Onion

Interactions between the row spacing x variety x nitrogen on leaf dry weight for the first trial revealed significant record where the varieties are statistically at par at 30 x 10 cm spacing where highest values of interactions of 4.10 and 3.76 g were observed at 100kg N/ha^{-1} and 120kg N/ha^{-1} respectively. At the spacing of 30 x 15 cm, good combination was obtained between V2 and the highest nitrogen rates with 3.90 g and 3.70 g for 100 and 120kg N/ha^{-1} respectively, values that are statistically at par. For 30 x 20 cm, both the varieties had outstanding record that are statistically at par at different row spacing in combination with the largest nitrogen rates that too recorded values statistically at par with the highest value being 3.73 g. For the second trial, at the spacing of 30 x 10 cm, the varieties are statistically at par and similar values were recorded by 100kg N/ha^{-1} and 120kg N/ha^{-1} (2.66 and 2.76 g respectively). The results showed that in the spacing of 30 x 15 cm, the two varieties recorded the highest values of 3.10 and 3.03 g in combination with the largest nitrogen rates having 2.70 g. Interaction in the spacing of 30 x 20 cm revealed that performance was uniform between the two varieties (3.06 and 2.83 g respectively) in combination of widest spacing (100kg N/ha^{-1} and 120kg N/ha^{-1}) recorded the highest values statistically at par of 2.73 and 2.86 g respectively. For the third trial, varieties had similar record at 30 x 10 cm spacing even though best combinations were witnessed at Widest nitrogen rates (100 and 120kg N/ha^{-1}) with 5.03 and 5.30 g respectively while 80kg N/ha^{-1} had 3.03 g. At the spacing interval of 30 x 15 cm, V2 in combination with 80kg N/ha^{-1} recorded 3.93 g while V1 had 2.90 g even though, the better interactions were witnessed in combination of the highest nitrogen rates where 5.00 and 5.13 g, values statistically at par were recorded. Interaction at the spacing of 30 x 20 cm showed that both the varieties combined with 100kg N/ha^{-1} and 120kg/ha^{-1} N to give the highest values that are statistically at par and higher than those recorded by 80kg N/ha^{-1} and control plot. This showed that the larger nitrogen rates interacted with all the three spacing and both the two varieties to give the desired result. The result contradicted the findings of Tibebu *et al.;* (2014) who revealed that there was no significant interaction between variety, nitrogen and phosphorous levels for all observed parameters.

Interaction of Spacing, Variety and Nitrogen on the Bulb Diameter of Onion

The result on interactions between the row spacing x variety x nitrogen on bulb diameter in the first trial showed at 30 x 10 cm, combination of variety two and 120kg/ha^{-1} N recorded the highest value of 41.80 mm. However, at 30 x 15 cm spacing, combination of V1 and 100 and 120kg N/ha^{-1} recorded the highest values of 45.60 and 42.86 mm respectively. At the spacing of 30 x 20 cm, better combination was observed between V2 and 100kg N/ha^{-1} where 46.06 mm was recorded but with 120kg N/ha^{-1}, V1 was the best with 41.93 mm. This showed that better results are obtained V2 was combined with 100kg N/ha^{-1} at 30 x 20 cm spacing. For the second trial, significant interaction was witnessed at the spacing of 30 x 10 cm where V2 recorded highest value (33.76 mm) in combination with 100kg N/ha^{-1} nitrogen while 80kg N/ha^{-1} had 26.90 mm. At the spacing of 30 x 15 cm combination of both the varieties and 100kg N/ha^{-1} and 120kg N/ha^{-1} recorded the highest mean values. The results indicated that at 30 x 20 cm spacing the varieties recorded values that are statistically at par where better interaction was observed in combination with 120kg N/ha (33.76 mm) while 100kg N/ha^{-1} had 32.10 mm. For the third trial, significant interaction was witnessed at 30 x 10 cm where V1 in combination with 100kg N/ha^{-1} recorded 39.56 mm followed by 120kg N/ha^{-1} with 38.80 mm while 80kg N/ha^{-1} had 29.86 mm. At the spacing interval of 30 x 15 cm V2 in combination with 120kg N/ha^{-1} recorded 40.83 mm while 80kg N/ha^{-1} had 29.96 mm. The two varieties are statistically at par at the spacing of 30 x 20 cm combination with 100kg N/ha^{-1} and 120kg N/ha^{-1} that recorded similar values while 80kg N/ha^{-1} had 30.06 mm. This result showed that significant interactions recorded were observed in combination with the widest rates of nitrogen (100kg N/ha^{-1} and 120kg N/ha^{-1}) and the varieties at different row spacing. The result was in agreement with the findings of Dasash *et al.,* (2022) who reported that the main effects of nitrogen and intra-row plant spacing as well as their interaction effect highly significantly ($P < 0.01$) influenced the onion bulb diameter. However, the result was not in conformity with the findings of of Tabebu *et al.;* (2014) a who reported that all interaction effects of variety, N and P_2O_5 on mean bulb diameter were non-significant ($P \leq 0.05$)

CONCLUSION

Where interaction was significant between spacing x variety x nitrogen rates, the results indicated that highest values were recorded in combination of V2 (*Zobo*), wider spacing and the largest nitrogen rates.

REFERENCES

Bagali, A.N. Patil, H.B. Guled, M.B. and Patil, R.V. (2012). Effect of scheduling of drip irrigation on growth, yield and water use efficiency of onion (*Allium cepa* L.). *Journal of Agricultural Science,* 25 (1):116-119.

Boukary, H., A. Hoaugui, M. Barage, T. Adam, A. Roumba, and M. Saadou, (2012)."Agro-morphological evaluation of local varieties and / or ecotypes of Niger onion," *International Journal of Biological and Chemical Sciences*, vol. 6, pp. 3098- 3106,

Dasash A., Melkamu A. and Dessalegn, A. (2022). Effects of Intra-row Spacing and Nitrogen Fertilizer Rates on Growth, and Yield of Onion (*Allium cepa* L.) Under Irrigation in

Mecha District of Amhara, Ethiopia. *International Journal of Bioorganic Chemistry* 2022; 7(1): 17-22 ISSN: 2578-9384 (Print); ISSN: 2578-9392 (Online)

George, E.B., Stanley, C., Esendugue, G.F., Kerry, A. and William, C.H. (2007). Onion Production Guide Bulletin No. 1198-2 College of Agric., and Environmental Sciences, University of Georgia.

Griffiths, G., Trueman, L., Growther, T., Thomas, B., Smith, B. (2002). Onions – a global benefit to health. *Phytotherapy Resource* 16: 603 –615.

Joosten, F., Boselie, D., Bekele, W. and Dessalegn, L. (2011). "Exporting fruit and vegetables from Ethiopia: Assessment of the development potentials and investment options in the export-oriented fruit and vegetable sector," presented at the Ethiopian Horticultural Development Agency and Ethiopian Horticultural Producers and Exporters Association, Addis Ababa, Ethiopia,

Nikus O. and Mulugeta. (2010). Onion Seed Production Techniques: A Manual for extension agents and seed producers, FAO- CDMDP, Asella, Ethiopia.

Tibebu, S., Melese, T., Abrham, S., & Samuel, U. (2014). The effect of varying, Nitrogen and Phosphorus fertiliza- tion on growth and bulb yield of onion (*Allium Cepa* L.) At Wolaita, southern Ethiopia. *Journal of Biological Agriculture and Healthcare*, 4(11), 89–96.

UBRBDA, (2015). Upper Benue River Basin Development Authority Dadinkowa, *Annual Reports.*

Welbaum, G. E. (2015). Vegetable Production and Practices. varginia tech university. USA http//www.eah.org. 486 pp (CABI,

Table 1: Interaction Effect of row spacing x variety x nitrogen rates on Leaf Dry Weight of Onion (*Allium cepa* L.) in Dadinkowa

		Nitrogen Rates											
		2021				2022				2023			
Row spacing	Variety	0kg/ha	80kg	100kg	120kg	0kg	80kg	100kg	120kg	0kg	80kg	100kg	120kg
30x10cm	*`Yar rumi* *Zobo*	1.83	1.86	3.76	3.66	0.63	1.76	2.50	2.80	2.26	3.03	5.06	5.03
	`Yar rumi *Zobo*	1.80	2.23	4.10	3.93	0.96	1.93	2.66	2.76	2.10	3.10	5.13	5.06
30x15cm	*`Yar rumi* *Zobo*	1.70	2.56	3.53	3.73	1.20	1.86	3.10	2.70	2.20	2.90	5.06	5.13
	LSD	2.53	2.46	3.90	3.70	1.00	1.93	3.03	2.70	2.90	3.93	5.03	5.00
30x20cm		1.93	2.26	2.90	2.70	0.90	1.66	3.06	2.73	2.06	2.93	5.13	5.30
		1.76	2.10	3.73	3.73	1,23	1.96	2.83	2.86	2.20	3.06	4.93	5.06
				0.4190		0.4006				0.3347			

Table 2: Interaction Effect of row spacing x variety x nitrogen rates on Bulb Diameter of Onion (*Allium cepa* L.) in Dadinkowa

		Nitrogen Rates											
		2021				2022				2023			
Row spacing	Variety	0kg/ha	80kg	100kg	120kg	0kg	80kg	100kg	120kg	0kg	80kg	100kg	120kg
30x10cm	*`Yar rumi* *Zobo*	36.13	36.50	44.76	40.06	19.16	26.07	32.54	33.00	29.56	36.60	44.93	42.00
	`Yar rumi *Zobo*	34.96	37.06	44.06	41.80	19.18	25.90	32.33	33.66	28.96	37.06	43.93	41.96
30x15cm	*`Yar rumi* *Zobo*	30.76	35.90	45.60	42.83	17.83	26.12	32.43	32.70	29.93	36.13	44.83	42.10
	LSD	30.30	36.86	44.73	41.86	19.25	26.00	32.29	31.76	29.86	37.00	44.93	41.96
30x20cm		35.33	36.80	44.83	41.93	19.34	26.20	32.33	32.80	28.86	36.80	44.86	42.03
		36.13	35.33	46.06	41.06	19.16	25.86	32.63	33.36	29.06	35.96	45.10	42.13
		0.7262				0.7574				0.5496			

THE EFFECT OF SEED RATE ON YIELD AND YIELD COMPONENTS OF IRRIGATED SPRING WHEAT (*Triticum aestivum* L.) IN SUDAN SAVANNAH ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2021 and 2022 dry seasons at Flour Milling Association of Nigeria Research Farm. Ringim Local government Area of Jigawa State (Latitude 12.165372° and longitude 9.187985 with an elevation of 415m above sea level) to study the effect of seed rate on yield and yield components of spring wheat. The treatments consisted of factorial combinations of wheat varieties (Norman and Borlaug) and seed rate of (100kg/ha, 150kg/ha, 200kg/ha) and spacing (0cm, 15cm, 30cm and 45cm) these were laid out in a split plot design with three replications. Data collected included Establishment (no of seedling per M^2), Days to 50% heading, Number of tillers per M^2, No of fertile spikelet/spike, Days to 50% maturity and Grain yield/ha adjusted to 12.5% moisture content. The result showed that Borlaug at 100kg/ha with a spacing of 0cm and Borlaug at 150kg/ha at 15cm spacing both recorded the lowest heading at 55days at 2021 and Borlaug at 100kg/ha with spacing of 30cm in 55days at 2022 respectively. Similar trend was observed with respect to Physiological maturity At 2021, Physiological Maturity days were lowest with 100kg and 15cm (Borlaug), 150kg and 30cm (Borlaug) and 200kg and 30cm (Borlaug) which is 104days and 105 days respectively. The effect of 1000grain yield weight at 100kg and 30cm(Borlaug) produced the heaviest 1000 Grain yield (55days) and highest yield (4466.6kg) In 2021, while in 2022 season 200kg and 30cm (Borlaug) had the heaviest 1000 grain yield weight of 55.5g and 150kg with a spacing of 15cm (Norman) produced the highest grain yield of 4050kg/ha. Based on the findings of the study it is concluded that the planting of wheat at 100kg seed rate Borlaug on 30cm spacing and 100kg seed rate of Norman on 0cm spacing are recommended in the study area.

Key words: Wheat Varieties, Seed rate, Spacing

INTRODUCTION

Wheat is the most extensively cultivated cereal grain around the globe and holds a crucial place in agriculture (Anam *et al.,* 2022; Kizilgeci *et al.,* 2021; Kumar *et al.,* 2013). It is a principal nutriment for 36% of the world's populace and is propagated in 70% of the world's cultivated regions (Khan *et al.,* 2011; Riaz *et al.,* 2021). According to the FAO, 2005 report, about 620 million metric tons of wheat was produced from 217 million hectares in the year 2005/06 with an average yield of 2.85 metric tons per hectare. In some countries, straw is used as a roof thatching material. In most Africa countries, wheat stubble is grazed by ruminant livestock after completion of the harvest (Raemsackers, 2002). The government spends approximately $1.8bn NBS (2020) on wheat imports alone and with the growing demand for non-traditional food such as past, increase in wheat will lead to increase in Nigeria's imports bill. While Nigeria produces approximately 60,000mt of wheat FAO (2020), the demand is much higher at 5.26mn tons USAD (2020). There is a huge gap making Nigeria the least self-sufficient country in Africa when it comes to meeting its wheat demand. The low yield of wheat in the country is on account of many production limiting factors, among these planting density of wheat, which determines the proper stand establishment of the growing crop and crop vigor through balancing competition for production resources among plants, which ultimately affects the yield of the crop (Korres *et al*., 2002). High seed rate increases the competition among crops for common resource particularly water, nutrients and sunlight which resulting in low quality and low yield. If low seed rate is used yield will be less due to lesser number of plants per unit area (Hameed *et al*., 2002). Proper row spacing is important for maximizing light interception, penetration, light distribution in crop canopy and average light utilization efficiency of the leaves in the canopy and, thus, affects yield of a crop (Hussain *et al*., 2003). Farmers do not use the recommended seed rate by research and they usually prefer to use higher seed rates. Excess seed rates and increased plant population above the recommended level inflate the cost of production and cause yield reduction (Alemu, 2019). The research is going to be contacted with the major aims of getting scientific insight into the evaluation of seed rate using different spacing on wheat varieties reflecting on a new methodological approach that can be useful to effectively assess performance. This indicates that the need to conduct research to determine the optimal seed rate and proper spacing requirements growing areas as one of the important agronomic management to improve production and productivity of wheat in Nigeria. This research was carried out with the following objectives:

- To determine the effect of seed rate on yield of different wheat varieties
- To access the optimum row spacing and seed rate of different wheat varieties

MATERIAL AND METHODS

Treatment and Experimental Design

The research was conducted at Flour Milling Association of Nigeria Research Farm, Ringim Local government Area of Jigawa State, during 2021 and 2022 dry seasons the site is located at Latitude 12.165372° and longitude 9.187985° with an elevation of 415m above sea level. The treatments consisted of factorial combinations of wheat varieties (Norman and Borlaug) and seed rate are (100kg/ha, 150kg/ha, 200kg/ha) and spacing (0cm, 15cm, 30cm and 45cm). The experiments were laid out in a split plot design having 24 treatments with 3 replications on a plot size of 5m x 2m with a total of 72 plots (24 treatment by 3 replicates). A distance of 0.5m was maintained between plots and 1.5m distance between replication to facilitate easy movement within the experimental field.

Data collection and analysis

Data was taken on establishment (no of seedling per M^2), days to 50% heading, Number of tillers per M^2, Number of fertile spikelet/spikes, Plant height, Days to 50% maturity and grain yield adjusted to 12.5% moisture content. All best field agronomic practices for wheat production were adhered. The data collected were subjected to analysis of variance (ANOVA) and significant differences were tested. While mean were separated using Student Newman-Keulas test (SNK).

RESULTS

Heading Date and Physiological Maturity

Effect of Seed rate and Spacing on Heading Date and Physiological maturity is presented in Table 1. The result showed that heading date and physiological maturity of Norman were statistically similar. However, at 2021 season Borlaug significantly produce the earliest heading date and physiological maturity than Norman. Application of Borlaug 100kg Seed rate at 30cm spacing has the earlier heading date of (54days) and (55days) in 2022 season while the application of Borlaug 200kg seed rate at 0cm spacing has the longest heading date (60days) and (58days) in 2021 and 2022 season.

Similar trends were observed in both seasons except that the result 2021 and 2022 season was similar in the Physiological maturity days which shows that there is no significant difference on Norman while in Borlaug significant difference is observed on 100kg seed rate and 30cm spacing in 2021 season similarly in 2022 season Borlaug in 100kg seed rate at 30cm spacing and 150kg seed rate at 30cm spacing were significant. No significant different observed from all other.

Number of spike/m^2

Effect of Seed rate and Spacing on Number of spike/m^2 in 2021 and 2022 Season is presented in Table 2. Significant differences were observed on Norman and Borlaug. Norman on 100kg seed rate at 30cm spacing produced the highest number of spike (385), also Norman with 150kg seed rate at 30cm spacing produced the lowest number spike (295). Borlaug at 100kg seed rate at 30cm spacing and 150kg seed rate at 15cm spacing produced the highest number of spike/m^2 (330) which is significant. Borlaug at 100kg seed rate at 30cm spacing (350) and 150kg seed rate at 15cm spacing (345) produced the highest number of spike/m^2 which is significant. The lowest number of spike/m^2 is observed on 200kg seed rate at 30cm spacing (285)

Number of grain/spike and Spike length

The result revealed significant difference among the treatments in both 2021 and 2022 seasons. Table 3 indicate the effect of seed rate at both locations which showed that 100kg seed rate recorded high values as compared to other rates for Number of grains/spike and spike length. The effect of spacing showed that Borlaug at 30cm spacing had higher number of grains/spike and spike length also as compared to Norman. At 2022 season however, significant difference were observed between the varieties for Number of grains/spikes. Borlaug variety had longer spike (12cm) than Norman variety with a value of (10cm). Similarly, Norman recorded a lower spike length (6.5cm) as compared to Borlaug (7cm) respectively.

1000 Grain weight and Grain yield

The effect 1000grain weight and grain yield for both locations are presented in Table 4. Borlaug variety had significant effect over Norman variety on 1000grains yield and grains yield at 2021 and 2022. The results revealed that 100kg seed rate had the highest grains yield in 2021 except for 1000grains yield and that showed no significant difference between them.

Effect of spacing revealed that 30cm spacing had higher 1000grains weight (54g) and grain yield (4467kg) as compared to 0cm, 15cm, 30cm and 45cm in 2021. At 2022 however, 30cm spacing produced higher grain yield (4050g). The 1000 grain yield were not significantly affected by the spacing at this location.

DISCUSSION

The results of this study clearly demonstrate the significant effect of variety, seed rate and spacing on various yield parameters in wheat. Key traits such as heading date, physiological maturity, number of spikes per square meter, number of grains per spike, spike length, and grain yield were affected by the variety, seed rate, and spacing combinations. These findings align with previous studies, highlighting the importance of optimizing these factors to achieve better wheat productivity.

Borlaug's response to seed rate and spacing, particularly at a 30 cm spacing with a 100 kg seed rate, was highly notable. This combination led to early heading, higher yield, and improved grain quality. The results suggest that wider row spacing can improve light distribution within the crop canopy, enhancing photosynthetic efficiency and overall yield. These findings are consistent with the work of Hussain et al. (2003), who noted the role of proper spacing in maximizing light interception and utilization in wheat.

Conversely, higher seed rates, especially 200 kg combined with narrow spacing, led to a reduction in spike production and grain yield. Overcrowding can increase competition for nutrients, water, and light, which ultimately reduces crop productivity. This observation aligns with Alemu (2019), who reported that excessive seed rates could inflate production costs while negatively impacting yield. Singh *et al*. (2019) reported that high seed rate also reduces individual seed size due to increased competition for the same resource as a result, the physical and physiological quality of the seed produced will be reduced. On the other hand, research results indicated that use of proper seed rate encourages nutrient availability, proper sun light penetration for photosynthesis, good soil environment for uptake of soil nutrients and water use efficiency; and all necessary for crop vigor and consequently increase the production and productivity of the crop (Alemayehu, 2015).

On the other hand, Norman displayed more stability across treatments, with no significant changes in physiological maturity or grain yield under different seed rate and spacing combinations. This suggests that Norman is less responsive to varying agronomic conditions, making it potentially suitable for environments where flexibility in management practices is limited. Alemayehu (2015) emphasized that the correct seed rate improves nutrient uptake and crop vigor, contributing to increased yield. Ozturk *et al.* (2006). Noted that Reducing seed rate may result in more tillers and spike per plant and more spikelet per spike but in many cases reduced grain yield per hectare.

In this study, Borlaug, at a 100 kg seed rate and 30 cm spacing, showed superior performance in terms of grain yield and 1000-grain weight, indicating that balanced seeding and spacing are critical for enhancing resource-use efficiency.

CONCLUSION

The result of this study showed that growth and yield characters of wheat were significantly influenced by variety, seed rate and spacing in the study areas. These findings offer valuable insights for farmers seeking to optimize wheat production by adjusting seed rates and spacing according to the specific variety and environmental conditions. The result revealed that planting 100kg seed rate at 30cm spacing recommended the best also Borlaug had significant advantage over Norman in both seasons.

REFERENCES

Alemayehu, M. (2015). Effect of seed rate on crop growth, nutrient availability, and yield optimization. *International Journal of Crop Science*, 12(1), 22-30.

Alemu, T. (2019). Impact of seed rate on wheat yield in Ethiopia. *Journal of Agricultural Research*, 12(3), 45-55.

Alemu, A. (2019). Impact of seed rate and plant population on wheat yield and production cost. *Journal of Agronomy*, 56(4), 245-258.

Alemayehu, A. (2015). Effect of seed source and rates on productivity of bread wheat (*Triticum aestivum* L.) Varieties at Kersa, Eastern Ethiopia.

Anam, M., Rahman, M., & Ahmed, Z. (2022). Global wheat production and its significance: A review. *International Journal of Agricultural Science*, 14(2), 233-245.

FAO. (2005). *World agriculture: Towards 2015/2030*. Food and Agriculture Organization of the United Nations.

FAO. (2020). *Cereal production data*. Food and Agriculture Organization of the United Nations.

Hameed, A., Hussain, M., & Ahmad, A. (2002). Effect of seed rate on wheat yield. *Pakistan Journal of Agricultural Science*, 39(2), 120-126.

Hussain, M., Malik, M. A., & Randhawa, S. M. S. (2003). Effect of row spacing on light interception and yield in wheat. *Journal of Agronomy*, 35(1), 120-125.

Khan, M. A., Jabeen, T., & Rafiq, A. (2011). Wheat production and significance in global food security. *Food Security Journal*, 6(4), 145-159.

Kizilgeci, F., Kaya, C., & Uygun, N. (2021). Impact of climate change on wheat production and quality. *Journal of Crop Improvement*, 35(3), 202-217.

Korres, N. E., Froud-Williams, R. J., & Chachalis, D. (2002). Effects of seed rate and weed competition on wheat yield. *Weed Research*, 42(1), 53-60.

Kumar, R., Sharma, S., & Singh, M. (2013). Wheat: A global perspective on its importance and challenges. *Agricultural Reviews*, 34(2), 108-117.

NBS. (2020). *National Bureau of Statistics: Nigeria wheat import report*. National Bureau of Statistics.

Raemsackers, R. H. (2002). **Crop Production in Tropical Africa**. Directorate General for International Cooperation.

Riaz, M., & Haq, M. A. (2021). Wheat consumption patterns and production strategies. *Journal of Cereal Science*, 57(1), 34-41.

Singh, R. K., Rathore, S. S., Ram, H., Shekhwat, K., Singh, C. & Upadhyay, P. K. (2019). Agronomic interventions for high seed productivity and quality of wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences*, *89*(7): 1071–1076.

USAD. (2020). *United States Agriculture Department: Wheat production and demand*. USDA Reports.

Table 1. Effect of Variety, Seed rate and Spacing on Heading Date and Physiological maturity

Treatment	2021			2022		
	Heading Date	Physiological maturity	No. of Spike/ m^2	Heading Date	Physiological maturity	No. of Spike/ m^2
100kg and 0cm (Norman)	68bc	118cd	310jk	67bc	117cd	360ab
100kg and 15cm (Norman)	69ab	119bc	320g	66e	119ab	365a
100kg and 30cm(Norman)	68bc	117df	385a	67bc	117cd	355bc
150kg and 0cm(Norman)	68bc	118cd	315i	67bc	119ab	340ef
150kg and 15cm (Norman)	69ab	120ab	314j	67bc	115f	340ef
150kg and 30cm(Norman)	68bc	119bc	295m	67bc	116e	320hi
200kg and 0cm(Norman)	66d	120ab	330de	68ab	118bc	330g
200kg and 15cm (Norman)	69ab	119bc	340c	69a	120a	355bc
200kg and 30cm(Norman)	68bc	120ab	350b	68ab	117cd	280m
100kg and 0cm (Borlaug)	56i	107df	305l	58fg	106hi	360ab
100kg and 15cm (Borlaug)	57gh	105fg	290n	57gh	108g	295j
100kg and 30cm(Borlaug)	54k	104hi	330de	55j	105ij	350d
150kg and 0cm(Borlaug)	55j	106gh	317h	57gh	106hi	325h
150kg and 15cm (Borlaug)	56i	107df	330ab	59f	106hi	290k
150kg and 30cm(Borlaug)	57gh	104hi	310jk	56hi	105ij	345e
200kg and 0cm(Borlaug)	60e	106gh	285o	58fg	106hi	340ef
200kg and 15cm (Borlaug)	57gh	107df	325f	56hi	106hi	320hi
200kg and 30cm(Borlaug)	58f	105fg	335d	58fg	107gh	285l
Probability level	0.034	0.012	0.005	0.036	0.009	0.008

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 2. Effect of Variety, Seed rate and Spacing on Number of grain/spike and Spike length

Treatment	2021		2022	
	No. grain/ Spike	Spike length	No. grain/ Spike	Spike Length
100kg and 0cm (Norman)	48hi	8ij	56de	9.5bc
100kg and 15cm (Norman)	56cd	9de	56de	9.5bc
100kg and 30cm(Norman)	49gh	10ab	52hi	9cd
150kg and 0cm(Norman)	48hi	10ab	60b	9.5bc
150kg and 15cm (Norman)	56cd	9de	56de	10ab
150kg and 30cm(Norman)	59b	8.5gh	48k	9cd
200kg and 0cm(Norman)	41lm	7lm	38n	6.5j
200kg and 15cm (Norman)	61a	8.8f	59c	10ab
200kg and 30cm(Norman)	58bc	8.5gh	54fg	9cd
100kg and 0cm (Borlaug)	49gh	9.5c	52hi	9cd
100kg and 15cm (Borlaug)	50ef	10ab	54fg	9.5bc
100kg and 30cm(Borlaug)	58bc	11a	64a	12a
150kg and 0cm(Borlaug)	41lm	8	54fg	8.5ef
150kg and 15cm (Borlaug)	42k	7.5k	56de	8.5ef
150kg and 30cm(Borlaug)	48hi	8ij	52hi	8g
200kg and 0cm(Borlaug)	46j	7lm	46m	7i
200kg and 15cm (Borlaug)	50ef	9de	51j	8.5ef
200kg and 30cm(Borlaug)	48hi	8ij	47l	7.5h
Probability level	0.045	0.023	0.004	0.041

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 3: Effect of Variety, Seed rate and Spacing on 1000grain weight and grain yield

Treatment	2021		2022	
	1000grain weight(g)	Grain Yield(kg)	1000grain weight(g)	Grain Yield(kg)
100kg and 0cm (Norman)	41.0o	3600.0e	44lm	3866.6e
100kg and 15cm (Norman)	43.5j	2600.0	46.5k	2933.3gh
100kg and 30cm(Norman)	49.5cd	2133.3	52de	2800.0i
150kg and 0cm(Norman)	43.0k	4266.6b	48i	3933.3c
150kg and 15cm (Norman)	42.5l	2333.3	43o	1333.3r
150kg and 30cm(Norman)	49.0e	3200.0gh	52de	3890.0d
200kg and 0cm(Norman)	42.0m	2666.6	47j	2666.6j
200kg and 15cm (Norman)	49.5cd	3200.0gh	52de	2600.0k
200kg and 30cm(Norman)	54.0b	3476.6cf	53.5c	2466.6m
100kg and 0cm (Borlaug)	47.0g	2666.6	49.5h	2000.0pq
100kg and 15cm (Borlaug)	45gh	3200.0gh	45m	2000.0pq
100kg and 30cm(Borlaug)	55.0a	4466.6a	56a	4000.0b
150kg and 0cm(Borlaug)	41.5n	2800.0	44n	2933.3gh
150kg and 15cm (Borlaug)	48.0f	3933.3c	54b	2533.3l
150kg and 30cm(Borlaug)	53.0c	3866.6d	51f	4050.0a
200kg and 0cm(Borlaug)	40.0p	2400.0	45.5m	2333.3n
200kg and 15cm (Borlaug)	44.0i	3200.0gh	51g	2200.0o
200kg and 30cm(Borlaug)	45gh	3400.0cf	50.5g	3066.5f
Probability level	<.001	<.001	<.001	<.001

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

RESPONSE OF PUMPKIN (*Cucurbita Maxima* L.) VARIETIES TO MORINGA LEAF EXTRACT AND SOWING DATE IN SUDAN SAVANNAH ECOLOGICAL ZONE OF NIGERIA: YIELD AND YIELD COMPONENTS

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ABSTRACT

The extract of Moringa leaves has been used as a plant growth enhancer on several crops. A field study was conducted during the 2019 rainy season at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University Kano and Dawakin Kudu located in the Sudan Savannah of Nigeria; to evaluate the response of moringa leaf extract and sowing date on the yield and yield components of pumpkin varieties. The treatments comprised four levels of moringa leaf extract (0, 2, 3, and 4%), three sowing dates (late June, early July and mid-July) and two varieties (Yar-Madina and Ex-Ajiwa). The experiment was laid out in a split-plot design (SPD) with three replications in a factorial combination with sowing date and varieties allocated to the main plot while, moringa leaf extract was assigned to the sub plot. Based on the results of this experiment application of moringa leaf extract at 4% was significantly superior in influencing the number of fruits per plant, fruit circumference, fruit length and weight. However, 3% and 4% were statistically similar and result in higher yield per hectare over 2% than the control. The results also indicated that sowing date had a significant effect on the yield and yield components of pumpkin. Significantly higher fruit yield per hectare was recorded on pumpkin sown in late June than on other sowing dates. Yar-Madina pumpkin variety was superior to Ex-Ajiwa in respect of yield and the yield characters examined. Based on the findings in this study, application of moringa leaf extract at 4% and sowing in late June are recommended for higher yields of pumpkin in the Sudan Savannah ecological zone of Nigeria.
Keywords: Pumpkin, Moringa Leaf Extract, Sowing Date, Yield and Yield Components

INTRODUCTION

Pumpkin (*Cucurbita maxima* L.) is an important vegetable crop that belongs to the genus cucurbita and the family *Cucurbitaceae*, which is one of the largest vegetable kingdoms consisting of many edible species (Alekar *et al.*, 2015). The major pumpkin-producing countries of the world are China, India, Russia, the United States of America, Iran, Egypt, Italy and Ukraine (FAO, 2012). In Africa, it is grown in Nigeria, Cameroun, Mali and Niger. Many varieties of the crop are grown in the Savannah region of Nigeria (Aissami, 2005). These varieties have different characteristics and vary in growth and yield (Lawan *et al.*,2009). Pumpkin is a warm-season crop that can be grown in hot and humid climates with at least 6 hours of direct sunlight every day. It thrives on a wide range of soil types but does best on well-drained soil rich in organic matter. Loams, sandy loams and loamy sands are generally most suitable for growing cucurbits. A soil pH range of 6.5-7.5 is preferred. It is moderately tolerant to soil acidity of up to soil pH of 5.5 but the crop is sensitive to saline soil conditions. It requires about 6 hours of direct sunlight every day, day and night temperatures of 32^0C and 25^0C respectively are suitable for a good harvest, while yields are depressed by frost. Moringa is gaining significance in the world due to its numerous economic uses. Stakeholders such as the health sector are promoting moringa as a food supplement and the medicinal water sector is promoting moringa for water treatment, while agronomists reported moringa as a plant growth hormone which enhances seed germination, growth and yield of crops (Foidl *et al.*, 2001; Edward and Jenny, 2009; Phiri and Mbewe, 2010). Martin (2000) and Foidle *et al.* (2001) reported that the juice from fresh moringa leaves produced an effective plant growth hormone, increasing yields by 20-30 % for nearly all crops. One of the active substances in the plant is zeatin: a plant hormone from the cytokinins group. The foliar spray of moringa should be applied along with other fertilizers and sound agricultural practices for enhanced efficacy. The objective of this study is to evaluate the effect of moringa leaf extract and sowing date on the yield and yield components of pumpkin varieties in Sudan Savannah of Nigeria.

MATERIALS AND METHODS

The field experiment was conducted during the 2019 rainy season at the Teaching and Research Farm Faculty of Agriculture, Bayero University, Kano (11^0 58' N, 08^0 33' E and 475 m above sea level) and Dawakin kudu (11^0 50'05'' N, 8^0 35'53'' E and 444 m above sea level). Both locations are in the Sudan savannah agroecological zone of Nigeria. The treatments consisted of four concentrations of aqueous moringa leaf extract (0%, 2%, 3% and 4%), three sowing dates at ten days intervals (late June, early July, and mid-July) and two varieties (Yar-Madina and Ex-Ajiwa). The experiment was laid out in a split-plot design with three replications. Sowing date and varieties were allocated to the main plot while aqueous moringa leaf extract was assigned to the subplot. Foliar spray of the extract commenced at 2 WAS and continued fortnightly until 8 WAS. The land was harrowed and ridged 0.75 m apart divided into plots (36 m^2) separated by alleys of 1 m between plots and 2 m between replications.

Before land preparation, soil samples were randomly collected at various points within the experimental plots at a depth of 0-30 cm. They were labelled appropriately, bulked, air-dried and subjected to routine analysis as suggested by Blake and Harge (1986). The seeds were treated with Apron Star (20% w/w thimethoxan, 20% w/w metalaxyl-m and 2% w/w difenoconazole) at the rate of 10 g per 5 kg of seed against fungicides and insecticides before planting. Three seeds per hill were sown and later thinned to two pumpkin seedlings per stand after germination. Weeds were controlled by manual hoe weeding at 3, 5 and 7 weeks after sowing (WAS) using hoes.

Moringa leaves were crushed separately with water (10 kg of fresh material in 1 litre of water) and filtered out. Liquid extract obtained were diluted with water in the following concentrations: 2% (2 ml of extract / 98 ml of water), 3% (3 ml of extract / 97 ml of water), and 4% (4 ml of extract / 96 ml of water) as suggested by Fuglie (2008). The fruits were harvested with sharp knives when they were ripped. The following characters were determined using standard procedures: the number of fruits plant^{-1}, fruit circumferences at the middle of the fruits, fruit length from the peduncle to the distil end of the fruit and fruit weight (kg). Harvested fruit per net plot were weighed and extrapolated to kg t ha^{-1}. Data collected were subjected to analysis of variance (ANOVA) using Genstat 17th edition. Significant treatment means were ranked using the Student Newmans Keuls Test (SNK).

RESULTS AND DISCUSSION

The results from the experiment revealed that the application of moringa leaf extract significantly influenced most of the yield components of pumpkin in both locations (Tables 1 and 2). The higher number of fruits, longer fruit and wider fruit circumference was associated with treated pumpkins compared to the control. This was corroborated with the findings of Muhamman *et al.* (2011) who reported higher growth and yield characters on crops treated with moringa leaf extract. The results further showed that heavier and larger fruits were produced by treatment with highest moringa leaf extract application. The pumpkin fruit yield and its quality were greatly enhanced due to the application of moringa leaf extract compared to the control at both locations. It was observed that the higher rate of moringa leaf extract caused the maximum increased in the number of fruits per plant, fruit weight and fruit yield t ha^{-1}. Matthew (2016), and Mvumi *et al.* (2012 and 2013) confirmed this on snap bean, pepper, maize, beans and tomato buttressing the work of Fuglie (2000) that there were increased crop yields when crops were sprayed with moringa leaf extract. This result therefore, indicated that moringa leaf extract played an important role in pumpkin production because significantly increased yield and yield characters compared to the control.

The effect of sowing date was significant on yield and yield components of pumpkin in this study. At both locations pumpkin sown in late June produced significantly higher number of fruits per plant, wider fruit circumference, longer fruits, heavier fruits, and higher fruit yield t ha^{-1} (Tables 1 and 2). This is because early sowing enables the crop to grow well and produced a higher yield since it has enough time to exploit all the environmental resources required to support the growth and yield development. This corroborated with the work of Bannayan *et al.*

(2017) who reported an increased crop growth and yield with optimum sowing date and a reduction in crop growth when sowing was delayed. The results further show that by delaying the sowing date to mid-July, all yield parameters of pumpkin were significantly decreased; this might be a result of the negative impacts of weather extremes such as high temperatures. Delgado *et al.* (2013) reported that delaying the sowing date can cause significant differences in environmental conditions during crop growth, usually causing crops to grow with increasing temperatures and diminishing moisture conditions, which results in growth suppression of crops. Intra-annual temperature variations which resulted from different sowing dates can lead to the variation in pumpkin growth and yields. Therefore, by adopting the optimum sowing date, the various growth stages of this crop coincided with the optimum temperature resulting in higher crop growth and yields in comparison with non-optimum sowing dates.

The results showed that the response of varieties to most of the yield characters evaluated was significant. However, few recorded non-significant effects such as fruit circumference and fruit length (Table 1). The varieties were statistically different in respect to yield characters such as number of fruits per plant, fruit weight and fruit yield t ha^{-1}. The improved (Yar-Madina) variety had a significant advantage over the local (Ex-Ajiwa) with respect to these characters. This might be because Yar-Madina is an improved and early maturing variety that is adapted to Northern Guinea and Sudan Savannah ecological zone of Nigeria (Lawal *et al*., 2009; Awole, 2011; Eifediyi & Remison 2009) These variation could also be due to the genetic variation among the varieties and their ability to exploit the environmental factors under field conditions.

CONCLUSION

The findings of this research indicated that the application of moringa leaf extract and sowing date appeared to have a substantial impact on pumpkin performance. Based on the result of this study application of moringa leaf extract at 4% resulted in higher fruit yield t ha^{-1} and yield components. Similarly, pumpkin sown in late June recorded significantly higher yield and yield characters compared to other sowing dates. Yar-Madina pumpkin variety had a significant advantage over Ex-Ajiwa in most of the yield components evaluated.

REFERENCES

Aissami, M. B. (2005). Growth and yield of four varieties of squash pumpkin (*Cucurbita maxima* L.) in response to varying rates of N.P.K. compound fertilizer. (Unpublished B. Agric Project). Ahmadu Bello University, Zaria Nigeria. PP 50.

Alekar, A. N., Hirve, P. S., Deshmukh, G. N. and Kharde, R. P. (2015). Study of the effect of integrated nutrient management on yield and nutrient uptake in pumpkin. *Journal of Horticulture*, 2: 136.

Bannayan, M., Mortazagoldani and Mohammad, R. N. (2017). Growth analysis of pumpkin (*Cucurbita pepo* L.) under various management practices and temperature regimes. *Agricultural Research and Technology: Open access Journal*, **11**(1):555801.

Blake, G. R. and Hartge, K. K. (1986). Methods of soil analysis Part 1 Agronomy Monographs No 9, 2nd Edition. *American Society of Agronomy and Soil Science*, Madison 161. Pp 20.

Delgado, J. A., Nearing, M. A. and Rice, C. W. (2013). Conservation practices for climate change adaptation. *Advances in Agronomy*, **121**: 47-115.

Edward, B. and Jenny, J. (2009). ECHO, N. Ft. Myers, FL 33917, USA.

Eifediyi, E. K. and Remison, S. U. (2019). Effect of time of planting on the growth and yield of five varieties of cucumber (*Cucumis sativus* L.). *Report and Opinion*, **1(5)**: 81 – 90

FAO, Fertilizers Conferences. (2012). Organic Manures Meeting Expectations? Proceedings, Rome. Development and Consultation Organization.

Foidle, N., Makkar, H. P. S. and Becker, K. (2001). The Potential of *Moringa oleifera* for agricultural and industrial Uses. In Fuglie, L. J. (Editor) *The Miracle Tree*: The Multiple attributes of moringa. CTA and CWS, Dakar, Senegal. 168 pp.

Fuglie, L. (2008). New uses moringa studies in Nicarrague. ECHO technical news. *http://www.echotech.org*. Retrieved.

Kassam, A. H., Kowal, J., Dagg, M. and Harrison, M. N. (1975). Maize in West Africa and its potential in Savannah Areas. *World Crops*. **27**: 73-78.

Lawal, A. B. (2009). Correlation and path coefficient studies in squash pumpkin (*Cucurbita maxima* L.). *Advances in Horticultural Sciences.* **23**(3): 197-200.

Martin, L.P. (2000). The Moringa Tree. ECHOTechnical Note. http:// www.echonet.org Retrieved.

Muhamman, M. A. (2011). Effect of aqueous extract of moringa (*Moringa oleifera* LAM.) and nitrogen rates on the performance of some crops. (Unpublished PhD thesis). Bayero University, Kano, Nigeria. Pp 20-140.

Mvumi, C., Jagwira, F. and Chiteka, A. Z. (2003). Effect of Moringa Extract on Growth and Yield of Maize and Common Beans. *Greener Journal of Agricultural Science.* **3**(1): 55-62.

Phiri, C. and Mbewe, D. N. (2010). Influence of moringa leaf extract on germination and seedling survival of three common legumes. *Int Journal Agric Biology*. **12**: 315-317.

Prabhu, M. A., Ramesh, K. A. and Rajamani, K. (2009). Influence of biostimulants on growth, yield and economics of kalmegh (*Andrographis paniculata*). *Madras Agricultural Journal*. **3**(3): 150-155.

Remison, S. U. and Mgbeze, (2004). Response of cowpea plant to foliar application of growth regulators and coconut Water. *The Nigerian Journal of Agriculture and Forestr*.**1**(1): 1-2.

Table 1: Effect of Moringa Leaf Extract and Sowing Date on Number of Fruits Plant^{-1}, Fruit Circumference (cm), Fruit Length (cm) of Pumpkin During 2019 Rainy Season at BUK and D/kudu

Treatment	Number of Fruits Plant^{-1}		Fruit Circumference (cm)		Fruit Length (cm)	
	BUK	D/kudu	BUK	D/kudu	BUK	D/kudu
Moringa Extract (%)						
0	1.89c	1.97b	56.98c	54.15b	30.71c	29.78b
2	2.09bc	2.09b	61.49b	59.85a	33.83b	30.74b
3	2.30ab	2.12b	64.47ab	60.04a	34.16ab	31.22ab
4	2.63a	2.53a	66.85a	63.00a	35.34a	33.01a
SE ±	0.123	0.086	1.247	1.184	0.476	0.671
Probability level	0.008	0.002	0.001	0.001	0.001	0.012
Sowing Date						
Late June	2.98a	2.95a	70.08a	61.40a	36.52a	31.77
Early July	1.87b	1.93b	61.16b	58.57b	32.21b	30.55
Mid-July	1.83b	1.65c	63.00b	57.81b	31.80b	31.24
SE ±	0.107	0.075	1.459	1.026	0.412	0.581
Probability level	0.001	0.001	0.004	0.041	0.001	0.341
Variety (V)						
Yar-Madina	2.45a	2.35a	63.48	58.75	33.82	31.85
Ex-Ajiwa	2.01b	2.00b	61.41	59.77	33.19	30.51
SE ±	0.087	0.061	0.882	0.838	0.336	0.475
Probability level	0.007	0.002	0.103	0.393	0.189	0.051
Interaction						
S x V	0.001	0.001	0.001	0.001	0.001	0.001
S x M	0.554	0.249	0.669	0.056	0.186	0.495
V x M	0.007	0.001	0.117	0.032	0.203	0.163
S x V x M	0.082	0.071	0.319	0.107	0.127	0.079

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Student–Newman Keuls Test.

Table 2: Effects of Moringa Leaf Extract and Sowing Date on Fruit Weight per plant and Fruit Yield (t ha^{-1}) of Pumpkin during 2019 Rainy Season at BUK and Dawakin kudu, Nigeria

Treatment	Fruit Weight (kg)		Fruit Yield (t ha^{-1})	
	BUK	Dawakin kudu	BUK	Dawakin kudu
Moringa Extract (%)				
0	11.65b	13.68	12.50c	11.55c
2	13.18ab	13.77	14.54b	13.28b
3	13.54a	15.18	15.19a	13.61ab
4	14.77a	15.37	15.44a	14.00a
SE ±	0.653	0.619	0.136	0.189
Probability level	0.015	0.111	0.001	0.001
Sowing Date (S)				
Late June	15.69a	16.46a	15.34a	13.90a
Early July	12.54b	14.62b	14.19b	13.61a
Mid-July	11.63b	12.40c	13.73c	11.83b
SE ±	0.566	0.536	0.118	0.164
Probability level	0.001	0.001	0.001	0.001
Variety (V)				
Yar-Madina	14.08a	15.38a	14.69a	13.82a
Ex-Ajiwa	12.49b	13.62b	14.14b	12.40b
SE ±	0.461	0.438	0.096	0.134
Probability level	0.018	0.007	0.002	0.001
Interaction				
S x V	0.001	0.001	0.001	0.001
S x M	0.457	0.006	0.001	0.001
V x M	0.550	0.013	0.016	0.002
S x V x M	0.425	0.156	0.121	0.130

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Student–Newman Keuls Test.

EFFECTS OF NITROGEN AND INTER ROW SPACING ON YIELD AND YIELD COMPONENTS OF PUMPKIN (*Cucurbita maxima* L.) VARIETIES IN SUDAN SAVANNAH ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

Important agronomic elements in the cultivation of pumpkins (Cucurbita maxima L.) are nitrogen and interrow spacing. A field experiment was conducted during the 2023 rainy season at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University, Kano and Bunkure, located in the Sudan Savannah of Nigeria. The study was aimed at determining the effect of nitrogen and inters row spacing on the yield of pumpkin varieties (*Cucurbita maxima* L.) in the study area. The treatment consisted of four levels of nitrogen (0, 40, 80, and 120kg N ha^{-1}), three inter-row spacing (1, 1.5, and 2 m), and two varieties (Yar-Madina and Ex-Ajiwa). Repeated three times in a split-split plot design (SSPD). Nitrogen was allocated to the main plot, inter-row spacing was in the subplot, and varieties were in the sub-subplot. At BUK and Bunkure, significant variations were observed in yield characteristics such as fruit length, fruit diameter, and fruit yield. There was no significant effect of row spacing on yield characters. The improved Yar-Madina was superior to the local Ex-Ajiwa concerning fruit diameter. However, they were statistically comparable concerning fruit length and fruit yield per hectare. Furthermore, the result showed an interaction between nitrogen and spacing on fruit length. Application of 80kg N at 1m row spacing on Yar-Madina recorded high values. Based on the results obtained in this study, it could be concluded that the application of 80kg N and a 1m row spacing interval is recommended for higher fruit yield of pumpkin in the Sudan Savannah ecological zone of Nigeria.

Keywords: Pumpkin, Row spacing, nitrogen, varieties, Yield, Sudan savanna

INTRODUCTION

Pumpkin is cultivated and consumed widely among the rural dwellers in Northern Nigeria, where the mature fruits serve as food security during the dry season because of their long shelf life. Pumpkin (*Cucurbita maxima L.)* is an important crop in the tropics, where it is grown for its large, fibrous but palatable fruit in many African countries like Niger, Cameroun, Mali, Uganda and Nigeria (John, 2004). In 2019, global production of *Cucurbita* species (*Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita pepo*) was estimated at 22,900,826 mt (FAOSTAT, 2019). According to the same source, African production is estimated at 2,793,530 mt. This vegetable is cultivated for several purposes ranging from nutritional to medicinal purposes, nutritionally, pumpkin seed kernels contain moderate concentrations of several minerals among which are; potassium, phosphorus, and magnesium, (Alfawaz, 2004).

The fleshy mesocarp of the fruit is used as an ingredient for making soup, it is especially good for thickening soups with or in the absence of tomato and pepper and other relatively more expensive ingredients (Lawan *et al.*, 2009). In Nigeria, Pumpkin is a traditional vegetable crop, grown mainly for its leaves fruits, and seeds and, consumed either by boiling the leaves and fruits or by roasting or baking the seeds. Thus, pumpkin production in Africa is very low when compared with other continents, there is a need to popularize this underutilized crop but potentially rich in nutrients to feed the growing population sustainably. With the increasing pressure on farmland for infrastructure development, limited land is available for this crop which requires a large expanse of area for its cultivation. Pumpkin vines can spread beyond 15 meters from its stand and cover the land within 45 days of planting (Oloyede, 2011). Hence, due to limited land resources, farmers now plant this crop on intensively cultivated lands, with inappropriate proper inter-row spacing which increases the need for land with wider spacing and limits its total yield with a limited crawling area. Farmers now use fertilizer to improve the yield of the crop due to Pumpkin serial harvesting and the use of depleted soils. The three major fertilizer elements known to be deficient in most Nigerian soils due to intense pressure on land as a result of continuous cropping are N, P, and K. **(**Aduayi *et al.*, 2002). Nitrogen plays an important role in plant growth (Weinhold *et al.*, 1995). This nutrient is a component of protein and nucleic acid and when the N amount in the soil is not optimal, growth is reduced (Weinhold *et al.*, 1995). Therefore, the objective of this research is to assess the growth response of pumpkins to nitrogen and inter-row spacing in the Sudan savanna of Nigeria.

MATERIALS AND METHODS

The experiment was conducted during the rainy season of 2023 at the Teaching and Research Farm Faculty of Agriculture, Bayero University, Kano. ($11^0$58 ′ N, $08^0$24′ E) 470.9m above sea level and Bunkure (11^0 50′ 05″ N, $8^0$35′ 53 ″E) and 444M above sea level. Both locations are in the Sudan savannah agroecological zone of Nigeria. The treatment consisted of three levels of inter-row spacing (1.0 m, 1.5 m, and 2.0 m), Four levels of Nitrogen (0 kg N/ha, 40 kg N/ha, 80 kg N/ha, and 120 kg N/ha), and two varieties (Yar-Madina and Ex-Ajiwa). Each plot was 72 m^2, 12 m wide and 6 m long. The two innermost rows were the net plot which is 3m x12m ($18m^2$). The experiment was laid out in split split plot (SSP). The land was harrowed and then marked into $72m^2$ plots and then the different rows were marked manually. Nitrogen was allocated to the Main plot inter-row spacing subplot while varieties were in the sub-subplot. Half of the Nitrogen (50%) was applied before sowing while the remaining half was applied at 3 WAS. Yield data were collected on the fruit length and fruit diameter using standard procedures.

RESULTS AND DISCUSSION

Effect of Nitrogen: The application of nitrogen had a significant effect on fruit length at both locations (Table 1) with 80 kg N having significantly longer fruits while further increase to 120 kg N ha^{-1} decreased the fruit length. Ahmad *et al.* (2007) reported that an increase in nitrogen application resulted in maximum fruit length, fruit weight, vine length, and yield of cucumber. However, the lack of response at 120 kg N ha^{-1} could be due to increased acidity which in turn results in nutrients in balance. According to Hao *et al*. (2020) at higher nitrate, the pH for optimum nutrient uptake is altered and this affects soil nutrient uptake. The effect of nitrogen on fruit diameter was only significant at BUK; with 40-120 kg N having similar fruit diameter significantly different compared with the control that recorded narrow fruit diameter. The increase in fruit diameter over the control could be due to the effect of nitrogen in promoting photosynthetic activities. Ahmad *et al*. (2009) reported that the optimum rate of N increased the photosynthetic process and net assimilation rate.

Application of 40-120 kg N recorded superior fruit yield to the control at BUK (Table 3) suggesting that the soil at the site was deficient in N. A similar report was made by (Waseem *et al.*, 2008) and (Niaz *et al*., 2016) in cucumber where application of 80 kg N ha^{-1} resulted in a higher number of fruits and eventually higher fruit yield. At Bunkure however, application of 40 and 80kgN resulted in similar fruit yield per hectare and were significantly higher than those obtained from 120 Kg N ha$^{-1.}$ The higher fruit yield at Bunkure might be due to favorable weather and soil conditions.

There was a significant interaction between nitrogen and variety in fruit length (Table 2). At every nitrogen level, longer fruits were obtained from Yar-Madina than Ex-Ajiwa which had shorter fruits. Also at each variety, there was an increase in fruit length with an increase in nitrogen level from 0-80 kg N, while further increase in nitrogen to 120 kg N, there was a decrease in fruit length for the two varieties. The result showed that the longest fruit was obtained from Yar-Madina at 80 kg N.

Effect of Row spacing: There was no significant effect of row spacing on fruit length and fruit diameter (Table 1) at both locations in the study area. Uwalaka *et al.* (2019) revealed that plant spacing did not have a significant effect ($P>0.05$) on fresh and dry matter yields of Fluted pumpkin (*T. occidentalis*). Sanni & Adenubi (2020) reported that the fruit diameter and fruit weight of cucumber were not significantly ($p<0.05$) affected by the different spacing evaluated. This result seems to be contrary to some theories as it suggests that wider spacing supports higher fruit yield per hectare due to less plant population coupled with abundant growth resources (nutrients, light, space, and moisture).

Varietal performance: The present study indicated that fruit yield and most of the yield characters evaluated were not significantly different (Tables 1 and 3) for the two varieties. Aissami (2005) observed lacked significant differences among Pumpkin varieties concerning yield and yield components could be attributed to the fact that the varieties have become genetically stable in the Northern Guinea savannah ecological zone of Nigeria, having been adapted following years of cultivation (Lawan *et al*., 2009). Further, it could be due to cross-pollination as observed by Benard *et al*. (2018) who reported that if pumpkin varieties were planted at a trekking distance of less than 250 m, cross-pollination would take place and this makes it difficult to get true to type crop yield performance. The present result corroborated that of Lawan *et al.* (2009) & Lassa and Wali (2015) who tested Yar-Madina and Ex-Ajiwa and reported that the two varieties had similar fruit yields because the local variety (Ex-Ajiwa) had become adapted to the savannah region, enabling it to adjust to local soil and weather condition.

CONCLUSION

The results of this study showed that the yield characteristics of pumpkin varieties were significantly influenced by the application of nitrogen in the study areas. Based on the results obtained in this study application of 80kg N produced the highest fruit yield. Further, the results showed that the 1m row spacing gave the highest fruit yield. The finding also revealed that Yar-Madina had a superior fruit yield over Ex-Ajiwa. Therefore, the application of 80kg N and a 1m row spacing interval is thereby suggested for higher fruit yield of pumpkin in the Sudan Savannah ecological zone of Nigeria.

REFERENCE

Oloyede, F., Agbaje, G. O., & Obisesan, I. O. (2013). Effect of NPK fertilizer on fruit yield and yield components of pumpkin (Cucurbita pepo Linn.). *African Journal of Food, Agriculture, Nutrition and Development, 13*(3).

Ahmed, N., Baloch, M. H., Haleem, A., Ejaz, M., & Ahmed, N. (2007). Effect of different levels of nitrogen on the growth and production of cucumber. *Life Sci. Int. J, 1*, 99-102.

Aissami, M. B. (2005). Growth and Yield of Four Varieties of Squash Pumpkin (*Cucurbita maxima* L.) in Response to Varying Rates of N.P.K. Compound Fertilizer. (Unpublished B. Agric Project). Ahmadu Bello University, Zaria Nigeria.

Alfawaz, M. A. (2004). Chemical composition and oil characteristics of pumpkin (Cucurbita maxima) seed kernels. *Food Science and Agriculture, 2*(1), 5-18.

Dean B, 2004. Effect of Intra-row Spacing on Muskmelon Growth and Yield. Institute for Agriculture and Tourism, Carla Huguesa 8, 52440 Porec, Croatia.

FAOSTAT (2019). Available online: http://faostat3.fao.org/home/E (Accessed 8th February 2021).

John KK (2004) Crop rotation in Kerala. A case study of Kaduthruthy Block, Kerala Research Programme on Local Level Development, Centre for Development Studies, Prasanth Nagar, Ulloor.

Lassa (2019). Integrated use of fertilizer and intra-row spacing in the performance of pumpkin (*Curcubita* maxima L.) varieties in the Sudan savanna ecological zone of Nigeria. Unpublished PhD. Thesis Department of Agronomy, Bayero University, Kano.

Lawal, A. B., Aissami, B. M. and Lawan, H. M. (2009). Influence of Mineral Fertilizer on Productivity and Growth of Four Varieties of Squash Pumpkin (*Cucurbita maxima* L.) *Advances in Horticultural Science*, **23**(3): 201-204.

Majia, U. M. 1999. The Effect of Nitrogen Levels and intra row spacing on Growth and Yield of Watermelon. Unpublished M.Sc. Thesis Department of Agronomy, A.B.U, Zaria.

Mujibu (2021). Response of pumpkin (Curcubita maxima L.) varieties to moringa leaf extract and sowing date in Sudan savannah ecological zone of Nigeria. Unpublished M.Sc. Thesis Department of Agronomy, Bayero University, Kano.

Oloyede F M Agronomic traits and Nutritional values of pumpkin (Cucurbita pepo Linn.) as influenced by NPK fertilizer. An unpublished Ph.D. Thesis submitted to the Department of Plant Science, Obafemi Awolowo University, Ile-Ife, Nigeria. 2011

Sanni, K. O., & Adenubi, O. O. (2020). Influence of intra-row spacing on weed suppression in cucumber (Cucumis sativus) production in humid rainforest agro-ecological zone of Lagos, Nigeria. *Global Journal of Ecology*, *5*(1), 038-043.

Statistix. Analytical Software. 2006. Statistix 8.1 User's Manual. Analytical Software, Tallahassee, Florida 2006.

Uwalaka, O. A., Uwanaka, C. E., Ibekwe, H. N., & Usifo, B. C. (2019). Effect of Spacing on Growth and Yield of Fluted Pumpkin Telfairia occidentalis (Hook f.) in Okigwe, Nigeria. *International Archives of Multidisciplinary Study*, *1*, 13-16.

Wienhold, B. J., Trooien, T. P., & Reichman, G. A. (1995). Yield and nitrogen use efficiency of irrigated corn in the northern Great Plains. *Agronomy Journal*, *87*(5), 842-846.

Table 1: Effects of Nitrogen and row spacing on fruit length (cm) and fruit diameter (cm) at BUK and Bunkure during the 2023 rainy season.

Treatment	BUK		Bunkure	
	Fruit length	Fruit diameter	Fruit length	Fruit diameter
Nitrogen (Kg/ha)				
0	21.9d	47.7b	34.1d	58.0
40	27.0c	56.3a	37.7b	64.8
80	31.7a	56.3a	39.9a	64.2
120	29.1b	54.0a	35.9c	60.6
Probability level	<0.001	0.022	<0.001	0.062
SE ±	0.479	1.542	0.479	1.542
Row spacing (m)				
1.0	28.1	53.8	37.5	62.1
1.5	27.1	54.8	36.6	63.1
2.0	27.2	52.1	36.6	60.4
Probability level	0.753	0.408	0.753	0.408
SE ±	1.017	1.41	1.017	1.41
Variety (V)				
Yar-Madina	28.3	56.6a	37.8	64.9a
Ex-Ajiwa	26.5	50.5b	36.0	58.9b
Probability level	0.075	0.023	0.075	0.023
SE ±	0.69	1.75	0.69	1.75
Interaction				
N*I	0.023	0.398	0.023	0.398
N*V	0.003	0.420	0.002	0.420
I*V	0.612	0.432	0.612	0.432
N*I*V	0.116	0.662	0.116	0.661

Means followed by the same letter in the same column are not different statistically at *P=0.05* using SNK.

Table 2: Interaction of Nitrogen and variety on fruit length (cm) plant^{-1} 4 WAS at Bunkure during the 2023 rainy season

Treatment	Variety	
Nitrogen (Kg/ha)	Yar-Madina	Ex-Ajiwa
0	25.8c	18.1d
40	24.9c	29.1abc
80	32.2a	31.2ab
120	30.4ab	27.7bc
SE±	1.377	

Means followed by the same letter(s) within the same column and row are not different statistically at *P=0.05* using SNK.

Table 3: Effects of Nitrogen and row spacing on fruit yield (t/ha) of Pumpkin at BUK and Bunkure during the 2023 rainy season.

	locations	
Treatment	BUK	Bunkure
Nitrogen (Kg N/ha)		
0	11.5b	19.0b
40	17.7a	24.4a
80	18.3a	24.2a
120	16.3a	20.1b
Probability level	0.002	0.005
SE ±	0.71	0.77
Row spacing (m)		
1.0	17.9	23.9
1.5	15.2	21.1
2.0	14.8	20.7
Probability level	0.304	0.304
SE ±	1.51	1.51
Variety (V)		
Yar-Madina	16.8	22.8
Ex-Ajiwa	15.1	21.0
Probability level	0.270	0.270
SE ±	1.08	0.78
Interaction		
N*I	0.205	0.150
N*V	0.148	0.076
I*V	0.546	0.754
N*I*V	0.180	0.260

Means followed by the same letter in the same column are not different statistically at *P=0.05* using SNK. WAS = Weeks after sowing

EFFECTS OF POULTRY MANURE TEA AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* [L.] Moench) IN KANO, SUDAN SAVANNA, NIGERIA

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ABSTRACT

Little attention has been paid to the use of organic fertilizers to reduce the rate of inorganic fertilizers applied to vegetables grown in the sub-Saharan African considering its negative impact. Poultry manure tea contains high organic matter content, essential macro and micro nutrients in available form easy to uptake by plants and cheaper than soil applied fertilizers. In view of this, field experiment was conducted at the Teaching and Research farm, Faculty of Agriculture, Bayero University, Kano (BUK) and Audu Bako College of Agriculture (ABCOA) Farm, Danbatta, in 2020 rainy season to evaluate the effect of poultry manure tea (PMT) and NPK on the growth and yield of okra. The treatments consisted of five levels each of NPK (0, 25, 50, 75 or 100%) and PMT (0, 50, 100, 150 and 200 mlm^{-2}) and laid out in spilt-plot design with NPK assigned to the main-plot while PMT is placed in the sub-plot. Data was taken on plant height, number of leaves/plant, leaf area index, number of fruits/plant and fruit yield and were subjected to analysis of variance (ANOVA) using Genstat 17th edition statistical software package and significant treatments were separated using Student Neuman-Keuls (SNK) at 5% probability level. Result showedthat the application of 100% NPK produced the tallest plants, more number of leaves, leaf area index (LAI) across the sampling regimes and locations. Similarly, the application of 200 mlm^{-2} PMT produced taller okra plants, more number of leaves and LAI across the sampling periods and locations. The combination of 50% NPK and 200 mlm^{-2} PMT produced the highest yield of okra (9,815 and 12,398 kgha^{-1}) at ABCOA and BUK respectively. The application of 200 mlm^{-2} can partly replace NPK fertilizers in the production of okra.
Key words: Okra, Poultry manure tea, Inorganic fertilizer, Growth, Yield

INTRODUCTION

Okra is grown in many parts of the world and it is produced mainly for its young leaves and green pods by peasant farmers, in-home gardens or in mix-cropping with cereal (Saifullah and Rabbani, 2009). The leaves and tender shoots which are equally rich in nutrients can be cooked and eaten and (Uzowuru, 2010). The intensive use of mineral fertilizer over time could constitute a setback to soil fertility (Krasilnikov *et al*., 2022)), and the continuous dependence on these fertilizers may be accompanied by a fall in organic matter content, increased soil acidity, degradation of soil physical properties and increased rate of erosion due to instability of soil aggregates (Olowoake and Ojo, 2014; Roba, 2018). Poultry manure tea (PMT) has been observed to enrich the soil chemical properties as well as improve the vegetative growth and yield of okra (Ojo Sokalu and Faramade, 2015). This study was therefore conducted to determine the effect of PMT and NPK on the growth and yield attributes of okra.

MATERIALS AND METHODS

Experimental sites

The study was conducted at the Teaching and Research farm, Faculty of Agriculture, Bayero University, Kano ($11^0$58.861'N; $008^0$31.177'E, 460 m above sea level) and Audu Bako College of Agriculture Farm, Danbatta ($12^0$25'59''N, $8^0$30'55''E, 470 m above sea level) during 2020 rainy season.

Treatments and experimental design

Treatments consisted of recommended rate of NPK (100 kg N, 60kg P_2O_5 and 50kg K_2O) at five levels (0, 25, 50, 75 and 100%) and five levels of poultry manure (PMT) (0, 50, 100, 150 and 200 mlm^{-2}). This was laid out in spilt-plot design with NPK been assigned to the main plot and PMT was placed in subplot and replicated three times.

Preparation and Application of treatments

The NPK was applied as treatments as 0% (No application), 25% (25 kg N, 15 kg P_2O_5 and 12.5 kg K_2O), 50% (50 kg N, 30 kg P_2O_5 and 25 kg K_2O), 75% (75 kg N, 45 kg P_2O_5 and 37.5 kg K_2O) and 100% (100 kg N, 60 kg P_2O_5 and 50 kg K_2O) at 2 WAS and the balance N was applied at flowering stage. The PMT was prepared as described by Ingham (2005). Poultry litter (10 kg) was collected and put in a jute bag and tied with a string and placed in containers without allowing the bag to touch the bottom and 20L of water was added. A litre of dissolved molasses was added to aid microbial activities. A lid was then put partially on the container and stirred twice daily for the first week and once a week for two weeks. The PMT was collected and diluted in a ratio of 2 (clean water): 1 (concentrated PMT). The PMT were applied from 3 to 8 WAS on a weekly basis as follows; 0 mlm^{-2} (No application), 50 mlm^{-2} (0.9 L), 100 mlm^{-2} (1.8 L), 150 mlm^{-2} (2.7 L) and 200 mlm^{-2} (3.6 L).

Cultural practices

The fields were ploughed and harrowed to a fine tilt and marked out into plots. Each plot consisted of 6 ridges of 4 m length (18 m^2). The net plot was the two inner rows, with the top and bottom 0.5 meters discarded giving a net plot size of 4.5 m^2. Seeds were treated with Apron Plus (Metalaxyl 10%, Carboxin 6%, Furathiocarb 34%) against fungicides and insecticides at the rate of 50g per kg prior to sowing as means of seed dressing and three seeds were sown per hole at intra row spacing of 40 cm on ridges and later thinned to two plants per stand after 7 days. Fertilizers were applied as per treatments and hoe weeding was done 3, 5 and 7 WAS. Harvesting was carried out at twice at crop physiological maturity stage.

Data collection and Data analysis

Data were collected on growth characters such as plant height, number of leaves per plant, leaf area index and on yield attributes such as number of fruits per plant and total fruit yield per hectare using standard agronomic procedure. The data collected were subjected to analysis of variance (ANOVA) using Genstat 17th edition statistical software package. The means were separated using student Neuman-Keuls (SNK) test at 5% probability level.

RESULTS AND DISCUSSION

Effect of NPK and Poultry manure tea levels on plant height and number of leaves per plant of okra at BUK and ABCOA.

The effect of NPK and PMT on plant height of okra at ABCOA and BUK in 2020 is presented in Table 1. The result showed that NPK had significant ($p<0.001$) effect on plant height at 6 WAS where the application of 100% NPK recorded significantly the tallest plant (17.76 and 31.55cm) at ABCOA and BUK, although it was at par with other rates except the control (0%) which had the shortest plant at 6 WAS at ABCOA. However, plant height did not differ ($p > 0.05$) significantly at 8 WAS at both locations, respectively. Result also showed significant ($p < 0.001$) effect of PMT on plant height at 6 and 8 WAS where the application of 200 mlm^{-2} of PMT produced the tallest plant at 6 and 8 WAS (16.79 and 35.43 cm) at BUK and at ABCOA, although it was at par with 150 mm^2 at BUK compared with other rates while control had the shortest plant at both locations, respectively. The interaction of NPK and PMT on the plant height of okra at 6 WAS at BUK was significant. Results revealed increase in plant height of okra as the concentration of PMT increased; but, the increase in the level of NPK showed variable response (Table 3).

The effect of NPK and PMT on number of leaves of okra at ABCOA and BUK experimental sites in 2020 rainy season is presented in Table 1. Result showed significant ($p<0.05$) effect of NPK on number of leaves at ABCOA and BUK. At ABCOA, at 6 WAS, 100% NPK and 75% (12.10 and 12.10) significantly produced more leaves although comparable with other rates of NPK while at 8 WAS, the application of 100 % NPK significantly resulted in more number of leaves which is at par with other treatments. Similar results were obtained at BUK at 8 WAS only, while at 6 WAS, the application of 50% NPK significantly resulted in producing more number of leaves per plant compared the other treatments. on the other hand, the application of PMT showed significant difference among the levels of tea applied. At 6WAS at ABCOA, 200 mlm^{-2} produced the highest (12.64) number of leaves and the least was recorded from 0 mlm^{-2} (8.22) and at 8 WAS, the application of 200 mlm^{-2} (19.03) and 50 mlm^{-2} (18.16) significantly produced more leaves than other manure rates. However, at BUK, the application of 200 mlm^{-2} resulted in producing more number of leaves per plant than other manure tea rates at 6 and 8WAS, respectively.

Effect of NPK and Poultry manure tea levels on leaf area index, number of fruits per plant and fruit yield of okra at BUK and ABCOA.

The effect of NPK and PMT on LAI of okra at ABCOA and BUK in 2020 is presented in Table 2. Result showed significant effect ($p<0.05$) of NPK on LAI at 6 and 8 WAS at ABCOA and at 8WAS at BUK. At 6 WAS at ABCOA, the application of 100% NPK V produced significantly the highest (0.33) LAI which was at par with other rates, while at 8 WAS, the application of 100% NPK significantly resulted in the highest LAI compared with other rates that had lower LAI. At BUK at 6 WAS, there was no significant ($p>0.05$) difference varying rates of NPK on LAI at 6 WAS. However, at 8 WAS, the application of 25-100% of NPK significantly ($p<0.05$) resulted in producing larger leaf area index compared to the control which had the least LAI. Result further showed significant difference among the levels of PMT. At 6 WAS, at ABCOA, the application of 150 and 200 mlm^{-2} significantly produced the highest LAI compared with the rest of the PMT rates that resulted in lower LAI at 6 and 8 WAS, respectively. While at BUK, the application of 200 mlm^{-2} PMT produced significantly the highest LAI (1.02) which was at par with other rates except the control (0.144) recorded the least LAI at 6 WAS. While at 8 WAS, the application of 200 mlm^{2} significantly had the largest LAI compared with other rates of PMT that resulted in lower LAI.

The effect of NPK and PMT on fruit number of okra at ABCOA and BUK 2020 is presented in Table 2. Result showed significant ($p<0.05$) effect of NPK on number of fruits at ABCOA and BUK. The number of fruits of okra increased with increased level of NPK applied up to 50% before the increase in the level results into a decrease. The highest number of fruit was obtained at 50 and 75 % NPK (13.05) compared with other rates of NPK while at BUK, the application of 50% NPK produced significantly the highest number of fruits per plant than other rates. On the other hand, the application of 200 mlm^{-2} of PMT significantly ($p<0.05$) resulted in highest number of fruits per plant than the control which resulted in lowest number of fruits per plant. Result also showed significant ($p<0.05$) interaction between NPK and PMT rates at ABCOA where the application of 150 and 200 mlm^{-2} of PMT with 50% NPK significantly produced more number of fruits per plant although at par with 150 and 200 mlm^{-2} with 75% NPK compared with the rest of the interaction effects (Table 4).

The effect of NPK and PMT on fruit yield of okra at ABCOA and BUK indicated significant ($p<0.05$) effect of NPK and PMT at both locations (Table 2). At ABCOA, 50% NPK increased the yield by 81% (7,060 $kgha^{-1}$) which was closely followed by 75% NPK (6,634 kg ha^{-1}) which increased the yield by 70% compared with other rates that resulted in lower fruit yield. Similar results were obtained for NPK at BUK. On the other hand, the application of 200 mlm^{-2} of PMT produced the highest fruit yield (7,664 kg ha^{-1}) at about 123% increase over the control; followed by 150, 100, 50mlm^{-2} which increased the yield by 98, 69 and 36% respectively over the control. Similar result was obtained at BUK.

Result also showed significant ($p<0.05$) interaction between NPK and PMT rates at both locations, the application of 200 mlm^2 of PMT with 50% NPK significantly produced higher yield compared with the rest of the interaction effects at ABCOA (Table 5). Similarly, at BUK, the application of 200 mlm^2 of PMT with 50% NPK significantly produced highest yield compared with the rest of the interaction effects (Table 5).

DISCUSSION

Effects of NPK on the growth and yield of okra

The application of NPK significantly enhanced the growth and yield of okra due to the possession of higher stomata inductance, better partitioning of photosynthetic materials towards economic yield (Kanneh *et al*., 2016). Similar results has been observed by Mohammad *et al*. (2017), who found that applying NPK fertilizer significantly affected the okra plant's leaf area, number of leaves, and plant height. Medeiros *et al*. (2019) reported significant effect of NPK fertilizer was highly significant on the number of fruits/plants. According to Iyagba *et al.* (2013), increasing the rate of NPK fertilizer would result in an increase in the yield performance of okra.

Effects of PMT on the growth and yield of okra

The application of PMT significantly affects the growth and yield of okra due to the beneficial role of PMT in enhancing soil N, P, K and other essential nutrients which improved growth and development of the plants. This agrees with Tiamiyi *et al*. (2012), who found that okra had taller plants in soils with poultry droppings. Abdulmaliq *et al*. (2020) reported significant effect of the PMT on the okra plant height/plant and number of leaves. Higher growth and yield characteristics were obtained with the application of 200mlm^{-2} and this could be due to readily available nutrients that made it easier for plant roots to absorb the nutrients for faster plant growth. Adesina and Wiro (2020) reported the growth and yield of okra are influenced by the rate of poultry manure applied.

Interaction effects of NPK and PMT on the growth and yield of okra

The combinations of 50% NPK and 200 mlm^{-2} PMT were found to influence growth and yield of okra and this is due to combination of PMT and NPK that favours increased production of photosynthates during the growth stages. This corroborates with the earlier research of Afe and Oluleye (2017) on the integration of organic and inorganic fertilizer for okra. The combination of PM and NPK improved the growth and development of okra (Reddy *et al.*, 2022) and Firoz (2009) also reported increase yield of okra due to NPK and PMT combination.

CONCLUSION

The combined application of PMT with NPK improves the growth and yield of okra better than the sole application of each and 50% NPK + 200 mlm^{-2} PMT recorded best results when compared to other treatment combinations. The application of 200 mlm^{-2} of poultry manure tea can partly substitute the NPK in the production of okra and still maintain optimum growth and yield.

REFERENCES

Abdulmaliq, S.Y., Kumar, N., Danjuma, S., Kareem, I., Adekola, O.F. & Bello, A. (2020). Liquid Poultry fertilizer (Manure Tea) for the Growth and Yield Enhancement of Okra Varieties in Southern Guinea Savanna, Nigeria. *Lapai Journals of Applied and Natural Science*, 5(1): 49-55.

Adesina, O.L. & Wiro, K.O. (2020). Influence of Poultry Manure Rates on the Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) in Rivers State. *Journal of Experimental Agriculture International*, 42(1): 116-120.

Afe, A.I. & Oluleye, F. (2017). Response of okra (*Abelmuschus esculenthus* L. Moench) to combined organic and inorganic foliar fertilizers. *International Journal of Recycle Organic Waste Agriculture*, 6(3): 189- 193. https://doi:10.1007/s40093-017-0166-6.

Firoz, Z.A. (2009). Impact of nitrogen and phosphorus on the growth and yield of okra (*Abelmoschus esculentus* (L.) Moench.) in hill slope condition. *Bangladesh Journal of Agricultural Research*, 34(4):713-722.

Ingam, E. R. (2005). The Compost Tea Brewing Manual. 5th Edition, Soil Food web Institute, Covalis. Pg 91.

Iyagba, A.G., Onuegbu, B.A. & Ibe, A.E. (2013). Growth and yield response of okra (*Abelmoschus esulentus* (L.)Moench) to NPK fertilizer rates and weed interference in Southeastern Nigeria. *International Research Journal of Agricultural Science and Soil Science (IRJAS).*, 3(9):328-335.

Kanneh, S. M., Osei, M. K., Akromah, R. & Gyau, J. (2016). Generation Mean Analysis of Yield and Yield Components of Early Generations of Interspecific Crosses of Tomato (*Solanum lycopersicum* L.). *International Journal of Plant Breeding and Genetics*, 10(2): 98–103.

Krasilnikov, P., Taboada, M.A., & Amanullah. (2022). Fertilizer Use, Soil Health and Agricultural Sustainability. *Agriculture*, 12(4):462. https://doi.org/10.3390/agriculture 12040462.

Medeiros, A.S., Júnior, S.O.M., Gonzaga, G.B.M., Santos, T.C. dos, Queiroz, M.M.F., Neto, R.A.A., Magalhães, I.D., Ferraz, R L.S., Costa, P.S., Andrade, J.R. & Pereira, M.O. (2019). Growth of Okra under Nitrogen Rates and Wastewater in the Brazilian Semiarid Region. *Journal of Agricultural Science*, 11(5): 408.

Mohammad, M. K., Fadhilah, N. M., Tahir, D., Mohammad, H. S., & Nashriyah, M. (2017). Effect of different rates of inorganic fertilizer on physiology, growth and yield of okra (*Abelmoschus esculentus*) cultivated on BRIS soil of Terengganu, Malaysia. *Australia Journal of Crop Science*, 11(07):880-887.

Ojo, A., Sokalu, A. & Faramade, A. (2015). Soil Chemical Properties, Growth Parameters and Yield as Affected by Poultry Manure Tea for Okra Production. *British Journal of Applied Science & Technology*, 5: 104-109. 10.9734/BJAST/2015/9340.

Olowoake, A. A. & Ojo, J.A. (2014). Effect of fertilizer types on the growth and yield of *Amaranthus caudatus* in Ilorin, Southern Guinea Savanna Zone of Nigeria. *Advances in Agriculture*, 3(4): 121-125.

Reddy, C. N., Thomas, T., Kumar, B. & Swaroop, N. (2022). Effect of different levels of NPK and poultry manure on growth and yield of okra (*Abelmoschus esculentus* L.) Var. Syndicate Spl. *The Pharma Innovation Journal*, 11(6): 303-306.

Roba, T. (2018) Review on: The Effect of Mixing Organic and Inorganic Fertilizer on Productivity and Soil Fertility. *Open Access Library Journal*, 5: 1-11. doi: 10.4236/oalib.1104618.

Saifullah, M. & Rabbani, M.G. (2009). Evaluation and characterization of okra (*Abelmoschus esculentus* L. Moench.) genotypes. *SAARC Journal of Agriculture*, 7: 92-99

Tiamiyu, R. A., Ahmed, H. G. & Muhammad, A. S. (2012). Effect of sources of organic manure on growth and yields of okra (*Abelmoschus esculentus* L.) in Sokoto, Nigeria. *Nigerian Journal of Basic and Applied Science*, 20: 213-216.

Uzowuru P. (2010). The effect of inorganic and organic fertilizers on okra, Retrieved on 21/10/2010 from http:www.indiastudychannel.com/attachment/resources/107413-28747.

Table 1. Effects of Inorganic Fertilizer and Poultry Manure Tea on Plant height and Number of Leaves of Okra at ABCOA and BUK Experimental Sites in 2020.

	ABCOA				BUK			
	Plant height (cm)		Number of Leaves		Plant height (cm)		Number of Leaves	
	Weeks after sowing (WAS)							
Treatment	6	8	6	8	6	8	6	8
NPK (%)								
0	12.92b	25.26	9.58b	14.52b	21.11d	33.94	10.95c	16.64b
25	14.03b	28.64	10.53ab	14.32b	25.60c	44.72	10.91c	15.23bc
50	14.14b	27.37	11.21ab	16.10ab	26.85bc	46.27	13.04a	17.23ab
75	15.03b	31.62	12.00a	16.66ab	30.21ab	51.68	12.95b	17.25ab
100	17.76a	34.74	12.10a	19.31a	31.55a	51.71	12.30b	18.15a
p-value	0.019	0.082	0.029	0.027	<.001	0.068	0.027	0.039
S.E ±	0.77	2.11	0.48	0.90	1.03	3.97	0.76	0.84
PMT (ml m^{-2})								
0	11.51d	22.31e	8.22e	11.57d	19.60e	33.97d	9.58e	13.33e
50	14.36c	27.90d	10.70d	15.23c	26.17d	43.56c	11.22d	15.47d
100	15.14b	29.88c	11.70c	16.93b	27.74c	46.53c	12.04c	16.60c
150	16.10a	32.11b	12.15b	18.16a	30.01b	50.44b	13.22b	17.85b
200	16.79a	35.43a	12.64a	19.03a	31.81a	53.82a	14.10a	19.26a
p-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
S.E ±	0.24	0.63	0.13	0.36	0.30	1.10	0.20	0.34
Interaction								
NPK × PMT	0.194	0.664	0.098	0.527	<.001	0.282	0.074	0.207

Means followed by the same letter(s) are not significantly different at 5%, PMT = poultry manure tea, WAS = weeks after sowing,

Table 2: Effects of NPK and PMT on LAI, Number of fruits/plant and fruit yield of okra at ABCOA and BUK experimental sites in 2020.

	ABCOA				BUK			
	Leaf area index		Number of Fruits plant^{-1}	Fruit Yield (kgha^{-1})	Leaf area index		Number of Fruits plant^{-1}	Fruit Yield (kg ha^{-1})
Treatments	6 WAS	8 WAS			6 WAS	8 WAS		
NPK (%)								
0	0.170b	0.574b	9.85c	3,898d	0.408	0.705b	14.67d	4,998d
25	0.159b	0.528b	10.56b	4,900c	1.021	1.343a	16.57c	6,231c
50	0.190b	0.528b	13.05a	7,060a	0.940	1.661a	19.71a	8,833a
75	0.252ab	0.673b	12.46a	6,634a	0.744	1.598a	17.19b	8,164a
100	0.334a	1.033a	10.86b	5,879b	0.891	1.778a	16.93c	7,642b
p-value	0.033	0.021	<.001	0.019	0.070	0.012	0.010	0.015
S.E ±	0.03	0.09	0.19	291.4	0.13	0.16	0.34	323.5
PMT (ml m^{-2})								
0	0.149c	0.463d	9.46e	3,433e	0.531d	0.984d	11.85e	4,559d
50	0.190bc	0.572c	11.03d	4,683d	0.705c	1.239cd	15.38d	6,161c
100	0.211b	0.672b	11.57c	5,804c	0.819bc	1.471bc	17.51c	7,073c
150	0.261a	0.772a	12.16b	6,787b	0.928ab	1.554b	19.18b	8,418b
200	0.293a	0.857a	12.53a	7,664a	1.021a	1.837a	21.16a	9,657a
p-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
S.E ±	0.01	0.03	0.07	277.7	0.04	0.09	0.42	360.3
Interaction								
NPK × PMT	0.365	0.381	0.030	0.016	0.700	0.727	0.734	0.039

Means followed by the same letter(s) are not significantly different at 5%, PMT = poultry manure tea, WAS = weeks after sowing

Table 3: Interaction of NPK and PMT on Plant height (cm) of okra at 6 WAS at BUK

NPK (%)	PMT (ml m^{-2})				
	0	50	100	150	200
0	15.99r	20.26q	21.97n-q	23.34m-p	23.98l-o
25	20.63opq	30.21e-h	31.50b-f	34.01bcd	34.72bc
50	20.02pq	26.17i-m	27.01g-l	29.67e-j	31.40b-f
75	19.17qr	24.54lmn	25.53lmn	28.30f-k	30.47d-g
100	22.19n-q	29.70f-i	32.69cde	34.74b	38.46a
S.E±			1.20		

Means followed by the same letter(s) are not significantly different at 5%, PMT = poultry manure tea, WAS = weeks after sowing.

Table 4: Interaction of NPK and PMT on Number of fruits per plant of okra at ABCOA

	PMT (ml m^{-2})				
	0	50	100	150	200
NPK (%)					
0	8.46o	9.48mn	10.18l	10.41i-l	10.70h-k
25	8.85no	10.22kl	10.55i-l	11.30gh	11.87f
50	9.03no	12.63de	13.26bc	14.14a	14.29a
75	10.13klm	12.25ef	12.76cd	13.36b	13.78ab
100	10.95g-j	10.55i-l	11.11hi	11.59fg	12.03ef
S.E±			0.24		

Means followed by the same letter(s) are not significantly different at 5%, PMT = poultry manure tea, WAS = weeks after sowing

Table 5: Interaction of NPK and PMT on Fruit yield (kg ha^{-1}) of okra at ABCOA and BUK

	PMT (ml m^{-2})				
	0	50	100	150	200
NPK (%)			ABCOA		
0	1,778g	3,510ef	4,258e	4,048e	4,457e
25	2,932f	3,944ef	5,147de	6,211cd	6,418cd
50	3,215f	5,817d	6,819cd	8,392b	9,815a
75	3,786ef	4,559e	5,829d	7,476bc	8,596b
100	4,452e	5,584de	6,962c	7,803bc	9,031ab
S.E±			341		
			BUK		
0	2,651g	4,424f	4,880ef	5,444e	6,088de
25	4,140f	5,216e	6,332de	7,481d	7,985d
50	4,150f	7,169d	8,677cd	10,363bc	12,398a
75	4,799ef	6,576de	7,270d	9,159bcd	11,054b
100	5,554e	7,415d	8,205cd	9,638c	10,761bc
S.E±			396		

Means followed by the same letter(s) are not significantly different at 5%, PMT = poultry manure tea, WAS = weeks after sowing

ECOFRIENDLY BOTANICALS AGAINST GUM ARABIC SEED BORER, *Bruchus baudni* Caill (Coloeptera: Bruchidae) DAMAGE ON STORED *Senegalia senegal* SEEDS

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ABSTRACTS

Ecofriendly capabilities of *Khaya senegalensis* and *moringa oliefera* seed oils and leaf powders have been available alternative in sustainable insect pests control strategy for their nontoxic and non-persistent nature. The treatments were separately applied on gum arabic seeds contained in plastic containers (size) at three different concentrations each (0.5, 0.75 and 1ml/100grms seeds for the seed oils and 2, 4, and 6grms/100 seeds for the leaf powders. Aluminum phosphide was used as standard check at the rate of 0.125g/100g gum Arabic seed and the untreated (control) check was also set up along with the treatments. The experiment was laid out in a Completely Randomized Design (CRD) and replicated three times. Data on seed perforation, seed damage and seed weight loss caused by *B. baudni* infestation were collected. Results showed that the application of mahogany and moringa seed oils significantly protect *S. senegal* seed against gum arabic borer compared with the leaf powders. Moreover, both the leaf powders and seed oils significantly reduced seed damage, seed perforation and seed weight loss. Therefore the present findings recommended that the seeds and leaves of mahogany and moringa could be use against *B. baudni* infestation in the store.
Key words: Evaluation, Botanicals, *Bruchus baudni, Senegalia senegal* seeds

INTRODUCTION

Gum Arabic "desert gold of Africa" is a dried exudation obtained from trunks and branches of Sub-saharan *(Senegalia senegal)* (L.) Britton belonging to the sub family Mimosoideae of the family Fabaceae (FAO, 1997; Dorthe, 2000; Wekesa *et al*, 2009). It is a drought resistant species suitable for Sudan and Sahelian Agro-ecological Zones of African continent notably Sudan, Nigeria, Chad, FDA (2002). In Indian desert the seeds of the plant are consumed by local inhabitants in the form of vegetable as one of the constituents of the desert delicacy known as "Puncttikutta" and the seed pods are used as fodder for goats, sheep and (Abdullahi, 2004; Nisha *et al*, 2008).

The gum produced by the tree crop is a multifunctional industrial additive used as adhesive and in pharmaceutical, confectionery, beverage and cosmetics industries (Navarro, 2008) and contributes significantly to the livelihood of the rural areas, national and global populace. Other uses of the crop include fencing, manufacturing of agricultural tools and handles, animal fodder, pods for tanin, timber production and nitrogen fixation into the soil (Aghughu, 1995). Locally the gum is used in local ink preparation, pottery pigments, liquid gum, dyeing of textile and various tree parts are exploited for fuel wood, charcoal and herbal medicine (FAO, 1996). The processed seeds of this plant are reported to have 37.2% protein, the highest among the seeds of 12 species of Acacia which is of medicinal value (Banerji *et al*., 1988).

The seeds are very susceptible to insect infestation both in the field and store Obeng-Ofori and Dankwah, (2002). *Bruchus baudni* attacks *S. senegal* seeds in almost all countries of the North Africa (Appleby and Credland, 2001). The adults lay their eggs on the pod or seed surface, and the larva then burrows into the seed, developing and feeding on the endosperm before subsequently emerging as an adult (Haines 1991; Appleby and Credland, 2001). Development of *B. baudni* from egg to adults range from 45-56 days depending on the temperature and relative humidity (Lale, 2002). *B. baudni* causes significant loss both in qualitaty and quantitaty of stored seeds ranging from 30-50% in Nigeria and Ghana if not control (Oparaeke and Bunmi, 2006; Golob *et al*., 1999; Haines, 1991).

Synthetic insecticides are often used for protecting stored *S. senegal* seeds. However due to health risk to the human, development of resistant pest strains, toxicity to non- target organisms and toxic residues left in the protected seeds (Oparaeke and Bunmi, 2006; Obeng- Ofori and Dankwah, 2002). Therefore, the search for an alternative that can give satisfactory protection, safe and ecologically friendly becomes imperative. Among promising alternatives are Mahogany and Moringa has low toxicity to mammals and it can be applied without specialized equipment. The plants kill insects by absorption of cuticular wax leading to water loss and desiccation (Korunic, 1998). Several Mahogany and Moringa powders and oils have been evaluated as grain protectant and many of them are now commercially available (Subramanyam and Roesli, 2000; Athanassiou *et al*., 2005). Moringa and Mahogany have been found in Northern Nigeria in large deposits. It can be used to control *Sitophilus oryzae* (L.) *Tribolium castaneum* (Hebst.) and *Phyzopertha dominica* (F.) effectively on stored grains and its efficacy is comparable to many commercial chemicals (Kabir *et al.*, 2011, 2013; Nwaubani *et al*., 2014). Many researchers have shown the potentials of Moringa and Mahogany with other IPM compatible control method Athanassiou, 2006; Otitadum *et al*., 2015; Yang *et al*., 2010. Therefore, this study aimed to evaluate the efficacy of Moringa and Mahogany for the control of *B. baudni* in stored *S. senegal*.

MATERIALS AND METHODS

The experiment was conducted in Entomology Laboratory of the Department of Crop Protection, Faculty of Agriculture, Bayero University, Kano,from March - July, 2018. The treatments consisted of two bio-pesticides (seed oil and leaf powder) obtained from *K. senegalensis*, *M. oleifera* at three (3) dosage/concentration levels (2, 4 and 6g/100g of seeds for leaf powders and 0.5, 0.75, and 1ml/100g of seeds for seed oils) and synthetic insecticide, Aluminum phosphide at 0.125g/100g seeds (standard check), control (untreated) (Parugrug and Roxas, 2008; Musa, 2013) which were laid out in a Completely Randomized Design (CRD) repeated three times.

Insect Preparations and Culture

The initial cultures of *B. baudni* were obtained from an already infested *S. senegal* seeds at the gum Arabic plantation of the Rubber Research Institute of Nigeria (RRIN), Gashua, Yobe State. This was allowed to reproduce in the laboratory at ambient temperature and relative humidity, to produce progeny insects of almost the same age which were used to conduct the experiments.

Preparation, Treatment and Maintenance of *S. senegal* Seeds

S. senegal seeds were obtained from the Rubber Research Institute of Nigeria (RRIN), Gum Arabic plantation, Gashua, Yobe state where *S. senegal* plantation was established and the trees had attained flower and pod bearing stage. Pully matured pods of *S. senegal* were harvested by shaking the branches over a tarpaulin on the ground. After collection, the seeds were extracted by hand peeling before cleaning. *S. senegal* seeds with emerged holes or egg debris on the testa were considered infested and removed then the seeds were put in a freezer at temperature below 0^oC for 5 days in order to kill and/ or prevent initial infestation in the seeds. The seeds were then removed from the freezer and laid out on the laboratory bench and covered with a screen so that the seeds could equilibrate for a period of three days and then kept until needed (Ileke *et al*., 2013).

Preparation of Bio-pesticides

Seed Oil

Matured fruits of *K. senegalensis* and *M. oleifera* were collected on tarpaulin sheets spread under the tree by striking the pods gently with a stick, after dropping, the seeds were removed and dried under shade to reduce its moisture content. These were ground with mortar and pestle and warm water was added (10ml/kg of seed powder) to form a paste. The paste was then kneaded with hand and oil pressed out. This was filtered with a sieve (mesh size 5x 0.5m) to remove particles and oil was transferred into plastic bottles and stored for usage in the laboratory (Stoll, 1988).

Leaf powder

The leaves of *K. senegalensis* and *M. oleifera* were collected from the Orchards of Audu Bako College of Agriculture, Danbatta, Kano State and BUK Orchard, respectively. These were shade-dried to a crispy condition (Yusuf and Ahmed, 2005) and thoroughly pound in mortar with pestle. The pounded plant parts were passed through 40µm sieve to give fine powder.

Laboratory bioassay

Hundred grams' seeds of *S. senegal* were placed in plastic containers (100cc) and then thoroughly mixed with the various concentrations of the two forms of bio-pesticides. Thereafter, five (5) pairs of newly emerged adults of *S. senegal* seed borer were introduced into each container. These containers were closed by muslin cloth and tightly secured by rubber band. The experiment was carried out at a room temperature.

Seed Perforation

At four (4) weeks intervals, for a period of 3 months the n**u**mber of exit holes was assessed by counting the number of holes which appeared on each seed with the aid of dissecting needle. The seeds were turned upside down and from side to side to ensure that no hole was left uncounted (Abduljalal *et al*., 2011).

Seed Damage rate

The effects of mixture of botanical were assessed from the proportion of seeds with *B. baudni* emergence holes. After 90 days, 30 seeds were taken randomly picked from the sample bottles and the seeds were separated into damaged and undamaged categories and these were counted. Seed with typical "emergence hole" were counted as damaged, thus percentage seed damage was calculated as described by Sibakwe and Donga (2015);

$$\%\ \text{Seed damage} = \frac{\text{Number of seeds damaged}}{\text{Total number of seeds}} \times \frac{100}{1}$$

Percentage of *S. senegal* seed Weight Loss

After 90 days, dead insects were removed and the seeds were cleaned and weighed and recorded to obtain the final seed weight of the sample. The differences in weight between the infested and the infested seeds gave the loss in weight as a result of *B. baudni* infestation percentage infestation Percentage was the calculated as follows:

$$\%\text{Weight loss} = \frac{(IGW - FGW}{IGW\ of\ Sample} \times \frac{100}{1}$$

Where, IGW= initial seed weight of the sample, FGW= final seed weight (Sibakwe and Donga, 2015).

DATA ANALYSIS

The original mortality data was corrected using Abbott's formula for natural mortality in untreated controls (Abbott, 1925). Numerical data collected were transformed using square root transformation $\sqrt{n+1}$ and the corrected mortality and other data obtained in percentages were arc sine transformed and subjected to analysis of variance (ANOVA) in a Completely Randomized Design (CRD) using Genstat 17th Edition computer Software. differences between significant treatment means were separated using Student-Newman-Keuls (SNK) test at 5% level of probability.

RESULTS

Effect of plant seed oil on seeds perforation caused by adult *B. baudni* on *S. senegal* seeds.

Results of the present study had shown that the perforation caused by *B. baudni* on *S. senegal* seeds was significant ($P<0.05$) and statistically similar at all the concentrations (ml/100g seeds) when treated with both Moringa and Mahogany seed oils and the synthetic insecticide (Table 1). The untreated checks recorded the highest perforation (7.78 and 7.23% for moringa and mahogany oils, respectively) which were significantly ($P<0.05$) different from the treated seeds.

Effect of Plant Leaf Powder on Seeds Perforation caused by Adult *B. baudni* on *S. senegal* Seeds

Table 2 shows seed perforation caused by *B. baudni* on *S. senegal* seeds mixed with Moringa and Mahogany leaf powders. Lowest seed perforation (2.37) was recorded by 6g/100g seeds concentration of moringa leaf powder treated seeds which was statistically at par with Aluminum phosphides. However, this was significantly ($P<0.05$) different with 4g (3.79) and 2g (3.27) leaf powder treatments. The highest seeds perforation was recorded in untreated control seeds (7.23). Similarly, mahogany leaf powder at all concentrations recorded significantly ($P<0.05$) similar perforations including the Aluminum phosphide which recorded the lowest perforation while the untreated control had the highest perforation.

Percentage Seed Damage caused by Adult *B. baudni* on *S. senegal* Seeds treated with some Plant Seed Oil

Findings in table 3 reveals the percentage seed damage caused by adult *B. baudni* on *S. senegal* seeds treated with plant seeds oils of moringa and mahogany had indicated a similar and significant ($P<0.05$) difference in preventing *S. senegal* seeds from damage (table 3). The highest seeds damage was recorded from the untreated seeds (38.9 to 77.1) which were significantly different from other treated seeds.

Percentage seed damage caused by adult *B. baudni* on *S. senegal* seeds treated with some leaf powder.

The effects of *M. oleifera* and *K. senegalensis* leaf powder on the damage caused by *B. baudni* infestation on *S. senegal* seeds are presented in Table 4. The results indicated that there was significant difference ($P>0.05$) among all the treatments of *M. oleifera*, K. *senegalensis* and the synthetic insecticide compared with the untreated control. However, all the *M. oleifera*, *K.*

senegalensis leaf powder treatments and the synthetic insecticide recorded statistically similar effects on *B, baudni* damage. Untreated control (77.2%) suffered great seeds damage.

Effect of plant seed oil on percentage seed weight loss caused by *B. baudni*

Data presented in Table 5 shows the percentage weight loss caused by *B. baudni* on *S. senegal* seeds was significant (P>0.05) and indicated that all the bio-pesticide oil and the synthetic insecticide treatments were statistically the same and better than the control checks. No weight loss (0.00) was recorded in all the bio-pesticides oil treatments, all being at par with one another and superior to control (38.1) in protecting gum Arabic seeds from *B. baudni*. The two essential oils did not significantly differ in preventing weight loss with Aluminum phosphide treatments.

Effect of plant leaf powder on percentage seed weight loss caused by *B. baudni*

The results of percentage seed weight loss caused by adult *B. baudni* and *S. senegal* seeds treated with plant leaf powder (Table 6). It is clear that minimum weight loss (0.20) was recorded in seed coated with 4g/100g moringa powder, followed by 6g (1.0) of moringa powder and 2g (1.6) all being same with one another at all levels. Equally no weight loss observed in Aluminum phosphide treatment and was significantly different (P<0.05) from the control (34.9). However, same trend was also recorded in mahogany leaf powder, no significant difference in the percentage seed weight loss recorded in all the treatment levels and all being at par with each. More so, control significantly (P<0.05) had high percentage of weight loss (36.7) compared to the treated seeds. Also no weight loss observed in Aluminum phosphide treatment. All the *moringa olifera* and *mahogany* leaf powders and the synthetic insecticide were statistically similar and recorded the lowest weight loss compared to the control check.

DISCUSSION

The present study showed that treatments containing botanicals regardless of their concentrations were toxic to *B. baudni*. The effectiveness of botanicals used had earlier been reported by many workers (Makut *et al*., 2008; Stoll, 2000; Yusuf *et al*., 2009). The botanicals tested in the present study showed that all the tested oils provided significant protection to *S. senegal* seeds from perforation by *B. baudni*. Also according to the report of (TUNC *et al*. 2000; Lale 2002) plant oils were observed to be readily biodegradable and less detrimental to non-target organisms than synthetic pesticides. The present study was in conformity with the report of Tripathi *et al*, (2006) who reported that neem oil was effective in reducing grain perforation in pigeon pea by *C. chinensis*. Nevertheless, the present findings are broadly consistent with earlier findings of many workers who had reported that essential oils have a low toxicity to warm- blooded animals, high volatility, and toxicity to stored- grain insect pests (Regnault- Roger and Hamraqu., 1993; Wudil, 2013). The presence of volatiles/essential oils in MSO and MHSO such as limonene citral, aromatic compounds and terpineol, which have ovicidal, toxic and deterrent effects on stored products Coleopteran (Yusuf and Dike, 2012) could have been responsible for its effectiveness.

The effectiveness of the plant leaf powders, of Moringa and mahogany at higher concentration was the most effective and had recorded the lowest perforation. Moringa and mahogany leaf powders have been found to be effective in suppressing weevil perforation in stored gum Arabic seeds. This findings support the findings of Dike and Mbah (1992), the number of holes and progeny emergence in the treatment was dosage dependent in which African nutmeg oil and moringa seed oil had the lowest perforation, they added that cowpea treated with African nutmeg may have been protected from damage due to the oil content of the material, which could have blocked or interfered with the respiratory tracts of the insects resulting in increased mortality, reduced oviposition and infertility of the egg. Ogunwolu and Wajilda, (1996) reported, the result of the experiment that the neem was slightly effective on the Acacia borers. It was noted from the study that all the tested oil significantly protects *S. senegal* seeds from the damage by *B. baudni* regardless of concentration treatments. Guillaume *et al*., (2005) reported the bioactivity of natural products with insecticidal properties which are used as grain protectants against weevils in storage. In the present study, the low grain damage due to *B. baudni* might be due to decrease in adult emergence that resulted in less damage. The findings of this study are consistent with those of earlier workers who have reported the effectiveness of ashes of the various plants used as grain protectant against various stored products pests. Furthermore, Datziel (1948) established that for medicinal purposes, the leaves and bark of *K. senegalensis* are used for treatment of stomach upset in both humans and livestock and in crop protection for preserving seeds for next year's planting.

Higher concentration treatment of moringa and mahogany leaf powders were found to be most effective t in reducing seed damage. Despite the fact that leaf powder was found to be slightly effective on *B. baudni* neem, leaf powder protecting however, been found affective in protecting Paddy rice against damage by *S. cerella* Ogunleye, (2000). More so, the increase in damaged seeds due to increase in duration of the study period may be attributed to an increase in the total number of gum arabic weevils with time and degradation of the effectiveness of the protectants with time.

The result of the study showed that all the treated seeds had no effect on the weight loss of *S. senegal* seeds regardless of treatment contained. The present findings were contrary to the finding of Tripathi *et al*, (2006), who reported that neem oil at 2ml/kg in pigeon pea seeds against *C. chinensis* reduced the weight loss. Singh *et al* (2006) recorded weight loss on pea seeds treated with mustard oil at 2ml/kg. Gum arabic seeds, coated with higher dosage of Moringa and mahogany seed oils suffer significant reduction in weight loss possibly due to the reduced oviposition and number of eggs that hatched; therefore, reducing larval feeding, this consequently lowered the percentages of seeds weight losses. The current result agrees with previous researchers (Adedire and Akinneye, 2004; Mbailo *et al*., 2006), who showed that powder and ethanolic extracts of tree marigold, *Tithonia diversifolia*, seed oils from *Azadiracta indica*, *Ricinus communis*, *Thevetia nerifolia*, *Balanites eagyptiaca*, *Moringa oleifera* and *Khaya senegalensis* protected stored cowpea seeds against *C. maculatus* infestation.

The number of seeds damaged by all treatments increased with duration of the study period. This may be attributed to increase in the total number of *C. maculatus* and this may have led to degradation of the effectiveness of the Moringa roots oil extract, which served as protectants with time. Gum arabic seeds, coated with higher dosage of Moringa roots oil extract suffers significant reduction in seed damage and lower weight loss possibly due to reduced oviposition and number of eggs that hatched; therefore, reducing larval feeding, this consequently lowered the percentages of seeds damaged and seed weight losses. The current result further agrees with previous researchers (Adedire and Akinneye, 2004; Mbailo *et al*., 2006), who showed that powder and ethanolic extracts of tree marigold, *Tithonia diversifolia*, seed oils from *Azadiracta indica*, *Ricinus communis*, *Thevetia nerifolia*, *Balanites eagyptiaca*, *Moringa oleifera* and *Khaya senegalensis* protected the stored cowpea seeds against *C. maculatus* infestation.

All the leaf powder treatments were very effective in reducing the weight loss caused by *B. baudni*. The finding of this study is in conformity with that of Seck *et al.* (1991). They also reported that leaves and kernel of *Azadirachta indica* increased adult mortality of *C. maculatus* and protected weight loss by more than 90%. This indicated the efficacy of neem seed powder and possibly some other concentration of neem leaf powder. The finding of this study is in conformity with that of Seck *et al*., (1991). They reported that leaves and kernel of *A. indica* increased adult mortality of *C. maculates* and protected weight loss by more than 90%. This indicate the efficacy of Neem seed powder and possibly some other concentration of Neem leaf powder.

CONCLUSION

The present findings showed that all the treatments were better than the control. Chemical insecticide (Aluminum phosphide), Mahogany and Moringa seed oils irrespective of their concentrations performed better than the leaf powders. However, among the leaf powder concentrations, better protection of the *S. senegal* seeds was achieved with Moringa and Mahogany at 6g dosage rate.

REFERENCE

Abbolt W. S, (1925). A Method of Computing the Effectiveness of an Insecticide. *Journal of Economic Entomology*, 18: 265-267.

Abdullahi, A. (2004). Report on Survey of Selected Agricultural Raw Materials in Nigeria. Document Prepared for the Nigerian Raw Materials Research and Development Council (RMRDC), Abuja Nigeria.

Adedire, C. O. and Akinneye, J. O. (2004). Biological activity of tree marigold, *Tithonia diversifolia*, on cowpea seed bruchid, *Callosobruchus maculatus* (Coleoptera: Bruchidae). *Annals of Applied Biology* 144(2):185-189.

Aghughu, O. (1995). Personal Tipping's from Gum Arabic Literature Collected During the Visit of E. African Rubber Research Institute, Nigeria.

Appleby, J.H. and Credland, P.F. (2001). Botanical and Polymorphism in Callosobruchus subinnotatus (Coleoptera: Bruchidae). Bulletin of Entomological Research, 91: 235-244.

Athanassiou, C. G., Kavallierators, N. G., Tomanovic, Z. (2006). Factors Affecting the Insecticidal Efficacy of the Diatomaceous Earth Formulation Silicosec Against Adults of the Rice weevil, Sitrophilus oryzae (L.) (Coloeptera: Curculionidae). Applied Entomology and Zoology: 41: 201- 207.

Benerji, R. Chowdury, A.R; Misra, G. and Nigam, S.K. (1988). Chemical Composition of *Acacia scleroxyla* Tuss. to Mycorrhizal Inoculation. *The International- Tree Crop Journals*. **65** (12): 1959-1960.

Das, G. P. (1995). Plants used in controlling the potato tuber moth Phathorimaea operculella (Zeller). *Crop Protection*, 14: 631–636.

Dike, M.C., Mbah, O.I. (1992). Evaluation of Lemon grass (*Cymbopogon citrates* Staph.) Products in the Control of *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) on Stored Cowpea. *Niger. Journal. Plant Protection*, 14: 88- 91.

Dorthe, J. (2000). *Acacia senegal* L. Willd, Seed Leaflet._Denida Forest Centre Denmark, http:// www.dfs. dk.

FAO, (1996). Quality Control of Gum Arabic in Nigeria (Project TCP/ RAF/ 4557 Document)

FAO (1997). Food and Nutrition. Food and Agricultural organization of the United Nation, Rome. 52:5.

FDA, (2002). Base Line Survey on Gum Arabic Production. Monograth by Federal Department of Agriculture in Collaboration with Rubber research Institute of Nigeria and Forestry Research Institute of Nigeria.

Golob, P., Moss, C., Devereau, A., Goodland, A. D., Andan, F. H., Atarigya, J. and Tain B.M.D (1999). Improvements in the Storage and marketing Quality of Grain Legumes: Final Technical report. NRI Report 2417. Project R 6503. Natural Resources Institute Chatham Maritime Kent. U.K. 246pp.

Guillaume, K. K., Koumaglo, H. K, Glitho, I. A. (2005). Inhibition of Callosobruchus maculatus (F.) (Coleoptera: Bruchidae) development with essential oil extracted from *Cymbopogan schoenanthus* L. Spreng. (Poaceae), and the wasp *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae) *Journal of Stored Products Research*, **41**(4): 363- 371.

Haines, C.P. (1991). Insects and Arachnids of TropicalStored Products: Their Biology and Identification (2nd edition). National Resources Institute, Chatha. UK. 246pp.

Ileke, K. D. Bulus, D. S. Aladegoroye, A. Y. (2013). Effects of Three Medicinal Plants Products on Survival, Oviposition and Progeny Development of Cowpea Bruchids. *Callosobruchus maculatus* (fab.) [Coloeptera: Chrysomelidae]. Infesting, Cowpea Seeds in Storage. *Jordan Journal Biology Sci*ence **6(**1): 61-66.

Ivbijaro, M. F. (1983). Preservation of Cowpea, *Vigna unguiculata* L. (Walp), with the Neem Seed, *Azadirachta indica* A. juss. *Protection Ecology*, 5 (2): 177-182.

Kabir, B.G.J., Lawan M. and Jidda M. B. (2013). Bioactivity of Raw Diatomaceous Earth Against Rhyzopertha dominica Fab. (Coleoptera: Bostrichidae). Effect of Grain Type Dose Rate and Exposure Period. *Journal of Agriculture and Veterinary Science*. 4:44-59

Korunic, Z. (1998). Diatomaceous Earths, a Group of Natural Insecticides. *Journal of Stored Products Research, 34 87-97.*

Lale, N.E.S. (2002). Stored Product Entomology and Acarology in Tropical Africa, First Edition. Mole Publications Maiduguri, Nigeria, 204pp.

Lucy, E., Aliyu, M. and Ojiekpon, I. F. (2016). Effect of Neem Powders (*Azadirachta indica* A. Juss) on the Preservation of Gum Arabic (*Acacia senegal* L. Willd) Infested with *Bruchus baudni* (Caill) in Gashua, Yobe State Nigeria. *Journal of Agriculture and Food Environment* **3**(2): 109-121.

Makanjuola, W. A. (1989). Evaluation of Extracts of Neem (*Azadirachla indica* A. juss) for the Control of Some Stored Pests. *Journal Stored Product Research*, 25:231-237

ISTA, (1996). Handbook of Vigour Test Methods (2ndedn). International Seed Testing Association, Zurich, Switzerland Pp28-37.

ISTA, (2006). International Rules for Seed Testing. International Seed Testing Association, Zurich. 33pp.

Makur, M. D., Gyar, S. D., Pennap, G. R. I. and Anthony, P. (2008). Phytochemical Screening and Antimicrobial Activity of the Ethanolic and Methanolic Extracts of the Leaf and Bark of *Khaya senegalensis. African Journal of Biotechnology*, 17(9): 1216-1219.

Mathur, S. B. and Kongsdal, O. (2003). Common Laboratory Seed Health Testing Methods for Detecting Fungi. International Seed Testing, Association Basers Dorfch- Switzerland 425p.

Mbailo, M., Nanadoum M., Automne B., Gabra, B. and Emmanuel, A. (2006). Effect of Six Common Seed Oils on Survival, Egg Lying and Development of the Cowpea Weevil, *Callosobruchus maculatus. Journal of Biological Science* 6(2): 420-25.

Musa, A.K. (2013). Influence of Plant Powders on Infestation by Adults and Larvae of Khapra Beetle, *Trogoderma granaria* Everts (Coloeptera: Dermestidae) in Stored Groundnut. Australian. *Journal of Basic and Applied Sciences*, **7**(6): 427-432.

Navarro, A. (2008). Sudan's Manna from Heaven and Strategic Weapon, AFP. Archived 28 May 2013 at the Way Back Machine.

Nawrot, J., Harmatha, J., Kosotova I, Ognyanov I. (1989). Antifeedant activity of Rotenone and Some Derivatives Towards Selected Insect Storage Pests. *Biochemical Systematic Ecology*, **7**(1): 55-57.

Nisha, Patel, S.K., Jindal, Majit singh and Anjly Pancholy, (2008). Bruchid Infestation in Pod and Seed in Exotic Collections of *Acacia Senegal* (L.) Willd. In the Thar Desert. *Anals of Arid Zone* (47) 1; 55-61.

Obeng-ofori, D. and Dankwah, J. A., (2002). Biological Effects of Four Protectants applied to Stored Bambara Groundnut Against Infestation by Callosobruchus maculatus (Fab.) (Coleoptera: Bruchidae). *Journal of Ghana Science Association* 4(2): 41-51

Ogunleye, B. M. (2000). Check List of Plant Pests in Nigeria. FDA (Plant Quarantine Service) Nigeria Federal Ministry of Agriculture and Rural Development.

Ogunwole, E. O. and Odunlami A. T., (1996). Suppression of Seed Bruchid (*Callosobruchus maculatus*). Development and Damage on Cowpea (*Vigna unguiculata* L. Walp), with Zanthoxylum zanhoxyloides (Lam). Waterm. (Rutaceae). Root Bark Powder and Pirimiphos Methyl, *Crop Protection* 15:603-607.

Operaeke, A. M. and Bunmi, O. J. (2006). Insecticidal Potential of Cashew (*Anacardium occidentale* L.,) for Control of Beetle *Callosobruchus subinotatus* (Pic.) (Bruchidae) on Bambaragroudnut (*Voandzia subterranea*) (L.). Verdc. *Archives of Phytopathology and Plant Protection*, 39: 247- 251.

Otitodun, G.O., Opit, G. P., Nwaubani, S.I., Okonkwo, E.U. and Gautam, S.G., (2015). Efficacy of Nigerian- Derived Diatomaceous earh, Botanical and Riverbed Sand Against Sitophilus oryzae and Rhyzopertha domica on Wheat. *African Crop Science Journal* 23: 279-293

Ojiekpon, I. F. and Aghughu, O. (2011.) Studies on the Production Pattern of Gum Arabic in

Parugrug, M. L. and Roxas, A.C. (2008). Insecticidal Action of Five Plants Against Maize Weevil, *Sitophilus zeamais* Motsch, (Coloeptera: Curculionidae). *KMITL Science. Technolology S.*, 8(1): 24-38.

Regnault-Roger C, A. Hamraoui., (1993). Efficiency of Plants from the South Used as Traditional Protectants of *Phaseolus vulgaris* L. Against its Bruchids *Acanthoscelides obtectus* Say. In: Proc. The 6th International Working Conference on Stored Products Protection Desmatchelier J.M. (Edition), Volume 2. Pp.723.

Seck, D., B. Sidibe, E. Haubruge and C. Gaspar, (1991). La Protection des. Strocks de niebe (*Vigna unguiculata* (L.) Walp.) en milieu rural: Utilization de Differentes Formulations a Base de Neem (*Azadirachta indica* A. juss.) Provenant du Senegal. Mededelingen Van de Faculteit Landbouw wetenschappen, Jijksuniversiteit Gent, 56:1217-1224.

Sibakwe, C. B. and Donga, T. (2015). Laboratory Assessment of the Levels of Resistance in Some Bean Varieties Infested with Bean Weevils (*Acanthoscelides obtectus and Zabrotes subfasciatus.) International Journal of Plant & Soil Science.* 4(2): 124-131.

Singh, K. M., Sureja, A. K. and Sarma, A. K. (2006). Bio-efficacy of Some Botanicals Against *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) on Pea. *Indian Journal of Entomology*, **68**(4): 404-406.

Stoll, G. (1988). Natural Crop Protection Based on Local Farm Resource in the Tropics and Sub-Tropics**.** 3rd Edition, Weikerssheim, Germany, Margraf Publishers, Scientific Books. 188pp.

Stoll, G. (2000). Natural Crop Protection in the Tropics: Letting Information Come to Life. 2nd Enlarged Edition. Margraf Verlag.

Tanzubil, P.B. (1991). Control of Some Pests of Cowpea (*vigna unguiculata* L. Walp.) with Neem (*Azadirachta indica* A. Juss.) In Northern Ghana. *Tropical Pest Management*, 37(3): 216-217.

Tripathi S, Awasthi S and Chandralekha. (2006). Efficacy of Different Grain Protectants Against *Callosobruchus chinensis* (Linn.) on Pigeon Pea. *Indian. Journal of Pulses Research*, **19**(2): 272-276.

Tunc, L., B. M. Berger., F. Erler and Dagli, (2000). Ovicidal Activity of essential Oils from Five Plants against two Stored- Product Insects. *Journal of Stored Product Research* 36: 161-168.

Wekesa, C., Makenzi, P., Chikamai, B.N., Lelon, J.K., Luvanda, A.M and Muga, M. (2009). Gum Arabic Yield in Different Varieties of *Acacia senegal* (L.) Willd in Kenya. *African Journal of Plant Science*, 3 (11): 263-276.

Wudil, B. S. (2013). Effects of the Essential Oils of Mahogany, *Khaya senegalensis* A. Juss. and Neem, *Azadiracta indica* A. Juss. on Cowpea for the Control of Pod Sucking Bugs Complex (*Clavigralla spp*) in Bauchi, Nigeria. *Techno Science Africana Journal*. Vol. 8 No 1, pp 46-52.

Yang, N.W., Li, A. L., Wan, F. H., Liu, W. X and Johnson, D. (2010). Diamaceous Earth Enhances the Toxicity of Garlic Allium sativum. Essential Oils Against Stored Product Pests. *Journal of Stored Products Research, 46: 118-123.*

Yusuf, S. R., and Ahmed, B. I., (2005). Potential of *Khaya Senegalensis* on *Callosobruchus maculatus. Journal of Stored Product Research* 13: 19-23.

Yusuf, A.U., (2009). Comparative Efficacy of Plant Materials and Pirimiphos- Methyl in the Suppression of *Callosobruchus maculatus* F. (Bruchidae; Coloeptera) Development and Damage in Cowpea Seeds. *Savannah Journal of Agriculture* 4: 45-53.

Yusuf, A. U., (2012). The Use of Locally Available Botanicals as Protectants of Stored Cowpea Seeds Against Callosobrucus maculatus (F.) in Bauchi Samaru journal Agriculture Research 24: 1- 10.

Table 1: Mean seeds perforation caused by Adult *B. baudni* on *S. senegal* seeds treated with some plant seed oil bio-pesticides.

	Mean Number of Seed Perforated	
Concentration (ml/100g seeds)	**Moringa Seed Oil**	**Mahogany Seed Oil**
0.5	1.14b	1.00b
0.75	1.00b	1.00b
1.00	1.00b	1.00b
Aluminum Phosphide	1.00b	1.00b
Control	7.23a	7.78a
SE±	0.117	0.083

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test. Data was transformed using $\sqrt{n+1}$

Table 2: Mean seeds perforation caused by adult *B. baudni* on *S. senegal* seeds treated with some plant leaf powder bio-pesticides.

	Mean Number of Seed Perforated	
Concentration (g/100g seeds)	**Moringa Leaf Powder**	**Mahogany Leaf Powder**
2	3.27b	4.46b
4	3.79b	3.07b
6	2.37bc	2.15b
Aluminum Phosphide	1.00c	1.14b
Control	7.23a	8.01a
SE±	0.489	1.062

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test. Data was transformed using $\sqrt{n+1}$

Table 3: Percentage Seed Damage caused by Adult *B. baudni* on *S. senegal* Seeds treated with some Plant eed Oil Bio-pesticides.

	Percentage Mean Seed Damage	
Concentration (ml/100g seeds)	**Moringa Seed Oil**	**Mahogany Seed Oil**
0.5	0.00 (0.00b)	0.00 (0.00b)
0.75	0.00 (0.00b)	0.00 (0.00b)
1.00	0.00 (0.00b)	0.00 (0.00b)
Aluminum Phosphide	0.00 (0.00b)	0.00 (0.00b)
Control	38.9 (38.57a)	77.1 (61.43a)
SE±	7.231	7.231

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 4: Percentage seed damage caused by adult *B. baudni* on *S. senegal* seeds treated with some plant leaf powder bio-pesticides.

	Percentage Seed Damage	
Concentration (g/100g seeds)	**Moringa Leaf Powder**	**Mahogany Leaf Powder**
2	0.03 (0.93b)	0.04 (1.05b)
4	0.01 (0.47b)	0.02 (0.69b)
6	0.00 (0.00b)	0.00 (0.00b)
Aluminum Phosphide	0.00 (0.00b)	0.00 (0.00b)
Control	69.7 (56.63a)	77.2 (61.47a)
SE±	5.896	7.220

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 5: Percentage seed weight loss caused by adult *B. baudni* on *S. senegal* seeds treated with some plant seed oil bio-pesticides.

	Percentage Seed Weight Loss	
Concentration (ml/100g seeds)	**Moringa Seed Oil**	**Mahogany Seed Oil**
0.5	0.00 (0.00b)	0.00 (0.00b)
0.75	0.00 (0.00b)	0.00 (0.00b)
1.00	0.00 (0.00b)	0.00 (0.00b)
Aluminum Phosphide	0.00 (0.00b)	0.00 (0.00b)
Control	34.1 (35.71a)	38.3 (38.24a)
SE±	0.989	0.441

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 6: Percentage seed weight loss caused by adult *B. baudni* on *S. senegal* seeds treated with some plant leaf powder bio-pesticides.

	Percentage Seed Weight Loss	
Concentration (g/100g seeds)	**Moringa Leaf Powder**	**Mahogany Leaf Powder**
2	1.6 (7.35b)	0.03 (0.87b)
4	0.20 (2.60b)	0.53 (4.20b)
6	1.0 (5.80b)	0.09 (1.78b)
Aluminum Phosphide	0.00 (0.00b)	0.00 (0.00b)
Control	34.9 (33.25a)	36.7 (37.26a)
SE±	4.353	1.259

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

EFFECTS OF MICRONUTRIENT FERTILIZER ON GROWTH, YIELD AND YIELD COMPONENTS OF WHEAT (*Triticum aestivum* L.) VARIETIES IN SAHEL SAVANNA, JIGAWA STATE, NIGERIA

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ABSTRACT

Field experiments were conducted during 2022/2023 and 2023/2024 dry seasons at Flour milling Association of Nigeria Research farm, Ringim LGA of Jigawa state situated in the sahel Savannah agro-ecological zone Nigeria to evaluate the efficacy of different fertilizer treatments with micronutrient fertilizer on growth, yield and yield components of wheat varieties. The experimental entries consisted of seven (7) treatments with a single control plots imposed on two varieties (Norman and Borlaug). The treatments include Control plot, Sole OCP Micronutrient fertilizer, OCP Micronutrient fertilizer with NPK 15:15:15, OCP Micronutrient Fertilizer with Urea 46:0:0, OCP Micronutrient fertilizer with NPK 42:0:5, OCP Micronutrient Fertilizer with Less NPK 15:15:15, OCP Micronutrient Fertilizer with Urea Super Granules (USG) laid out in randomized complete block design and replicated three times. Data were taken on days to 50% heading, days to maturity, number of spike per m-^{2}, number of fertile grains/spike, plant height, days to 50 maturity and grain yield, which were subjected to analysis of variance and significant means were compared using SNK at 5% level of significance. The result indicated that the wheat varieties and the micronutrient fertilizer treatment combination showed significant effect on number of spikes/m^{2}, days 50% heading, number of grain/spikes and grain yield. It can be concluded that application of OCP Micronutrient Fertilizer with Urea 46:0:0(200kg/ha of OCP Micronutrient fertilizer applied basal and 300kg/ha of Urea applying 200kg/ha basal and 100kg/ha 3 weeks) produced the highest grain yield compared to other treatments and control.

Key words: Micro nutrient, fertilizer combination, growth, yield, wheat

INTRODUCTION

Spring wheat (*Triticum aestivum* L.) is an important grain crop in Nigeria and in the world. Increased in agricultural productivity occurred largely due to the development of high-yielding cultivars and increased fertilizer use. Because of the increase in the rate of population growth and the decrease of areas of arable land, improving the grain yield is the way to meet food demand. Optimal fertilizer management is necessary to maintain sustainable yields, improve nutrient use efficiency of fertilizers, and save fertilizer resources (Chuan *et al.*, 2016). The macro- and micronutrients play an important role in the crop nutrition and thus they are important for achieving higher yields, better growth and development of plants (Imran & Gurmani, 2011).

With a growing population and rapid economic development, especially in developing nations, the world's demand for food is set to rise (Westcott and Trostle, 2012). Fertilizing is a common agronomic strategy for increasing the yield and mineral content nutritional value of food crops.

However, understanding the variables affecting micronutrient bioavailability in a soil-plant system is crucial to correctly forecast a crop's response to micronutrient fertilization (Alloway, 2008; Rahman *et al.,* 2020). The lack of readily available micronutrients in the soil for wheat, as for any cereal crop, and their effects on crop productivity are two of the most urgent issues in current agro chemistry. Improving crop production may have a negative influence on agricultural land resources, which is necessary to provide food and nutritional security. Growing of high-yield cultivars lacking micronutrient fertilization has raised concerns because it could gradually reduce soil micronutrient content below the necessary level and cause problems with sufficiency for future crop production (He *et al.,* 2005). Additionally, growing staple crops on soils deficient in micronutrients causes both yield and nutritional quality losses due to the diminishing levels of vital human minerals like Zn and Fe (Alloway, 2008). In order to improve food and nutrition security, micronutrient content in regular diets must be increased and therefore a modern agriculture approach aims to simultaneously enhance staple crops with bioavailable micronutrients while improving efficiency in terms of yield (Rahman and Schoenau, 2020). The objective of the study was to determine the appropriate time of fertilizer application and appropriate quantity of fertilizer required by wheat to attain maximum yield

MATERIALS AND METHODS

Experimental site and description

A field experiment was conducted to evaluate the efficacy of different fertilizer treatments with micronutrient fertilizer on growth, yield and yield component of wheat at Flour milling Association of Nigeria (FMAN) Research Farm, Ringim LGA, in Jigawa state situated in the Sahel Savannah agro-ecological zone, (latitude 12° 17'N and longitude 9° 28'E). The experiments were conducted during the two succeeding seasons of 2022-2023 and 2023-2024. Before sowing, soil samples were taken from the experimental site in both study seasons for physical and chemical analysis.

Experimental design and layout

The experiment was laid out in a Randomized Complete Block design (RCBD) with three replications. The experimental entries consisted of seven (7) treatments with a single control plot imposed on two varieties (Norman and Borlaug). The treatments included control plot (300 kg/ha NPK 15:15:15 applied basal and 150 kg/ha Urea applied as 100 kg/ha at 4 weeks (WAS) and 50 kg/ha at 6 WAS), Sole OCP Micronutrient fertilizer (200 kg/ha OCP Micronutrient fertilizer applied basal and 200 kg/ha OCP Micronutrient fertilizer applied as 100kg/ha at 3 WAS and 100 kg/ha at 6 WAS), OCP Micronutrient fertilizer with NPK 42:0:5(200 kg/ha OCP

Micronutrient fertilizer applied basal and 200 kg/ha OCP Micronutrient fertilizer applied as 100 kg/ha at 3 WAS and 100kg/ha at 6 WAS), OCP Micronutrient fertilizer with NPK 15:15:15(200 kg/ha of NPK 15:15:15 applied basal and 300 kg/ha of OCP Micronutrient fertilizer applied as 200 kg/ha basal and 100kg/ha at 3 WAS), OCP Micronutrient Fertilizer with Urea 46:0:0(200 kg/ha of OCP Micronutrient fertilizer applied basal and 300 kg/ha of Urea applying 200 kg/ha basal and 100 kg/ha 3 WAS), OCP Micronutrient Fertilizer with Less NPK 15:15:15(100kg/ha of NPK 15:15:15 applied basal and apply 200kg/ha OCP Micronutrient Fertilizer as 100 kg/ha basal and 100kg/ha at 3 WAS), OCP Micronutrient Fertilizer with Urea Super Granules (USG) (250 kg/ha of OCP Micronutrient Fertilizer applied basal and Apply urea granule at 3 WAS spaced 20 cm apart within rows) all treatments were replicated 3 times on a plot size of 2 m x 3 m, totaling 42 plots.The crop was sown with row hand drill on a well prepared seedbed using a seed rate of 100 kg/ha. All other agronomic practices were kept normal and uniform for all the treatments. Wheat was manually harvested at physiological maturity. Component of OCP Micronutrient Fertilizer are (NPK 20:20:10 + 1Mg +0.5S+0.3Zn+1B+1Mo)

Data collection and Data analysis

Data was taken on plant height, days to 50% heading, days to 50% maturity, spike length, number of grains per spike, 1000 grain weight and grain yield. All best field agronomic practices for wheat production were adhered to. Data collected were subjected to analysis of variance (ANOVA) and significant treatment means were separated using Student Newman-Keulas test (SNK) at 5% probability level.

RESULTS AND DISCUSSION

Days to 50% heading and Days to physiological maturity

Table 1 showed that the wheat varieties and fertilizer combination had significant difference on days to 50% heading in both years. Maximum number of days to heading for the wheat variety Norman was recorded as 68 days while minimum number of days was recorded as 65 days. Also, higher number of days to heading for the wheat variety Borlaug was recorded as 57 days while minimum number of days was recorded as 53 days. The variation in the number of days to heading might be due to genetic variable characters of wheat varieties (Shahzad *et al.*, 2002).

Days to physiological maturity as influenced by varieties and the micronutrient fertilizer treatment combination showed significant effect in both years (Table 1). The highest number of days to maturity for Norman was recorded as 119 days while the least was recorded as 115 days. The highest number of days for Borlaug was recorded as 106 days while the least was 102 days. The ultimate reason of variable number of days to physiological maturity might be due to heritable characteristics among wheat cultivars (Munsif *et al* 2015).

Number of spike/m^2 and Plant height (cm):

Table 3 revealed significant effect of micronutrient fertilizer and treatment combination on tillers production. Application of Micron + Urea 46:0:0 produced the highest number of productive tillers (spikes) in both years of Borlaug variety while Sole Micron produced the least number of spikes. Tillering is an important developmental stage that allows the plants to compensate under low plant populations or taking advantage of good growing conditions. The appearance of tillers is closely coordinated with leaves on the main stem while the number of tillers formed depends on the variety and growing conditions (Reddy, 2004). Table 3 further showed that varieties and micronutrients fertilizer had significant effect on the plant height of wheat The maximum plant height was observed in treatment 13 (Micron+USG) of Norman variety in both year while the minimum plant height was recorded in treatment 2 (control plot) of Borlaug variety. The difference in plant height might be due to that genetic variability of the wheat (Hussain *et al* 2001). Khan *et al*. (2009) reported that if wheat is treated with 10 kg Zn/ha then plant height increases up to 5.8% as compared to untreated wheat. Increase in plant height may be due to increased Indole-acetic acid (IAA) and chlorophyll formation due to foliar application of micronutrients which finally resulted in improved plant height (Rawashdeh and Sala, 2013).

Number of grain/spike and Spike length (cm)

Number of grains per spike is one of the most important yield determinants. A considerable variation in number of grains per spike was observed in different treatments for application of micronutrient fertilizer (Table 3). Maximum grains was observed with the application of Micron + Urea (46:0:0) in Baulag variety above the control plot in both season while the least was recorded in treatment 3 (Sole Micron). Variation in numbers of grains per spike occurred due to variable genetic potential of varieties for the trait (Tahir *et al.,* 2008). Also, superiority of treatment 10 might be due to micronutrients which play a key role in plant reproductive growth such as boron plays an important role in fruit setting, grain filling and pollen tube formation but Cu plays key role in pollen viability in plants, resulting in more seed set. Similarly, the spike length differed significantly among the micronutrient fertilizer treatment and the wheat variety (Table 3). The maximum spike length was observed in treatment 9 while the least was recorded in treatment 8 in both years. Increased in spike length might due to balanced availability of nutrients in the rhizosphere, their uptake and absorption by the plant (Blevins and Lukaszewki, 1998).

1000 grains weight and Grain yield

Table 4 showed that significant influence of the wheat varieties and the treatment application was observed on 1000 grains weight. In 2023, Micron + NPK 15:15:15(N) produced the highest 1000 grains weight while Micron + NPK 15:15:15(N) produced the least. In 2024 season, Micron + Urea 46:0:0(B) produced the highest number of 1000 grains weight while Sole Micron(N) produced the least. The Variation in 1000 grain weight occurred due to variable water and nutrients use efficiency of varieties (Tahir *et al* 2008). This result is in agreement with the finding of (Khan *et al* 2008) who also find out that zinc has improved water and nutrients availability to roots and consequently increased 1000 grains weight (g). Crop productivity is the rate at which a crop accumulates organic matter which depends primarily on the rate of photosynthesis and conversion of light energy to chemical energy by green plants (Reddy, 2004). Grain yield is the most integrative trait of a particular genotype (Araus *et al.*, 2001). Result further revealed that the wheat varieties and the treatment combination have significantly affected grain yield trait (Table 4). The application of Micron+Urea 46:0:0(B) produced the highest number of grain yield in both years while Micron+USG(N)3 recorded the least number of grain yield in 2023 Sole Micron(N) and Micron+NPK 15:15:15(N) had the least number of grain yield in 2024 season. This result is similar with the finding of (Iqtidar *et al* 2006) who reported that genetic variability among varieties might be responsible for variable grain yield. Similar result is also obtained by (Hafeez *et al.*, 2013) who reported that application of adequate amount of zinc has improved water and nutrients availability, enhanced cell physiology which may lead to improved grains yield.

CONCLUSION

The present research study revealed that micronutrient fertilizer and their application methods had significant effect on the growth and yield of wheat. It can be concluded that treatment 10, application of OCP Micronutrient Fertilizer with Urea 46:0:0(200kg/ha of OCP Micronutrient fertilizer applied basal and 300kg/ha of Urea applying 200kg/ha basal and 100kg/ha 3 weeks) gave the highest number of grain yield compared to other treatments and control.

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REFERENCE

Alloway, B. J. (2008). Zinc in soils and crop nutrition. (2nd ed). Brussels, Belgium and Paris, France: IZA and IFA. *Journal of Pharmacognosy and Phytochemistry, 7*(S4), 206-208.

Araus, J.L., J. Casaduseus and J. Bort. 2001. Recent tools for the screening of physiological traits determining yield. In: *Application of Physiology in Wheat Breeding. CIMMYT*, pp. 59-77.

Blevins, D.G. and Lukaszewski, K.M. (1998) Boron in Plant Structure and Function. *Annual Review of Plant Physiology and Plant Molecular Biology*, 49, 481-500. http://dx.doi.org/10.1146/annurev.arplant.49.1.481

Chuan, L., He, P., Zhao, T., Zheng, H., & Xu, X. (2016). Agronomic characteristics related to grain yield and nutrient use efficiency for wheat production in China. *PLoS ONE*. 11(9), e0162802. DOI: 10.1371/ *journal.pone*.0162802.

Hafeez, B., Khanif, Y.M. & Saleem, M. (2013). Role of zinc in plant nutrition. *American Journal of Experimental Agriculture*, 3(2), 374-391.

He, Z. L., Yang, X. E., & Stoffella, P. J. (2005). Trace elements in agroecosystems and impacts on the environment. *Journal of Trace elements in Medicine and Biology*, *19*(2-3), 125- 140.

Hussain, S., Hussain, M.I., & Saleem, M. (2001). Growth and yield response of three wheat varieties to different seeding densities. *International Journal of Agriculture and Biology*, 03 (2), 228- 229.

Imran, M., & Gurmani, Z.A. (2011). Role of macro and micro nutrients in the plant growth and development. National Agricultural Research Centre. Retrieved March 3, 2018, from: http://agris.fao.org/agris-search/ search.do?recordID=PK2012000898.

Iqtidar, H., Ayyaz, K.M. & Ahmad, K.E. (2006). Bread wheat varieties as influenced by different nitrogen levels. *J Zhejiang Univ Sci Biol*, 7(1), 70-78.

Khan, H., Hassan, ZU & Maitlo, A.A. (2006). Yield and micronutrients content of bread wheat *(Triticum aestivum L.)* under a multi-nutrient fertilizer (Hal-Tonic). *International Journal of Agriculture and Biology*, 8(3), 366-370.

Khan, R., Gurmani, A.R., Khan, M.S. and Gurmani, A.H. (2007) Effect of Zinc Application on Rice Yield under Wheat Rice System. *Pakistan Journal of Biological Sciences*, 10, 235- 239.

Khan, R., Gurmani A.R., Khan, M.S. & Gurmani, A.H. (2009). Residual, direct and cumulative effect of zinc application on wheat and rice yield under rice- wheat system. *Soil and Environment*, 28, 4-28.

Munsif, F., Arif, M., Jan, M.T., Ali, K., & Khan, M.J. (2015). Influence of sowing dates on phenological development and yield of dual-purpose wheat cultivars. *Pakistan Journal of Botany*, 47(1), 83-88.

Rahman, M. N., Hangs, R., & Schoenau, J. (2020). Influence of soil temperature and moisture on micronutrient supply, plant uptake, and biomass yield of wheat, pea, and canola. *Journal of Plant Nutrition*, 43(6), 823-833. https://doi.org/10.1080/01904167.2020.1711941

Reddy, S.R. (2004). Principles of crop production – growth regulators and growth analysis, 2nd edition, Kalyani Publishers, Ludhiana, India. *World Journal of Agricultural Science*, 6 (6), 696-699.

Shahzad, K., Bakht, J., Shah WA, Shafi M & Jabeen (2002). Yield and yield components of various varieties as influenced by sowing dates. *Asian Journal of Plant Science*, 1(5), 522-525.

Tahir, M., Tanveer, A., Ali, A., Ashraf, M. & Wassaya, A. (2008). Growth and yield response of wheat varieties to different potassium levels. *Pakistan Journal Life Social Science,* 6(2), 92- 95.

Westcott, P., & Trostle, R. (2012). Long-term prospects for agriculture reflect growing demand For food, fiber, and fuel. *Annals of Agricultural Sciences*, 39, 1-13

Table 1: Effect of Micronutrient fertilizer and Variety on Heading date and Date to physiological maturity of wheat during 2022/23 and 2023/24 dry seasons.

	2022/2023		2023/2024	
Treatment	Days to Heading	Days to physiological maturity	Days to Heading	Days to physiological maturity
Control (N)	68[a]	116[ab]	66[b]	119[a]
Control (B)	56[c]	103[d]	54[de]	105[cd]
Sole Micron(N)	65[ab]	117[a]	67[ab]	114[b]
Sole Micron(B)	55[c]	106[c]	55[d]	106[c]
Micron+NPK 42:0:5(N)	67[ab]	114[b]	68[a]	118[a]
Micron+NPK 42:0:5(B)	54[cd]	102[e]	57[c]	103[d]
Micron+NPK 15:15:15(N)	66[ab]	116[ab]	67[ab]	115[ab]
Micron+NPK 15:15:15(B)	55[c]	104[d]	55[d]	105[cd]
Micron+Urea 46:0:0(N)	68[a]	114[b]	66[b]	116[ab]
Micron+Urea 46:0:0(B)	54[cd]	105[cd]	54[de]	104[d]
Micron+NPK <15:15:15(N)	67[ab]	116[ab]	68[a]	114[b]
Micron+NPK <15:15:15(B)	53[d]	102[d]	56[cd]	106[cd]
Micron+USG(N)	67[ab]	115[b]	66[b]	118[a]
Micron+USG(B)	55[c]	103[d]	54[de]	103[d]
LSD	4.65	*	5.23	*

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 2: Effect of Micronutrient fertilizer and Variety on Number of spike/m^2 and Plant height of wheat during 2022/23 and 2023/24 dry seasons.

Treatment	2022/2023		2023/2024	
	Number of Spike/ m^2	Plant height (cm)	Number of Spike/ m^2	Plant Height (cm)
Control (N)	288^{c}	95^{b}	380^{bc}	97^{ab}
Control (B)	295^{bc}	82.5^{e}	365^{c}	87.5^{c}
Sole Micron(N)	270^{d}	94^{b}	370^{c}	99^{a}
Sole Micron(B)	298^{bc}	85^{e}	380^{bc}	86^{c}
Micron+NPK 42:0:5(N)	310^{b}	90.5^{bc}	385^{b}	96^{ab}
Micron+NPK 42:0:5(B)	275^{c}	86^{e}	410^{ab}	88^{bc}
Micron+NPK 15:15:15(N)	265^{cd}	93^{b}	370^{bc}	98^{a}
Micron+NPK 15:15:15(B)	320^{b}	87^{cd}	385^{b}	87^{c}
Micron+Urea 46:0:0(N)	330^{b}	95.5^{a}	410^{ab}	94^{b}
Micron+Urea 46:0:0(B)	385^{a}	86.5^{e}	435^{a}	86^{c}
Micron+NPK <15:15:15(N)	250^{e}	90^{bc}	350^{d}	95^{ab}
Micron+NPK <15:15:15(B)	265^{cd}	84^{f}	375^{c}	84.5
Micron+USG(N)	299^{bc}	97^{a}	365^{cd}	99^{a}
Micron+USG(B)	267^{d}	88^{c}	385^{b}	85^{d}
LSD	*	4.45	*	4.75

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 3: Effect of Micronutrient fertilizer and chemical fertilizer on Number of Spike/m^2 and Plant height of wheat during 2022/23 and 2023/24 dry seasons.

Treatment	2022/2023		2023/2024	
	No. grain/ Spike	Spike length (cm)	No. grain/ Spike	Spike length (cm)
Control (N)	44^{d}	9.5^{ab}	52^{c}	9.5^{ab}
Control (B)	46^{cd}	8.5^{b}	56^{b}	8.5^{bc}
Sole Micron(N)	42^{de}	9^{ab}	48^{cd}	9^{b}
Sole Micron(B)	54^{ab}	8.5^{b}	53^{bc}	8^{c}
Micron+NPK 42:0:5(N)	48^{c}	10^{a}	54^{bc}	10^{a}
Micron+NPK 42:0:5(B)	46^{cd}	9^{ab}	42^{e}	9.5^{ab}
Micron+NPK 15:15:15(N)	52^{b}	9.5^{ab}	56^{b}	8^{c}
Micron+NPK 15:15:15(B)	56^{a}	8^{b}	48^{cd}	7.5^{cd}
Micron+Urea 46:0:0(N)	49^{c}	10^{a}	56^{b}	11^{a}
Micron+Urea 46:0:0(B)	56^{a}	9.5^{ab}	67^{a}	10^{a}
Micron+NPK 15:15:15(N)	53^{b}	8.5^{b}	54^{c}	8.5^{bc}
Micron+NPK 15:15:15(B)	48^{c}	9^{ab}	49^{cd}	8^{c}
Micron+USG(N)	44^{d}	9.5^{ab}	46^{d}	9^{b}
Micron+USG(B)	46^{cd}	8^{b}	52^{c}	8^{c}
LSD	*	3.25	*	2.95

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 4: Effect of Micronutrient fertilizer and chemical fertilizer on 1000 grain weight and Grain yield of wheat during 2022/23 and 2023/24 dry seasons.

Treatment	2022/2023		2023/2024	
	1000 grain weight (g)	Grain Yield (kg/ha)	1000 grain weight (g)	Grain Yield (kg/ha)
Control (N)	49.5[b]	3777.7[c]	52[b]	4166.7[c]
Control (B)	43[b]	4000.0[bc]	48[cd]	4833.3[bc]
Sole Micron(N)	42.5[d]	3000.0[cd]	43[d]	3111.1[e]
Sole Micron(B)	49[b]	3222.2[cd]	54[ab]	3444.4[de]
Micron+NPK 42:0:5(N)	42[b]	3666.7[c]	47[cd]	3555.6[d]
Micron+NPK 42:0:5(B)	49.5[b]	3000.0[cd]	52[b]	3444.4
Micron+NPK 15:15:15(N)	54[a]	4500.0[b]	53.5[ab]	4722.2[b]
Micron+NPK 15:15:15(B)	47[bc]	4166.7[b]	49.5[c]	4777.8[b]
Micron+Urea 46:0:0(N)	45[c]	4000.0[bc]	45[d]	4722.2[b]
Micron+Urea 46:0:0(B)	45[c]	5333.3[a]	56[a]	5500.0[a]
Micron+NPK 15:15:15(N)	41.5[d]	3111.1[cd]	44[d]	3166.7[e]
Micron+NPK 15:15:15(B)	48[bc]	3666.7[c]	54[ab]	3777.8[d]
Micron+USG(N)	47[bc]	3000.0[d]	51[b]	4111.1[c]
Micron+USG(B)	49[b]	3166.7[cd]	54[ab]	4555.6[bc]
LSD	4.35	*	3.85	*

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

RESPONSE OF MAIZE (*Zea mays* L.) VARIETIES TO TRACE ELEMENTS IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2021 rainy season at the Teaching and Research Farm of Aliko Dangote University of Science and Technology Wudil and Research Farm of the Faculty of Agriculture Bayero University Kano, located in the Sudan Savanna of Nigeria to evaluate the response of maize varieties to trace elements. The treatments consisted of four levels of Boron and Zinc each at 5 kg ha^{-1} and 2.5 kg ha^{-1} as soil application, 1.12 kg ha^{-1} and 0.56 kg ha^{-1} as Boron foliar application while 0.5 kg ha^{-1} and 0.25 kg ha^{-1} as Zinc foliar applications respectively with a control. Two varieties of maize Sammaz 27 and Oba super1 was used, the experiment was laid out in Randomized Complete Block Design (RCBD). The treatments were applied at 2 and 4WAS and data was collected on plant height, chlorophyll content, fresh and dry weight as well as grain yield and subjected to analysis of variance using Genstat 17th edition. The result showed that maize treated with Zinc at 5kg ha^{-1} and Boron at 0.56kg ha^{-1} as soil and foliar application recorded significantly tallest plant at 83.50cm and 82.33cm of plant height at 6WAS at BUK and 106cm and 78.5cm at Gaya respectively. At BUK, chlorophyll content was highest with application of Zinc at 5 kg/ha at 62.98/6WAS while fresh plant weight recorded the highest value with foliar application of Boron at 0.56 kg /ha at 606.0g in BUK as against the control with 433.7g. Sammaz 27 shows appreciable response to the treatment levels of Boron 0.56kg/ha and Zinc 5kg/ ha as soil and folia application respectively, followed by Oba super1 hybrid with a moderate response to the same treatment levels and application method. Based on the findings of the study it has recommend the application of Zinc at 5kg/ha as soil application and 0.56kg/ha of Boron as folia application for maize improvement.
Key words: Boron, Zinc, Folia application.

INTRODUCTION

Maize is one of the most important staple food crops in Nigeria, among the cereals, it has the largest area devoted to its cultivation. Maize is a major cereal and one of the most important food, feed and industrial crops in Nigeria. Maize provides energy, vitamins and has some amount of protein. The livestock industry consumes more than half of the total maize production annually NAERLS, (2014)**.** Grain yield of maize in Nigeria over the last several decades has been hovering at 2/tons per hectare (t/ ha) which is far less than the yield of about 7t/ ha observed in well-managed field experiments (Fakorede and Akinyemiyu 2023). One of the plausible reasons for the huge Maize yield gap in Nigeria, as in other countries of Sub-

Saharan Africa is poor soil fertility, inherently low soil nutrient reserves as well as continuous cropping with inadequate nutrient replenishment. Maize is a heavy feeder requiring an intelligent fertilizer programs, it requires much of nitrogen, phosphorus, potassium, calcium and magnesium, in a related development by (Brandy *et al.*, 2002) has indicated that neglecting vital soil management and soil improvement practices contributed to soil nutrient depletion. Up to the present time emphasis has been on the application of nitrogen (N), phosphorous (P) and potassium (K) as fertilizer, while (Agbede *et al.*, 2004) emphasized that the optimum Maize production can be achieved by having soil consisting of accessible macro and micro nutrients. Blanket fertilizer application and continuous use of only major elements (NPK) without taking in to cognizance the vital role of other essential nutrients like Boron and Zinc contribute to low maize yield. Soil nutrient balance studies have shown depletion of soil nutrient as one of the most important constraints to sustainable agriculture in Savanna areas of Nigeria (Rego *et al.*, 2014). However, researchers in various locations in the Nigerian savanna have observed that the application of micronutrients coupled with the current intensive use of land could lead to high maize crop productivity.

MATERIALS AND METHOD

The experiment consisted of nine treatment levels as Boron and Zinc at 2.5kg/ha and 5kg/ha a direct soil application and another treatment levels of Boron at 1.12kg/ha and 0.56kg/ha as foliar application and 0.5kg/ha and 0.25kg/ha as Zinc foliar application on two varieties of maize with a control and replicated three times in a Randomized Complete Block Design (RCBD). The gross plot consisted of four ridges of 0.75m apart and 3m long given a total area of $9m^2$ /one plot. The two inner rows serve as net plot at $4.5m^2$ for yield assessment while the outer was used for sampling purpose and as discard. 0.5m was provided between plots and 1m between replication as lee ways respectively, each replication consisted of eighteen plots of $9m^2$ and replicated three times with total area estimate of $432m^2$.

RESULT

Plant height (cm)

Effect of Trace elements on maize varieties to plant height at BUK and Gaya during 2021 rainy season is presented in Table 1. The result showed that at 4 and 6WAS in BUK and Gaya the height of the two varieties were statistically similar. However, at Gaya Sammaz 27 significantly produced taller plant than Oba super1. Application of Boron and Zinc, however at 6 WAS in BUK at 0.56 kg ha^{-1} and Zinc at 5 kg ha^{-1} recorded significantly taller plants which were statistically similar to Boron at 2.5 kg ha^{-1}, but different from other rates of Boron and Zinc. Application of Zinc at 5kg/ha significantly recorded taller plants than Zinc at 0.25 and 2.5 as well as Boron at 2.5kg/ha at 4WAS. Similar trends were observed in the same location at 6WAS except that the result was similar with control but different from all other rates of Boron and Zinc. Interaction between Varieties and trace elements was significant at 6WAS in both locations as indicated in table 2. The height of maize varieties does not change with increase or decrease rate of the trace element except at Zinc 5kg/ha, were Sammaz 27 produced taller plants than Oba super1 in BUK. However, considering the varieties individually Sammaz27 was observed to significantly produced tallest plants with application of Boron at 0.56kg/ha and Zinc at 5kg/ha than other rates of trace elements in Gaya. The plant height does change significantly with Oba super1 by increase or decrease in Trace elements used. Table 1.

Chlorophyll content

Response of maize varieties to trace element on chlorophyll content at BUK and Gaya during 2021 rainy season is presented in Table 3. The result showed that at 6 WAS in both locations the chlorophyll content of the two varieties were not significant, significant difference in chlorophyll content was observed among maize varieties in both locations at 9 WAS. SAMMAZ 27 produced the highest level of chlorophyll content while the lowest content was observed from Oba Super 1. Application of Trace elements has no effect on chlorophyll content at 6WAS in both locations, however at 9 WAS there was a significant effect of Trace elements on chlorophyll content. The highest chlorophyll content was observed on plants treated with Boron at 0.56 kg ha-1 and Zinc at 5 kg ha-1 while the lowest value of chlorophyll was recorded on plants treated with Zinc at 0.25 kg ha-1 in both locations.

Plant fresh weight (g), dry weight (g) and grain yield (t/ha)

Response of maize varieties to trace element on plant fresh weigh, dry weight and grain yield of maize at BUK and Gaya during 2021 rainy season is presented on Table 4. The result showed that application of Boron at 0.56kg produced the heaviest fresh weight which is significant in both locations and the interaction between varieties and trace element on fresh Plant weight were not significant in both Buk and Gaya. On Plant dry weight Application of zinc at 5kg/ha is significantly different from all other rates of trace elements in both locations. The interaction between varieties and trace element rates on plant dry matter was not-significant in both locations. On Grain Yield Weight application of zinc at 5kg/ha is significantly different all other trace element, however on varieties SAMMAZ 27 produced the highest yield (1.36) which is significant.

DISCUSSION

The results of this study showed a significant effect of zinc on growth, yield and yield components of maize. The significant effect of zinc on plant height and chlorophyll content of maize could be attributed to the significant role in growth and metabolism of plant. Zn is an element present in the enzyme system as co-factor and activator of many enzymes, Blackie *et al*. (1993). Significant influence of zinc on leaf area and fresh plant weight might be attributed to plant height and more number of leaves in this treatment because Zinc enhances photosynthesis. This indicates that the micro nutrients help to activate the synthesis of tryptophan and precursor of IAA which is responsible for stimulation of plant growth and accumulation of biomass. A significant effect of zinc on dry cob weight, fresh cob weight, Stover weight, 100grain weight and grain yield this could be probably because sufficient plant nutrients like zinc were applied to the maize treatment. The significant influence of boron on plant height and chlorophyll content of maize could be due to the fact that boron is known to enhance photosynthetic and metabolic activity which leads to an increase in various plant pathways responsible for cell division and elongation, similar findings were also reported by Singh *et al*., (2017). Similarly Boron influenced leaf area and fresh plant weight which could be attributed due to plant height and more number of leaves was found in this treatment because of photosynthesis enhanced in the presence of boron. Differences in terms of growth and yield characters observed among maize varieties can be attributed to their diverse genetic constitution as a result of selection by plant breeders who selected the varieties according to diverse traits. The non-significant effect of varieties to the characters evaluated during the studies implies that the effects of all the treatment combinations were the same.

CONCLUSION

The results of the study shown the growth and yield characters of maize varieties were significantly influenced by the application of boron and zinc. Based on the result of the study, the following recommendations were made; application of Zinc at 5 kg/ha a direct soil mode of application and Boron at 0.56 kg/ha a folia mode of application resulted in higher growth, yield and yield component. Similarly, SAMMAZ-27 had significant advantage over OBA super-1 in most of the characters evaluated including interaction between variety and trace element.

REFERENCES

Adamu, A. K., (2010). Effects of Planting Pattern and Nitrogen Levels on Growth and Yield of Sorghum and Pepper Intercrop (Unpublished MSc Project). Bayero University Kano Nigeria, *pp* 1-67.

Agbede, O. O, and Otonko, E.A., (2004). Effect of Agrolyzer Micro-nutrient and NPK Nutrition on the Yield of Maize. *Nigerian Journal of Soil Science*. (2) 64-67.

Ahmad, A. R., Chang H.Y., and Rahman M.M., (2021). Effect of Zinc on the growth and yield of maize (zea mays.) cultivated in a tropical arid soil using different application techniques *Earth and Environmental Science* (4)756

Alloway, B. J., (2008). Zinc in Soils and Crop Nutrition. Paris France: IFA; and Belgum; *Ann Agric Sci* (3): 1035-1050.

Belgium, IZA. and Fertilizers Application on Maize at South Tahareer province. *Ann AgricSci* (3): 1035-1050.

Bingham, F.T. (1982). Boron. In, methods of soil analysis pat 2 *soc. Agron. Madison*, 431-448.

Bishinu, H, Jiban S and banduhu R. (2010). Effects of micro nurients on growth and productivity of maize in acidic soil,(NARP) napal agricultural programme international Resarch jornal of applied and basic science vol1-15 available on line at hattp 11 www.Ecisi. Com.

Black, R.E., (1993). Zinc deficiency, Infectious Diseases and Mortality in the Developing World of Nutrition, *jonal ofnutrition*, 133:1485-1489.

Brandy, N.C and Weil R.R.,(2002).**Micronutrient and other Trace Elements, the Nature and Property of Soil** (13TH Ed) Pearson education publishers Singhapur *pp*. 638-668.

Brandy, N.C and Weil, R.R (2002).**the Nature and Properties of Soil** (13th Ed) Prentice Hall, *Inc New jersey*, USA pp199-223

Das, D. K, Dang R, Shivananda TN, and Sur P. 2005 Interaction between phosphorus and Zinc on the Biomass yield and yield attributes of the medicinal plants stevia (satevia rebaudiana). Science world jornal, 5:390-395.

Das, D.K (2000). ***Micronutrients and their Behavior in Soils and Plants***. *Kalyani Publishers, New Delhi*, pp55- 61

Ezui, K.S., Franke, A.C., and Mando, A., (2016). Fertilizer requirements for balanced nutrition of cassava across eight locations in West Africa, *Field Crop Res*. 18569–78.

Fakorede, M. A. B., Akinyemiyu, O.A., (2003). Climatic change: eff ects on maize production in a tropical rainforest location. In: Badu-Apraku, B., Fakorede, M.A.B., Ouedraogo, M., Carsky, R.J., Menkir, A. (Eds.), Maize Revolution in West and Central Africa, *pp*. 272–282 Proceedings of regional maize workshop. Cotonou

Gomez, K. A. and Gomez, A.A., (1984). Statistical procedure for Agricultural research *intl. PP 12- 31*

ICRESAT, (2009). Innovations for Changing World, Annual Report 2008.Patancheru, Andhra Pradesh, India: *International Crops Research Institute for semi-Arid Tropics PP, 3:16-17, India.*

Lombin, G, and Mustafa, S. (1980) Fertilizer requirement of Cotton in the savanna areas of Nigeria. *Indian Journal of Agric. Sci*. 50: 851-857

Myer, R. J. K and Johansen, C. (2002). Nutrient Balances; A guide to improving the soil fertility Belgium, IZA. and Fertilizers Application on Maize at South Tahareer province. *Ann Agric Sci* (3): 1035-1050.

Nelson D.W and Sommers, L.E (1982). Total Carbon, Organic Carbon and Magnesium under Zinc New Jersey, USA PP199-223 and 33-379.

Ogunlela,V.B, Kumar V, and Ologunde O.O, (1986) Agronomic investigations of the effects of applied nitrogen, phosphorus, potash and boron on the yield of upland cotton(Gossypium hirsutum L.) in the northern states of Nigeria. Samaru conference paper ll. Inst. For Agric. Res., Ahmadu Bello University Zaria.

Reamaekers, (2001).Introduction to Tropical Crops.Plain Sand Drived Soils of Southeastern Nigeria*Productivity of Maize in Acidic Soil, PP,9-12.*

Rego, T. S, Seeling B, and NagesweraRao,(2014) V. *Research journal of applied and basic science vol 1-15 available online at hattp 11 www.*Ecisi.research station and in small holder (peasant) area of Zimbabwe soil science and plant analysis.

Samuel, L. Tisdale, Wemer L. Nelson, James D. Beaton and John L. Helvin, (1993*). S*oil fertilitys and Derived Soils of southern Nigeria.PP 46-86

Sasakawa Global (2000). Nigeria Project (2010) *Simplified Guide for Crop Production. PP 9-11.*

Singh, M.V., (2009). Micronutrient Nutritional Problems in Soils of india and improvement for human and animal health. *Journal of Fertilizers**5**(4): 11-26.*

UNICEF, (2012). Report – Pneumonia and Diarrhea: Tackling the Deadliest Diseases for the World's Poorest Children. *UNICEF 77 PP Widely and Sons.* Production, Marketing, Processing & Utilization in Nigeria Extension Bulletin No. 217 National Agricultural Extension Research Liaison Services NAERLS, Zaria, July 2014.

Table 1: Effect of Trace elements on Maize Varieties to Plant Height (cm) at BUK and Gaya during 2021 Rainy Season.

	BUK		Gaya	
	Weeks After Sowing			
Treatments	4	6	4	6
Varieties				
SAMMAZ 27	50.48	70.5	54.50a	81.70a
Oba Super 1	46.19	65.5	46.10b	68.00b
SE	3.03	2.71	2.19	3.58
Probability level	0.166	0.074	<0.01	0.010
Trace elements				
Control	44.80	64.17bc	51.67abc	77.50ab
Boron at 5 kg ha^{-1}	52.00	72.50ab	47.67bc	68.33b
Boron at 2.5 kg ha^{-1}	42.80	62.50bc	49.33abc	70.17b
Boron at 1.125 kg ha^{-1}	45.50	54.17c	50.33abc	80.67b
Boron at 0.56 kg ha^{-1}	58.20	82.33a	60.33ab	78.50b
Zinc at 5 kg ha^{-1}	48.00	83.50a	62.50a	106.0a
Zinc at 2.5 kg ha^{-1}	51.30	62.00bc	42.67c	67.17b
Zinc at 0.5 kg ha^{-1}	42.50	64.50bc	49.33abc	65.50b
Zinc at 0.25 kg ha^{-1}	49.80	66.50bc	39.00c	59.83b
SE±	6.44	5.74	4.64	7.60
Probability level	0.305	<0.01	<0.01	0.009
Interaction				
F x V	NS	**	NS	*

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

Table 2: Interaction between Varieties and Trace element on Plant Height (cm) 6 WAS in BUK and Gaya 2021Rainy season

Fertilizers (F)	**Varieties (V)**	
	SAMMAZ 27	Oba Super 1
	BUK 2021	
Control	62.00c	66.33c
Boron at 5 kg ha^{-1}	75.33c	69.67bc
Boron at 2.5 kg ha^{-1}	64.00c	61.00c
Boron at 1.125 kg ha^{-1}	52.00c	56.33c
Boron at 0.56 kg ha^{-1}	92.33ab	72.33bc
Zinc at 5 kg ha^{-1}	107.3a	59.67c
Zinc at 2.5 kg ha^{-1}	59.33c	64.67c
Zinc at 0.5 kg ha^{-1}	63.33c	65.67c
Zinc at 0.25 kg ha^{-1}	59.00c	74.00bc
SE±	5.74	
	Gaya 2021	
Control	75.00	80.00b
Boron at 5 kg ha^{-1}	63.33b	73.33b
Boron at 2.5 kg ha^{-1}	77.33b	63.00b
Boron at 1.125 kg ha^{-1}	80.00b	81.33b
Boron at 0.56 kg ha^{-1}	83.00b	74.00b
Zinc at 5 kg ha^{-1}	138.33a	73.67b
Zinc at 2.5 kg ha^{-1}	82.33b	52.00b
Zinc at 0.5 kg ha^{-1}	60.00b	71.00b
Zinc at 0.25 kg ha^{-1}	76.33b	43.33b
SE±	10.74	

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method.

Table 3: Response of Maize Varieties to Trace element on Chlorophyll Content during 2021 Rainy Season at BUK and Gaya

	BUK		Gaya	
	Weeks After Sowing			
Treatments	6	9	6	9
Varieties				
SAMMAZ 27	40.50	52.79a	33.02	40.50a
Oba Super 1	43.18	49.42b	34.43	29.60b
SE±	1.380	1.054	0.946	1.520
Probability level	0.178	<0.01	0.299	<0.01
Trace elements				
Control	40.88	48.67b	33.19	30.40b
Boron at 5 kg ha^{-1}	44.39	47.83b	36.10	27.95b
Boron at 2.5 kg ha^{-1}	39.40	46.60b	32.57	30.50b
Boron at 1.12kg ha^{-1}	38.24	47.41b	32.28	48.34b
Boron at 0.56 kg ha^{-1}	45.16	61.07a	33.23	55.6
Zinc at 5 kg ha^{-1}	46.19	62.98a	33.30	54.53a
Zinc at 2.5 kg ha^{-1}	42.64	50.66b	32.87	30.22b
Zinc at 0.5 kg ha^{-1}	38.45	47.41b	33.97	30.93b
Zinc at 0.25 kg ha^{-1}	45.16	46.42b	35.98	27.27b
SE±	2.927	2.235	2.006	3.230
Probability level	0.450	0.030	0.857	<0.01
Interaction				
F x V	NS	**	NS	**

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

Table 4: Response of Maize Varieties to Trace elements on Plant Dry Weight and Grain Yield during 2021 Rainy Season at BUK and Gaya

	Fresh Plant Weight (g)		Plant Dry Weight (g)		Grain Yield (t ha^{-1})	
Treatments	BUK	Gaya	BUK	Gaya	BUK	Gaya
Varieties						
SAMMAZ 27	424	341	176.6	252.7	1.330	1.362a
Oba Super 1	467	337	179.1	217.6	1.226	1.186b
SE±	20.6	18.5	6.020	13.43	0.041	0.039
Probability level	0.150	0.894	0.775	0.074	0.086	0.003
Trace elements						
Control	433.7b	324.3	184.1c	135.4c	1.068d	1.002c
Boron at 5 kg ha^{-1}	429.5ab	359.7	145.1c	182.5c	0.734e	1.219bc
Boron at 2.5 kg ha^{-1}	392.8b	386.7	135.9c	186.1c	1.071d	1.147c
Boron at 1.125 kg ha^{-1}	396.2b	289.0	159.0c	164.6c	1.272bcd	1.307bc
Boron at 0.56 kg ha^{-1}	606.0a	367.0	265.1b	315.8b	1.542b	1.355bc
Zinc at 5 kg ha^{-1}	529.7ab	353.5	312.3a	553.0a	1.854a	1.868a
Zinc at 2.5 kg ha^{-1}	435.3b	332.7	118.8c	213.3c	1.487bc	1.502b
Zinc at 0.5 kg ha^{-1}	414.8b	342.7	155.4c	197.9c	1.301bcd	1.051c
Zinc at 0.25 kg ha^{-1}	369.8b	295.7	144.8c	167.9c	1.176cd	1.011c
SE±	43.7	39.3	12.78	28.48	0.124	0.117
Probability level	0.013	0.710	<0.01	<0.01	<.001	<.001
Interaction						
F x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

PRODUCTIVITY OF STRAWBERRY AS INFLUENCED BY DIFFERENT FERTILIZER SOURCE IN JOS, PLATEAU STATE, NIGERIA

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ABSTRACT

Field experiment was conducted at the National Root Crop Research Institute Kuru, Jos Nigeria during 2017/2018, 2018/2019 and 2019/2020 seasons to study the performance of strawberry (Fragaria ananassa Duch) as influenced by different fertilizer source. The treatment consisted of poultry manure, cow dung, NPK15:15:15 and control. The treatments were factorially combined and laid in a randomized complete block design with three replications. Parameters such as number of runners, days to 50% flowering, percentage ripe fruit number, fruit yield, fruit firmness and ascorbic acid were studied. Data on yield characters such as percentage ripe fruit number and fruit yield were taken twice per week and aggregated at 30 days interval beginning from 116 days after transplanting (DAT) until 326 DAT. Reproductive characters such as number of runners and days to 50% flowering including fruit quality parameters (firmness and ascorbic acid) on the other hand were recorded only once. Strawberry fertilized with either poultry manure or cattle dung produced maximum number of runners with minimum days to 50% flowering. The use of either poultry manure or cow dung produced higher monthly percentage ripe fruit number and fruit yield with better firmness and ascorbic acid content. Strawberry fertilized with either poultry manure or cow dung had better performance in terms of fruit yield and quality in the study area.

INTRODUCTION

Strawberry (*Fragaria ananassa Duch*) belongs to the family *Rosaceae.* The crop is one of the most important fruits of the world which has attained a leading position in the world fruit market not only as fresh fruit but also in the processing industries (Deneker, 2021). Strawberry is an herbaceous plant with prostrate growth habit which behaves as annual in high altitude of the tropics and subtropics while it is perennial in temperate region (Rayees, 2017). Among the producing countries of the world China rank first with 3,724,647 metric tons followed by United State of America with 1,449,280 metric tons in 2017 while in Africa, Egypt is the highest producer with 407,204 metric tons followed by South Africa with 8,043metric tons and Kenya ranked third with 942 metric tons (Food and Agricultural Organization Statistic [FAOSTAT] 2019). In Nigeria, most strawberries used to be imported from countries like Kenya and South Africa but now with the help of domestic production Jos the Plateau State capital is gradually the main supplier of the fruit in Nigeria (Adamu, 2019). Strawberry produce and product are widely use in Nigeria, the supply of the fruit is seasonal and unpopular in the country. The effort of the World Health Organization (WHO) to increase the demand of fruit and vegetable of which their consumption is below recommended level for effective health and diseases prevention especially in developing countries (Kalmpourtzidou *et al.*, 2020) can be achieved through improvement in production of fruit crops like strawberry. The strawberry farmers in the study area over depend on chemical fertilizer due to the low nutritive status of the soil. The continuous use of chemical fertilization leads to the deterioration of soil characteristics including fertility leading to low fruit yield, accumulation of heavy metal in plant tissue affecting the fruit nutritional value and edibility while that of organic manure produced high fruit yield and quality (Chandini *et al.*, 2019). Since the production of the crop is not popular in the country and only grown in few areas of Jos and under rainfed through dry season with irrigation, there is need to conduct research on better agronomical practices such as use of different fertilizer source among others to extend it production to zones of the country with similar weather condition.

MATERIALS AND METHODS

The experiment was conducted at National Root Crop Research Institute (NCRI) Potato Programme Farm Kuru, Jos located at latitude of 9°41"36.27N and longitude 8^0 52"16.33E and altitude of 1242m above sea level. The research was carried out during the 2017/2018, 2018/2019 and 2019/2020 wet and dry seasons using irrigation. The average minimum temperature of the area is about 10.4°C during dry season (December to February) and 15°C during the raining season (May to August) while maximum temperature rarely exceed 34.4°C with an average annual rainfall of about 1400mm (metrological unit of NCRI Potato Programme Kuru, Jos) as presented in Table 1. The treatment consisted of three fertilizer sources with control (Poultry manure, cow dung, NPK 15:15:15 and no fertilizer). The treatments were factorially combined and laid in a randomized complete block design with three replications. The field was first ploughed and harrowed twice to obtain a fine tilth. A plot size of 3 x 3m^2 was adopted with 100 cm between plot and 160cm between blocks. Ridges of 10cm height of 80cm apart were constructed. Organic source of fertilize from poultry manure and cow dung were applied at the rate of 7.5t $ha^{-1}$and 16.5t ha^{-1} respectively prior to the completion of ridges before transplanting. NPK15:15:15 fertilizer was applied at the rate of 150 $kgha^{-1}$ N, 150 $kgha^{-1}$ P_2O_5 and 150 $kgha^{-1}$ K_2O after full establishment of the transplants with three split doses within an interval of two months at the rate of 50 $kgha^{-1}$ N, 50 $kgha^{-1}$ P_2O_5 and 50 $kgha^{-1}$ K_2O. The transplanting was carried out by crown division. Strawberry plants of a year old (dormant crown) were removed with lump of soil around the root of each plant. The strawberry crown clustered were cut into division and the crown with at least five to ten healthy roots of a crown diameter of not less than 1.3cm were used. The planting holes of each dormant crown were dug on the ridges constructed slightly deeper than the root ball of the crown such that the crown is roughly 1.3cm below the surface of the soil. The roots of the crown were gently put inside the hole and soil was placed on it and followed by covering of the crown with soil leaving the foliage and stem exposed. The intra row spacing of 30cm with total of 30 plants per net plot was adopted. Furrow method of irrigation was adopted, and irrigation was twice per week. Weeding was carried out as of when do. Harvesting was carried out in two phases. The first phase was carried out by harvesting of the fruit. The picking of the berries was done when the fruit were completely reddish indicating the ripeness of the fruits. The process of the harvesting involved pinching the stalk behind the fruit cap with thumb nail or twisting the stalk by holding the fruit. The second phase of the harvest took place at the end of each growing season by carefully uprooting the whole strawberry plant with clustered of dormant crown. The uprooted plants were used as planting material through crown division for subsequent production. Data on reproductive characters such number of runners per plant and 50% days to flowering including yield characters such as percentage ripe fruit number and fruit yield were obtained from randomly selected 10 plants in all the plots. Data on reproductive characters were recorded once while that of yield characters were taken during harvest once per week at early fruit setting and two to three times at the peak of berry production and aggregated at 30 days interval beginning at 116 until 326 DAT. During the peak period of fruit production at 251 DAT, five plants were randomly selected and one fruit was also randomly picked in each stand for all the treatments for the determination of the fruit firmness and ascorbic acid content. All the data collected were subjected to analysis of variance (ANOVA). Treatment means observed to be significant different were however separated using Duncan Multiple Range Test (DMRT) following the procedure of Duncan (1955).

RESULTS AND DISCUSSION

Reproductive characters and fruit quality

The different fertilizer source significantly ($P \leq 0.05$) influences the reproductive characters of strawberry (Table 2). Higher runner production was noted with the strawberry plots incorporated with either poultry manure or cow dung than that of NPK15:15:15 and control. The better performance in number of runners exhibited by the organic manure source of fertilized strawberry may be attributed to the manure vital role in enhancing soil moisture retention, aeration and microbial activities including supply of wide range of nutrients. Cristina and Jorge (2011) supported the finding and attributed it to plant growth regulating substance associated with crop established within organic matter medium.

Days to 50%Flowering

Influenced of fertilizer type on days to 50% flowering revealed significant (P≤0.05) effect during the investigation (Table 2). It was observed that strawberry grown in the plot incorporated with either poultry manure or cattle dung significantly (P≤0.05) produced flowers within shortest number of days than that of NPK15:15:15 while the least was obtained in the control plot (table two). This result may be due to wide range of nutrients release by the manure which favour fast growing, development and flowering. Early research by Herencia (2011) supported the finding and attributed it to early onset of flowering due to organic manure application to strawberry.

Firmness (N)

Fruit firmness revealed significant (P≤0.5) difference among the fertilizer sources. The use of either cow dung or poultry manure in strawberry produced the most firmness fruit while the least was with that of NPK 15:15:15 (Table 2). The observed result may likely be due to calcium and magnesium release in the manure which play structural role in cell wall of plant leading to strengthening of the ripe berry. Research work of Avila *et al*. (2012) supported the result and reported that organically produced berry had higher value of firmness than that of mineral fertilizer. The season of the research differed significantly (P≤0.5) with 2018/2019 season producing the most firmness fruit than that of 2017/2018 and 2019/2020 (Table 2). This result may be attributed to the minimum temperature at 251 DAT period coupled with the lower mean annual temperature in 2018/2019 season than the other two seasons (Table 2).

Ascorbic acid (mgml^{-1})

Significant difference (P≤0.5) on ascorbic acid was revealed among the fertilizer sources. Strawberry grown in plots incorporated with either poultry manure or cow dung produced higher ascorbic acid fruit content while the least was with that of NPK15:15:15 (Table 2). This finding may be attributed to all the required nutrients release from the organic source of the fertilizer used. The result concur with the research of Shaubash *et al*. (2018) which revealed that organic manure application to strawberry positively enhance ascorbic acid content in the berry than that of mineral fertilizer.

Percentage ripe fruit number

Percentage ripe fruit number significantly (P≤0.05) differ among the fertilizer source and the control. Strawberry fertilized with either poultry manure or cow dung produced higher percentage ripe fruit number while the least was with that of the control plot in all the DAT

(Figure 1). The observed result may be due to adequate balance nutrients release by organic manure which is known to enhance ripening of fruits. This agrees with the finding of Dimitrous (2018) which noted that application of organic manure to strawberry enhance sustainable early ripening. Figure 2 shows significant ($P \leq 0.5$) difference on percentage ripe fruit number among the seasons investigated. Higher percentage ripe fruit number was produced at 116, 146, 176, 206 and 326 DAT by the strawberry grown in 2017/2018 season including 2019/2020 at 236, 266 and 296 DAT. Strawberry grown in 2018/2019 and 2019/2020 produces the least percentage ripe fruit number at 116, 146, 176, 206, and 326 DAT compared to 2017/2018 season. It was also noted at 236 and 266 DAT that strawberry grown in 2017/2018 gave the least and was at par with that of 266 DAT in 2018/2019 season. This may be due to prevailing weather condition during the harvest of the fruits. Earlier research by Delpozo Infrans *et al*. (2006) concur with the finding and associated it to solar radiation and temperature suitable to impact photochemical biosynthesis which enhance fruit ripening.

Fruit yield (kgha^{-1})

Figure 3 shows the effect of nutrient source on fruit yield. There was significant difference throughout the study period where the crop grown in plots fertilized with either poultry manure or cow dung produced significantly ($P \leq 0.05$) higher fruit yield at 146, 176 and 236 DAT including 116 DAT irrespective of the fertilizer source. Poultry manure treated strawberry had the maximum fruit yield at 206, 266 and 296 DAT but at 326 DAT that of cow dung had the highest fruit yield. Control plots however consistently produced the least fruit yield. This result may be attributed to improvement of soil structure characterized by organic manure. Organic manure fertilization to strawberry facilitates higher absorption of nutrients and increase fruit yield (Heerendra *et al*., 2017). The steady release of nutrients from the organic manure to strawberry right from tillage and the quick supplied of nutrients at the crop establishment by chemical fertilizer as earlier noted by Tejorda and Garcia (2006) may have also influenced the result. The three seasons differed significantly ($P \leq 0.05$) on fruit yield but only at 146, 176, 266, 296 and 26 DAT (Figure 4). Strawberry grown in 2019/2020 season consistently had significantly ($P \leq 0.05$) higher fruit yield but was at par with that of 2017/2018 season at 176 DAT. Strawberry grown in 2018/2019 season consistently produced the least fruit yield but was at par with that of 2017/2018 season at 146 and 266 DAT. The observed result may be due to conducive weather especially temperature range of 15-20^{o}C in 2019/2020 season (table one) which concur with the temperature requirement earlier reported by Palencie *et al*. (2008) for fructification in strawberry.

CONCLUSION

Strawberry fertilized with either poultry manure or cattle dung had the maximum number of runners with minimum days to 50% flowering, higher percentage ripe fruit number including fruit yield of better firmness and ascorbic acid. Fertilization of strawberry with either poultry manure or cow dung can lead to better performance in fruit yield and quality of strawberry.

REFERENCES

Adamu, R. (2019). Jos, plateau state capital is gradually the main suppliers of strawberry fruit in Nigeria. **Daily trust,** April 6, P 23.

Amanullah, M. M., Vaiyapuri, K. and Alagesan, A. (2006). Effect of intercropping and organic manures on the yield and Biological efficiency of cassava (*Manihot esculenta crantz*) Intercropping system. *Journal of Agriculture Biological Science*. 2(5): 201-208.

Avila, J. M. M., Toralles, R. P., Cantillano, R. F. F., Peralba, M. C. R. and Pizzolato, T. M. (2012). Influence of organic and conventional on storage of fruit. Cencia Rural Santa Maria 42(12): 2265-2271.

Ayesha, R., Fatima, N., Ruqayya, M., Quresh, M.K., Hafiz, A.I., khan, S. K and kamal A (2011). Influence of different growth parameters of strawberry(*Fragaria ananassa*). *Journal of Medecinal Plant Research*. 5(26):6224-6232.

Chandini, R.K., Ravendra, K and Prakash, O.M (2019). The impact of chemical fertilizer in our environment and ecosystem. In book: Research trend in environmental science. Pp 69-89.

Cristina, L and Jorge D (2011). The use of vermicompost in sustainable agriculture on plant growth and soil fertility. In soil nutrients. Nova Science publisher. 10:2-16.

Deneker, L. (2021). Benefit of global strawberry trade (first place). University of library prize finalist for first season seminar 22.https//www.exhibit.Xavieredu/library-prize/22

Delpozo-Infrans, D., Duncan, C. E., Yu, K. C., Talcon, S. T. and Chandler, C. K. (2016). Polyphenolics ascorbic and soluble solid concentration of strawberry cultivars and selection grown winter annual hill production system. *Journal of American society of Horticultural Science* 131:89-96.

Dimitrious, B., Magdalini, K., Loanis, R., Panayiota, P., Ilias, T., Nikolina, C. and Argyro, D. (2018). Effect of organic and inorganic fertilization on yield and quality of processing tomato (*Lycopersicon esculentum mill*). *Folia Horticulture*, **30**(2):321-332.

Duncan, D. B (1955). Multiple range and Multiple F test. Biometrics.11:1-42 Food and Agricultural Organization (2019). Statistical Data Base. Rome, Italy.

Heerendra, P., Parambeet, S., Meena, K. and Solank, S. P. S. (2017). Effect organic manures and Biofertilizer on Plant Growth, Yield and Quality of Horticultural Crop: A Review. *International Journal of Chemical Studies*. 5 (1): 217-221.

Herencia, J. F., Garcia-Galavisa, P.A. and Doradoa, J.A.K and Maqueda, C. (2011). Comparison of nutritional quality of crops grown in an organic and conventional fertilized soil. *Journal of Horticultural Science* 129: 882-888.

Kalmpourtzidou, A., Eilander, A and Talsma E. F. (2020). Global vegetable intake compare to recommendation. A systemic review. *Nutrients Journal*.**12**(6):1558 doi 10.3390/nu1261558.

Palencia, P., Martinez, F., Medina, J. J., Vazquez, E., Flores, F. and Medina-Lopez, J.(2008). Effect of climate change in strawberry production. *Acta Horticulture Euroberry Research*. 838: 14-20.

Rayees, A. W., Johangeer, A. B., Hakeem, S. A., Sabahat, R. Q., Yusra, A. B., Umar, J. Seecrat, G., Sabiya, B., Mir, M. A., Pamdit, A. H., Ansarulhaq, S., Fayaz, A. B., Najeeb, M., Tanveer, A. M., Basir, A. A. and Prasad, V. M (2017). Influence of differential combination of fertilizer and manure combination on vegetative growth, yield and quality of strawberry (*Fragaria ananassa* Duch). *International Journal of Microbiology and Applied sciences*. 6(11) 3396 – 3404.

Shuabash, S., Amit, K., Rajkuma, C., Praval, S., Singh, S., Ruhul, K. and Saurabh, D. (2018). Effect of organic manure and Biofertilizer on ground yield and quality of strawberry (fragaria ananassa Duch) CV Suleet Charlie. *Journal of Phytochemistry Pharmacognosy* 2:128-132.

Tejada, M. O. and Garcia, C. (2006). Application of two organic amendment on soil restoration effect on the soil biological properties. *Journal of Environmental quality*3:1010-1017.

Table 1: Temperature (T°C) and Rainfall (R) for Kuru, Jos during 2017/2018, 2018/2019 and 2019/2020 season of the experiments

	2017/2018			2018/2019			2019/2020		
	T°C		R(mm)	T°C		R(mm)	T°C		R(mm)
Months	**Max**	**Min**		**Max**	**Min**		**Max**	**Min**	
June	25	18	202.3	22	17	156.4	28	17	212.6
July	23	18	214.8	24	18	283.2	26	17	366.8
Aug	22	17	308.7	24	18	384.8	26	16	287.4
Sep	25	17	256.3	26	17	208.6	25	17	201.6
Oct	28	17	276.0	27	15	79.4	29	16	102.4
Nov	28	14	76	29	12	12.5	29	13	0
Dec	28	12	0	29	12	0	28	11	0
Jan	26	11	0	29	12	0	26	11	0
Feb	25	15	10.05	32	14	26.8	30	14	26
Mar	26	19	36	32	14	36.8	30	14	6.5
Apr	25	20	28	32	18	168	28	18	162.8
May	25	19	218.5	28	18	158.2	28	18	158.0
Total	**306**	**197**	**1606.65**	**302**	**185**	**1514.70**	**333**	**182**	**1524.1**
Mean	25.5	16.42	133.89	25.17	15.41	126.23	27.75	15.17	127

Table 2: Main effect of Fertilizer type on Reproductive Characters and Fruit Quality of Strawberry in Jos, Plateau State

Treatment	NRNS	D50%F	Firmness (N)	Ascorbic acid (Mg/Ml)
Fertilizer				
Control	7.02[c]	49.26[a]	1.78[b]	0.14[b]
Poultry manure	10.39[a]	42.72[c]	2.43[a]	0.32[a]
Cattle dung	9.70[a]	42.50[c]	2.51[a]	0.31[a]
NPK 15:15:15	8.87[b]	44.13[b]	1.18[c]	0.10[c]
LS	**	**	**	**
SE (±)	1.29	1.67	0.06	0.14
Season				
2017/2018	9.03[a]	44.58[a]	1.94[b]	0.22[a]
2018/2019	8.64[b]	45.21[a]	2.04[a]	0.22[a]
2019/2020	9.32[a]	44.17[a]	1.95[b]	0.22[a]
LS	NS	NS	*	NS
SE (±)	0.90	2.34	0.06	0.18
Interaction				
F x S	NS	NS	*	**

Means followed by same letter(s) on the same column do not differ significantly at 5% probability level by Duncan Multiple Range Test (DMRT). F=Fertilizer source, S=Season of the research. LS=Level of significant, *=Significant, **=Very significant, SE (±) = Standard error, NRNS= Number of runners, D50%F=Days to 50 percent flowering.

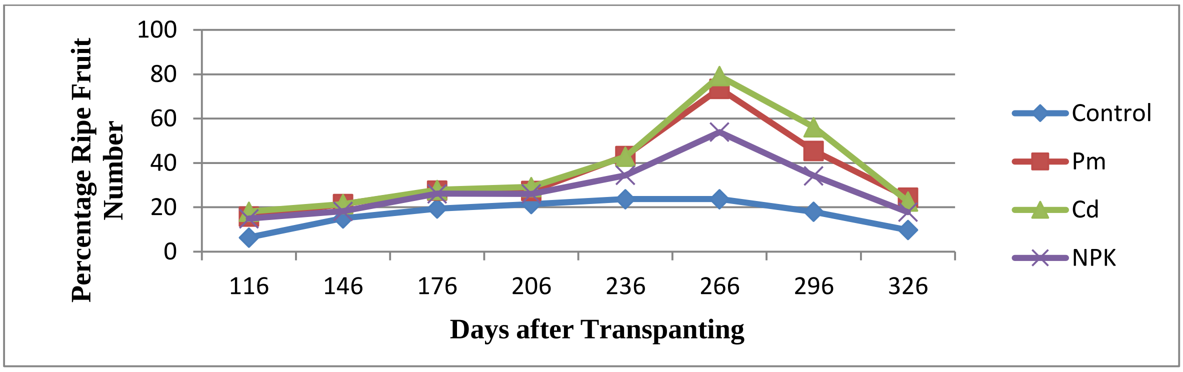

Figure. 1 Effect of Fertilizer source on Percentage Ripe Fruit Number at Days after Transplanting

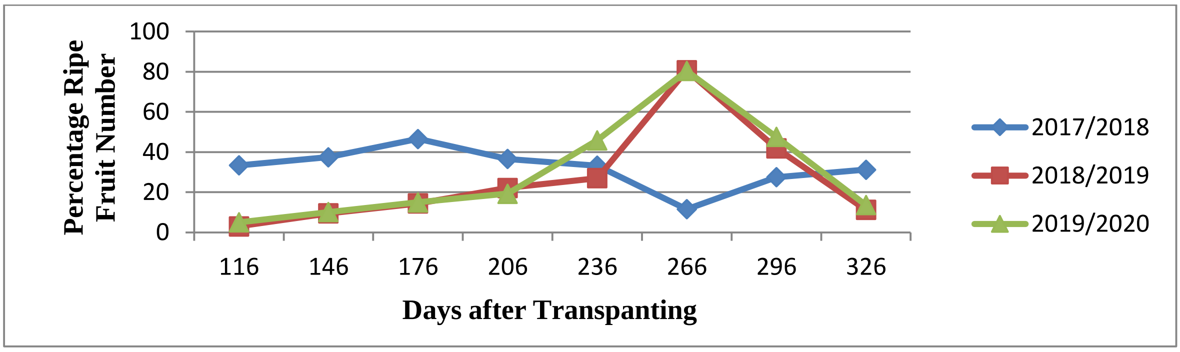

Figure. 2 Effect of season on Percentage Ripe Fruit Number at Days after Transplanting

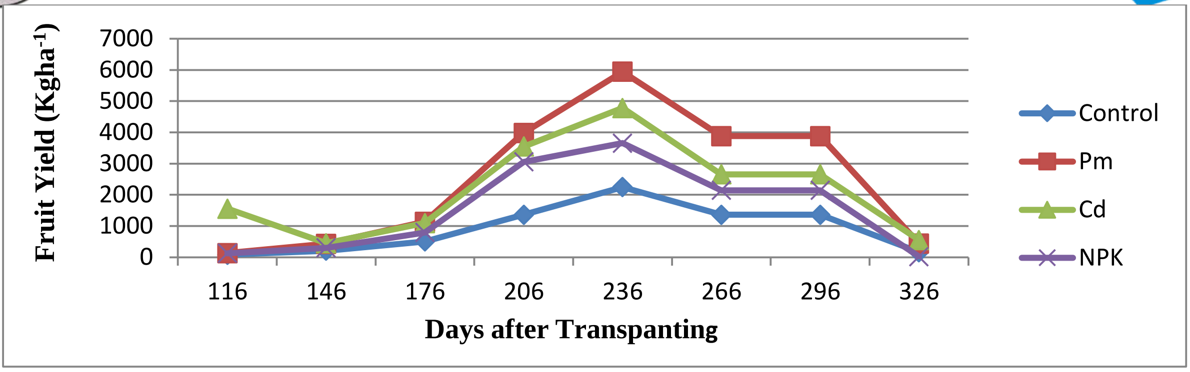

Figure. 3 Effect of Fertilizer source on Fruit Yield at Days after Transplanting

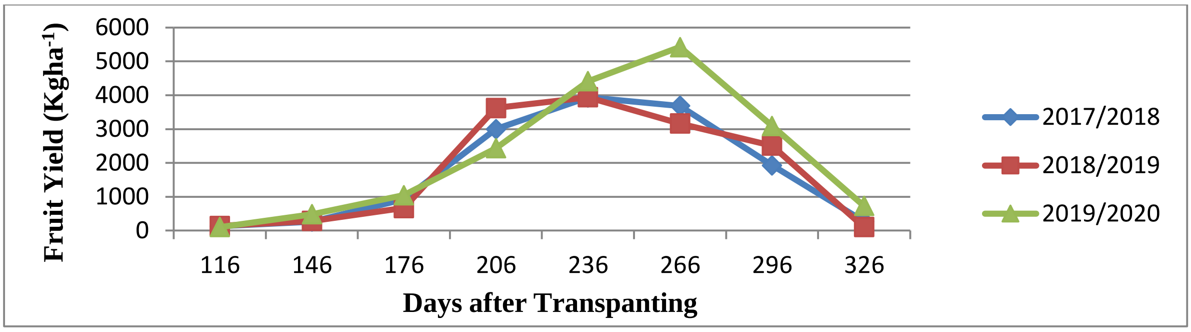

Figure. 4 Effect of season on Fruit Yield at Days after Transplanting

PRODUCTIVITY OF PEARL MILLET (*Pennisetum glaucum* (L) R. BR.) VARIETIES AS AFFECTED BY RICE HUSK AND NITROGEN FERTILIZATION IN THE SUDAN SAVANNAH OF NIGERIA

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ABSTRACT

The trial was conducted to study the productivity of Pearl millet varieties as affected by rice husk and nitrogen fertilization in the Sudan savannah ecology of Nigeria during 2019 and 2020 rainy seasons. The treatments consisted of three rice husk (0, 2 and 4t/ha), four levels of inorganic fertilizer (0, 30, 60, 80 kg N/ha) and the two varieties of pearl millet (local and sosat). The treatments were arranged in factorial combinations and replicated three times and were laid out in a split plot design, with the millet variety and nitrogen levels constituting the main plot and rice husk residues in the sub plot. Data was collected on some growth and yield characters which were subjected to analysis of variance (ANOVA), using JMP Pro14. The significant treatment means were separated using Student' Newman Keuls (SNK) at 5%. The results showed that at both Biu and Hawul grain yield per hectare were significantly affected by rice husk and nitrogen fertilizer. The application of4t/ha and 80kg N/ha of rice husk and inorganic fertilizer gave the highest grain yield per hectare with the local variety compared to the improved (Sosat) variety. Generally, there was a trend of increased in growth and yield with the rate of rice husk application within all the treatments were in the order: control<2t/ha rice husk <4t/ha rice husk. Rice husk can be used as a component in integrated soil fertility management to increase crop productivity. Thus, it is suggested that farmers should adopt these agronomic practices of using 4t/ha of rice husk as a component in integrated soil fertility management in Sudan savannah ecological zone of Nigeria

Keywords: Nitrogen fertilizer, pearl millet, rice husk, varieties, yield.

INTRODUCTION

It is approximated that in Africa about fifty-five percent (55%) of the land area is unsuitable for agricultural production. Merely 11% has high-quality soil that can successfully be managed to sustain more than twice the existing population over numerous countries (Eswaran *et al*., 1997). Most of the usable land is of medium or low potential, with at least one major limitation for agriculture. This might result in high threat of degradation under low input farming systems. Forty–three percent (43%) of Africa is dry lands (arid, semi-arid, and sub-humid zones) with population of over 485 million people (Reich *et al*., 2001). Just about 65% of agricultural land, 31% of permanent pastures and 19% of forest and woodland in Africa were approximated to be affected by some form of degradation (Oldeman, 1994). The current position is undoubtedly worse. Moisture stress essentially constrains land productivity on 86% of soils in Africa

(Eswaran *et al*., 1997). Soil fertility degradation now places an additional serious human induced restriction on productivity.

In sub-Saharan African (SSA) countries, the decline in soil fertility is attributed essentially to continuous cultivation, coupled with quick organic matter mineralization (Dovanan and Casey, 1998). Generally agricultural systems in Nigeria are categorized by low productivity, due to unreliable rainfall patterns, obsolete agricultural practices and low application of inputs. It is approximated that soil fertility loss via erosion could reduce agricultural income in the country by US$ 4.2 billion and could additionally cause a 5.4 % increase in the poverty rate during the period 2006–2015 (Quaye *et al*., 2010). Approximately 57 % of the economically active population in Nigeria is engaged in agricultural activities, chiefly as smallholder subsistence food crop farmers for their livelihoods. Food production is principally through the extensive system of shifting cultivation in which farmers "slash and burn" a piece of land, grow food crops in polyculture for 1–3 years and leave it to fallow. Though, the shifting cultivation system assists restoration of soil fertility, the improvement in reduction of the fallow period as a result of increasing population pressure makes it impossible for these soils to recover high levels of fertility (Quaye *et al*., 2010). In Nigeria, employed strategies for improved agricultural productivity include the use of inorganic fertilizers. However, the potential of this strategy is low due to problems of affordability and accessibility by smallholder farmers (Yeboah *et al.*, 2009). Currently it is approximated that 70 % of the people are engaged in agriculture in Nigeria. Rice husk application to soils is presently attaining universal attention due to its potential to improve water holding capacity, soil nutrient retention capacity, and sustainable carbon store, thus reducing greenhouse gas emissions (Downie *et al*., 2009). However, rice bran is readily available in large quantity from rice mill that abound in the rice producing areas of Cross River, Ebonyi, Kaduna, Borno, Niger, Sokoto, and Adamawa States of Nigeria (Marris, 2006). The suitability of any organic material as fertilizer will depend on the rate of mineralization and liberation of the nutrients present in them (Lehman *et al.*, 2008). Hence this study was carried out with the objectives of evaluating the effect of rice husk and nitrogen on the yield of millet of pearl millet.

MATERIALS AND METHODS

The experiment was carried out during the 2019 and 2020 rainy seasons in two locations. Department of Agriculture Research Farm, College of Education Waka –Biu ,Borno state,(Latitude 10°36' 40N, Longitude 12 °11'42E) in the Northeast extending into some localized volcanic areas, and rises to an elevation of forty to fifty meters above the sea level northern boundary and location two was conducted at Marama in Hawul Local Government Area about thirty kilometers away from Biu (Latitude 10° 26' 60N, Longitude 12° 13' 60 E) Which ranges from 900 feet to 2900 feet above sea level as displayed on World map coordinates. Both locations were within the Sudan savannah zone of Nigeria. The experiment consisted three (3) treatments rice husk ash (0. 2 and 4 t/ha), four levels of inorganic fertilizer (0,30 ,60 ,80 kg N/ha) and two (2) varieties of millet (pearl millet and Sosat variety). The treatments were arranged in all possible factorial combinations and replicated three times and were laid out in a split plot design, with the millet variety and nitrogen levels constituting the main plot and rice husk residues in the sub plot. Each plot received a basal fertilizer application of 30 kg P_2O_5/ha and 30 kg K_2O/ha to ensure adequate supply of these elements to the crop. In all, there were twenty-four (24) treatments combinations and three (3) replications.

The experimental field was cleared, ploughed, harrowed and ridged to create a favorable condition for plant establishment. Gross plots of 4.5 x 4.0 m (18m$^{2)}$ dimension was marked and each plot was made up of 6 rows (0.75 m). The border rows were made up of two outer ridges on each side, while the two inner ridges formed the net plot which is1.5 x 4.0 (6m^2). There was an alley of 0.5 m between plots and 1.0 m between replications. The rice husk was applied on the soil surface and then incorporated in to the soil using hoe a day before sowing. Millet was sowed at a spacing of 75 cm by 25 cm using 6 seeds per hole at to a depth of 4cm and then thinned to 2 plants per hole. Application of 30 kg P_2O_5/ha in the form of Single Super Phosphate and 30 kg K_2O/ ha in the form of Muriate of Potash were applied to ensure adequate supply of these elements to the crop. However, nitrogen was applied as dictated by the treatment combinations. Hoe weeding were carried out at 3 and 6 WAS to control weed

$$\text{Yield kg/ha/}\frac{10000}{Net\ plot\ size} \times 100$$

Data collected were subjected to analysis of variance (ANOVA) using JMP Pro14.The treatment means were separated using Student' Newman Keuls (SNK).

RESULTS AND DISCUSSION

The result of revealed that grain weight and yield were significantly influenced by season, location, variety, fertilizer and rice husk application. Growing millet in 2020 season significantly produced higher grain weight and grain yield than that of 2019 season. Growing millet at Biu significantly resulted in higher grain weight than that of Hawul in both seasons, while grain yield did not differ across the locations. In all the locations the crops showed a better percentage to germination and a better moisture retention capacity in plots with rice husk compared to plots without rice husk. The result of soil properties as shown in Table 3 indicates that application of rice husk singly and in combination with nitrogen fertilizer affected soil properties. Similar, results were recorded by Santhi and Selvakumari (2000) who observed that the application of plant materials has various advantages such as increasing soil physical properties, water holding capacity and carbon content apart from supplying good quality of nutrients. This improvement and increase in some physical and chemical properties of the soil treated with single and combined application of rice husk is a primary function of organic manure. The increase in PH in this research agrees with the work of Lal *et al.* (2000) who worked on rice straIn all the locations in both 2019 and 2020 application of rice husk significantly enhanced number of tillers, number of leaves and leaf area per plant. Quattara (2011) reported that manure improve a microbial activity, allows a better development of roots, makes it possible for the plant to benefit from the reserves of the soil.

In both years varieties differed in grain yield, Sosat produced higher yield per plant compared to local variety, while local variety produced higher yield per hectare than the sosat. This might be due to the higher number of productive tillers in local compared to sosat which had lower productive tillers hence lower number of panicles. Muhammed (2002), similarly reported that there were significant differences in yield and yield components with differences in varieties. In both 2019 and 2020 rainy seasons and in all the locations, nitrogen fertilization significantly influences all the measured yield characters of millet varieties. In most of the cases Nitrogen from 60 to 80 kg/ha significantly increased grain yield. Effect of Nitrogen at 60 and 80 kg/ha was often observed to be similar on plant growth and yield characters. Manga (2010) reported that NPK fertilization had significant influence on plant, height, number of leaves, leaf area, dry matter and yield. Mustapha (2010) reported that the application of NPK fertilizer had significantly increased the number of tillers, number of panicles related in the availability of nutrients which support tillers and more panicles, also a significant increase in yield was observed due to NPK application.

The results in all locations revealed that the yield of both varieties was influenced by Nitrogen fertilization, which was observed to increase yield. Nitrogen at 80kg/ha gave significantly higher yield than 60 and 30 kg/ha. The lowest yield was obtained by the control. This confirm the findings of Manga (2010). Mustapha (2010) and (Ndor *et al*., 2016) who observed the highest yield of ‘’Acha’’ with 120kg/ha of NPK.

The same trend was reported by Manga (2010) that interaction between NPK and seed rate was observed to be significant on plant height, leaf area and dry matter. The interaction of rice husk, variety and fertilizer in both years and in all locations revealed that, panicle number per plant were significantly increased at 80k/ha and 2 and 4t/ha which were at par. Quattara (2011) reported that manure plays a significant role in the improvement of the properties of soil and the development of roots; which stimulates the absorption of mineral fertilizer. But that depends on the nature and the rate of mineralization of the manure.

CONCLUSION

Sosat variety had the highest yield per plant compared to local variety at both locations and in both years of experiments. Whereas, local variety had significantly higher yield per hectare than the sosat at both locations and in both years. The combined treatment of rice husk and inorganic N fertilizer resulted in higher nutrient content value than sole inorganic N applied in both grain and panicles. The result of the study revealed that the combination of rice husk with the inorganic N fertilizer had the greatest effect yield of both varieties of millet. The combination had increased yield in all the two locations. The agronomic and economic optimum of inorganic N fertilizer and rice husk for the best yield of millet were: 80kg/ha and 4t/ha. Based on the findings of the study the application of 80 kg N/ha and 4t/ha of nitrogen fertilizer and rice husk respectively could be recommended at Biu and Hawul for increased productivity of sosat variety of pearl millet

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REFERENCES

Dovanan, G. and Casey, F. (1998). Soil fertility management in sub-Sahara Africa. In: World Bank technical paper no. 480

Downie, A., Crosky, A. and Munroe, P. (2009). 'Physical properties of biochar', in Lehmann, J & Joseph, S, Biochar for environmental management: science and technology, Earthscan, United Kingdom: 13–32.

Eswaran, H., Almaraz, R., van den Berg, E. and Reich, P. (1997). An assessment of the soil resources of Africa in relation to productivity. Geoderma 77:1–18.

FAOSTAT (2008). The Food and Agriculture Organisation of United Nations FAOSTAT Databasefaostart.fao.org/default.aspx.

Ibrahim et al.,1995 in:Usman,Y.M.,Hussaini,M.,Baba-Musami,B.,Sheriff,B. (2014). Effect of Different Tillage Methods on the Growth and Yield of Pearl Millet under Rain fed conditions. *The international Journal of Science and Technology,* (2):62

Lal,R.(2000). Conservation Tillage for Sustainable Agriculture. Tropical versus Temperate Environment. *.Advance in Soil Science,* 42:85-197.

Lehmann, J. Solomon, D. Kinyangi, J. Dathe, L. Wirick, S. Jacobsen, C. (2008). Spatial complexity of soil organic matter forms at nanometre scales. *Nature Geoscience*,1, 238-242.

Manga, A.A. Mustapha,Y.and Abdullahi,H.(2010). Effect of NPK Fertilization and Seed rate on the Performance of Hungry rice (*Digitaria exilis* Stapf) 1: Growth Components. Biological and Environmental Science Journal of the Tropics:7(3):156-160.

Marris, E. (2006). Black is the new green. Nature 442(10):469–624.

Mohammed, A.I.B.(2002).Crop Production and Management Practices, BUK pp 12.

Mustapha,Y.Manga,A.A.and Abdullahi,H.(2010).Effect of Fertilization and Seed Rate on the Performance of Hungry rice (Digitaria exilis Stapf)11:Yield and Yield Components. Biological and Environmental Sciences, *Journal of the Tropics*:7 (4):207-211.

Ndor, E.,.Mamman,Jayeoba, O.J., and Dauda, S.N. (2016). Effect of Organic and Inorganic Fertilizer on Yield and Economic Return of ''Acha''(Digitaria spp) Varieties in Lafia. *Nigeria Global Journal of Agricultural Research*, 4(3), 13-20

Oldema,, L.R.(1994).The global extent of soil degradation In:Greenland D.J.,Szalodes T,eds.soil Resilience and sustainable Land use.Wallingford:CAB International.

Payne, W.A.,C.W.Wendt, and RJ. Lascano.1990. Root zone water balance of three low-input millet field in Niger, West Africa. Agron.J.82:813-819.

Quattara, A. (2011). Etude de 1'Association de laFumure Minerale et du Compost dans une Rotation Coton Mais en Zone Cotonnier OUEST du Burkina Faso Bobo Dioulasso pp 42.

Siddig,A.,Mohamed,Ali.,Kamal,I.Adam.,Ali,H.Bahar,ThabitA.Hassan.(2013).Effect of sowing Date and Variety on Growth and Yield of Pearl Millet (*Pennisetum glaucum*, L.).Grown on Two Soil Types under Rain-fed condition at Zalingei Area in Sudan. *ARPN Journal of Science and Technology*, 3(4):1

Quaye, K.,Hall,C.A.S.and Luzady,V.A.(2010).Environmental andsustainable Development,doi:10.1007/s10668-010-9234.

Reich, P.F., Numbem, S.T., Almaraz, R.A., Eswaran, H. (2001). Land resource stresses and desertification in Africa. In: Bridges E.M., Hannam I.D., Oldeman.

Snedeco,G.W.and Cochran,W.G.(1976).Statistical Methods. The lowa state University, 6th edition, Ames, lowa, U.S.A.p.593.

Varga J., (1966), A Koles.In..A novenytermesztes Kezikonyve I. Lang G.(szerk.).Mezogazdasagi Kiado. 181-189.

Watson,D.J. (1952).A physiological basis of variation in yield Advances in agronomy.

Watson, D.J.(1958).The dependence of net assimilation on Leaf Area Index. Annals of Botany 23-37-supp.

Yeboah, K.E.Ofori, P.Quansh, G.W.Dugan.,E.Sohi.(2009).Improving soil productivity through biochar amendments to soils. *African Journal of Environmental science and Technology*. *3(2):34-41*.

Table 1: Grain Weight per Plant (g) and Grain Yield per Hectare (kg/ha) at Biu and Hawul as influenced by Variety, Fertilizer rate and Rice Husk in 2019 and 2020 combined.

Treatments	Grain Weight (g)	Grain Yield (kg/ha)
Year (Y)		
2019	25.9b	480.7b
2020	26.9 a	489.8a
P-value	0.0001	0.0001
SE+	0.08	1.61
Location (L)		
Biu	38.4a	485.4
Hawul	14.5b	485.1
P-value	0.0001	0.869
SE+	0.08	1.61
Variety (V)		
Sosat	27.2a	461.3b
Local	25.7.b	509.1a
P-value	0.0001	0.0001
SE+	0.08	1.62
Fertilizer (F)		
0	15d	184.1d
30	27.2c	479.7c
60	30.1b	582 4b
80	23.9a	694.7a
P-value	0.0001	0.0001
SE+	0.11	2.29
Rice Husk (RH)		
0	24.9c	448.0c
2	26.4b	486.6b
4	28.0a	521.0a
P-value	0.0001	0.0001
SE+	0.12	2.29
Interactions		
Y*L	0.0001	0.0001
Y*V	0.7489	0.429
Y*F	0.993	0.0003
Y*RH	0.8946	0.2386
L*V	0.9563	0.0447
L*F	0.0001	0.5786
L*RH	0.7958	0.0001
V*F	0.0001	0.012
V*RH	0.0015	0.023

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using Student Newman Keuls Test.

Table 2: Interaction between Variety and Fertilizer on Grain Weight per Plant at Biu and Hawul during 2019 and 2020 rainy seasons.

	Fertilizer (Kg/ha)			
Variety	0	30	60	80
Sosat	15.9g	27.8e	30.9c	34.2a
Local	15.4h	26.6f	29.2d	31.7b
SE+			0.15	

Means followed by the same letter(s) within a set of interaction are not significantly different at 5% level of probability, using Student Newman Keul.

Table 3: Interaction between Variety and Rice husk on Grain Weight per Plant at Biu and Hawul during 2019 and 2020 rainy seasons.

	Rice Husk (t/ha)		
Variety	0	2	4
Sosat	25.4c	27.2b	28.9a
Local	24.5d	25.6c	27.1b
SE+		0.14	

Means followed by the same letter(s) within a set of interaction are not significantly different at 5% level of probability, using Student Newman Keul.

Table 4: Interaction between Fertilizer and Rice husk on Grain Weight per plant at Biu and Hawul, during 2019 and 2020 rainy seasons.

	Rice Husk (t/ha)		
Fertilizer	0	2	4
0	13.5k	15.4j	18.0i
30	25.8h	27.5g	31.3c
60	29.2e	29.9d	31.3a
80	31.3c	32.8b	34.7a
SE+		1.30	

Means followed by the same letter(s) within a set of interaction are not significantly different at 5% level of probability, using Student Newman Keul.

GROWTH AND YIELD RESPONSE OF PIGEONPEA (*Cajanus cajan* L. Millsp.) GENOTYPES TO PHOSPHORUS APPLICATION IN SUDAN SAVANNAH OF NIGERIA

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ABSTRACT

This study evaluated the effects of phosphorus application and genotype selection on the growth and yield of seven pigeon pea genotypes during the 2020 rainy season. The experiment was conducted at the Bayero University Teaching Farm and the National Horticultural Research Institute (NIHORT). Treatments included seven genotypes (ISC150, ISC1, ISC117, ISC203, ISC140, ISC183, ISC179) and two phosphorus levels (0 and 40 kg P_2 O_5 /ha) and these were laid out in a Randomized Complete Block Design with three replications. Growth parameters such as plant height, number of leaves, and branching as well as yield components, including the number of days to flowering, number of seeds per pod, pod length, pod weight and grain yield were assessed. Result revealed that phosphorus application significantly influenced early leaf production but not plant height or branching. Genotypic differences were pronounced, with ISC179 and ISC183 exhibiting superior height and leaf counts. Significant genotypic differences ($P<0.001$) were observed, particularly in flowering patterns, which were influenced by photoperiod sensitivity and environmental factors. Genotypes ISC117 and ISC140 flowered early, while ISC183 and ISC150 were late-flowering, with early flowering linked to higher yield potential. Genotype ISC150 exhibited the highest number of seeds per pod (5.3), while pod length and weight showed significant variability among genotypes, with ISC140 having the longest pods and ISC179 the heaviest pods. No significant phosphorus effect on grain yield was found, but genotypes with medium flowering periods, such as ISC117, produced higher yields. The interaction between phosphorus levels and genotypes significantly affected seed yield, with ISC150 demonstrating the most responsiveness to phosphorus application. Overall, the findings underscore the importance of genotype selection in optimizing growth and yield in pigeon pea, with ISC117, ISC179, and ISC140 identified as the best-performing genotypes across different locations. Phosphorus application has limited impact at the tested levels, genetic variability plays a critical role in yield potential.

Keywords: Pigeon pea, phosphorus, growth, yield, genotype, Kano, Nigeria

INTRODUCTION

Pigeon pea (*Cajanus cajan*) is the sixth most important legume crop globally, valued for its high protein content (18-26%) and versatility as food, fodder, and animal feed. Originally from South Asia, pigeon pea was introduced to Africa, where it is now vital for smallholder farmers, especially in semi-arid regions. India and Myanmar lead global production, while African countries like Malawi, Tanzania, and Nigeria also cultivate it. Pigeon pea is well-suited for drought-prone, low-input systems due to its deep-rooted nature and ability to fix nitrogen, enhancing soil fertility. It is commonly intercropped with maize, sorghum, millet, and root crops. Phosphorus (P) is a critical nutrient for nitrogen fixation in pigeon peas, but they are efficient at utilizing P from low-P soils compared to other legumes. This makes pigeon pea an essential crop for sustainable agricultural practices in Africa, contributing to food security and income generation for smallholder farmers. This study focuses on the effects of phosphorus application on the growth and yield of seven pigeon pea genotypes grown in two locations in Kano, Nigeria

MATERIALS AND METHODS

Experimental site

A field experiment was conducted during 2020 rainy season in two sites, the Research and Teaching Farm of Bayero University, Kano (11058' N, 80 26'E and 475m above sea level) and National Horticultural Research Institute (NIHORT) Bagauda sub-station, Bebeji local Government area of Kano State ($19^0$4'N, $12^0$26'E and 721m above sea level).

Treatments and experimental design

The experiment consisted of seven pigeon pea genotypes (ISC150, ISC1, ISC117, ISC203, 1SC140, ISC183, ISC179,) factorially combined with two levels of phosphorus (0 and 40kg P_2O_5/ha), laid out in a Randomized Complete Block Design and replicated three times. The field was demarcated into 60 plots with a discard of 0.5m between plots and 1m between replications. The gross plot size was made of four ridges 4×3m ($12m^2$) and the net plot is made up of two inner ridges 4× 1.5m ($6m^2$).

Cultural practices

The experiment field was prepared by harrowing and ridging to 75cm apart, with 60 plots separated by 0.5m and 1m between replications. Each gross plot measured $12m^2$ with a net plot size of $6m^2$. Seeds were sown on ridges at a depth of 10cm by dibbling, with 2 seeds per hole, letter thinned to 1 hill per stand after 2weeks.Fertilizer was applied during sowing, with Nitrogen(N) and potassium(K_20) at 25kg/ha and 30kg/ha and phosphorus(P_20_5) at 0 and 40kg/ha as per treatments. Pre emergence herbicide was applied a day after sowing, with hoe weeding at 4, 8, and 12 weeks after sowing. Harvesting was done manually at physiological maturity, followed by bundling and drying of plants, the pods and grains were separated by beating and winnowing.

Data collection

Data was collected on plant height and number of leaves and branches at intervals 8 and 12 weeks after sowing as well as number of days to first flowering, fodder weight, pod weight, pod length, yield and harvest index. The data was subjected to analysis of variance using Genstat 17th edition and significant means were separated using SNK at 5% level of probability.

RESULTS AND DISCUSSION

Growth Attributes

Table 1 shows the effect of phosphorus application rates (0 and 40 kg P/ha) and pigeon pea genotypes on plant height, number of leaves, and number of branches at 8 and 12 weeks after sowing (WAS). Phosphorus application did not significantly influence plant height at either location, although slight, non-significant increases were observed at 8 WAS with 40 kg P/ha. Phosphorus significantly increased the number of leaves at 8 WAS in BGD, but the effect diminished by 12 WAS, with no significant impact observed in BUK. Additionally, phosphorus negatively affected branch production at 12 WAS in BUK, where untreated plants produced more branches than those treated with phosphorus. Genotype selection significantly influenced plant height at 12 WAS in BUK, where genotypes ISC 179 and ISC 183 were the tallest, while ISC 203 had the shortest plants. Genotype also significantly affected leaf production at 12 WAS in BGD, with ISC 179 producing the highest number of leaves and ISC 117 the fewest. However, genotype had no significant impact on branching at either location. There was no significant interaction between phosphorus application and genotype, indicating that their effects on plant height, number of leaves, and number of branches were independent. Overall, phosphorus application mainly influenced early leaf production, while genotype selection had a greater impact on plant height and leaf production at later stages, with no combined interactive effect observed. The application of phosphorus did not have a significant effect on plant height across both locations, contradicting findings by Baboo and Mishra (2004), and Parihar *et al*. (2005), who reported that phosphorus supply significantly affects plant height at all growth stages. In this study, phosphorus-treated plants and non-treated plants had similar heights at 4 weeks after sowing (WAS), indicating no early influence of phosphorus. However, significant differences in plant height were observed among genotypes, these differences were likely influenced by environmental factors such as exposure to long-day conditions, as taller plants were observed in short-duration genotypes rather than extra short-duration types, consistent with findings by Reddy (1990) and Egbe (2007) that longer vegetative phases increase plant height. Phosphorus application also did not significantly affect the number of branches in either location. The number of primary branches ranged from 11.67 to 16, with a mean of 13.83, which aligned with Remanandan *et al*. (1988), who reported similar branch counts in global pigeon pea germplasm. Extra short-duration genotypes like ISC 140, ISC 179, ISC 183, and ISC 1 had the highest number of branches. While this observation contrasts with

Baldey (1988), who found that semi-spreading types had higher branching plasticity than compact types, it could be attributed to environmental conditions favoring early sowing, as Ram *et al*. (2011) also noted increased branching in early-sown pigeon pea. The study highlights the interplay between genotype, environmental conditions, and growth factors such as plant height, number of leaves and branching.

Yield and yield components

Phosphorus application on pigeon pea yield components, revealed that phosphorus had no significant effect (P>0.05) on yield components, such as the number of days to flowering, number of seeds per pod and pod length, pod weight and grain yield in both Bagauda and BUK (Table 2). However, significant genotypic differences (P<0.001) were observed. Flowering patterns showed high genetic variability, influenced by photoperiod sensitivity, temperature, and environmental factors. Genotypes such as ISC117 and ISC140 flowered early, while ISC183 and ISC150 flowered late, supporting studies by Silim *et al*. (2007) and Robertson *et al*. (2001). Differences in flowering time were tied to genotypic responses to day length and photoperiod sensitivity, with early flowering linked to higher yield potential (Ncube *et al*., 2002). The genotype ISC150 had the highest number of seeds per pod (5.3) in both locations, while ISC117 had the lowest in Bagauda and ISC203 had the lowest in BUK. The number of seeds per pod varied significantly among the pigeon pea genotypes studied, indicating substantial genetic variability. This variability is crucial as it directly impacts the overall yield of the crop. The observed differences in seed number could be attributed to the genetic makeup of each genotype and their adaptation to specific environmental conditions, as highlighted by Khatun *et al*. (2009), who noted that environmental factors and plant stress during flowering and pod development significantly affect seed set. Pod length showed significant differences (P < 0.001) among the genotypes in both locations. This variation in pod length is likely influenced by the genetic characteristics of each genotype, as well as environmental factors such as temperature and soil fertility. According to Singh *et al*. (2001), pod length is an important agronomic trait that can affect the number of seeds per pod and ultimately the yield. Longer pods typically accommodate more seeds, which can enhance overall productivity. The genotype ISC 140 exhibited the longest pods across both locations, emphasizing its potential for higher yield. Udensi and Ikpeme (2012) reported similar findings in pigeon peas, where longer pods increased the number of ovules, leading to enhanced weight. Pod weight also exhibited significant differences among genotypes, correlating positively with pod length and seed number. Heavier pods generally contain more seeds, contributing to higher overall yields. The results of this study align with findings from previous research, such as that of Upadhyaya *et al*. (2006), which highlighted the importance of pod weight as a critical component of yield potential in pigeon pea. The genotype ISC 179 had the heaviest pods, which suggests its superior ability to accumulate resources during pod development compared to other genotypes. The study also found no significant effect of phosphorus on grain yield. ISC117 had the highest yield in Bagauda (503), while ISC203 had the highest in BUK (589). Genotypes with medium flowering periods produced higher yields, consistent with Dasbak and Asiegbu (2012), who reported better yield performance in medium-maturing pigeon pea genotypes.

Interaction

Table 3 presents the interaction between phosphorus levels (0 and 40) and various pigeon pea genotypes regarding the number of seeds per pod in Bagauda. Among the genotypes, ISC 150 exhibits the highest number of seeds per pod under both phosphorus treatments, with values of 5.000 at 0 P and 5.667 at 40 P, indicating a strong responsiveness to phosphorus application. ISC 140 also shows commendable performance, with 5.000 seeds per pod at 0 P but declining to 4.000 at 40 P, suggesting potential sensitivity to increased phosphorus levels. In contrast, ISC 117 has the lowest number of seeds per pod at 40 P (3.667), indicating lack of favorable response to phosphorus compared to other genotypes. ISC 1 and ISC 203 demonstrate moderate performance, with ISC 1 decreasing from 4.333 to 4.000 under higher phosphorus, while ISC 203 shows a slight improvement. The interaction between phosphorus levels and genotypes significantly influences seed yield in pigeon pea, with ISC 150 being the most effective genotype across both phosphorus conditions

CONCLUSION

The seven pigeon pea genotypes evaluated in this study showed limited response to phosphorus application at the tested levels. The study highlights the significant influence of genotype selection on growth and yield characteristics of pigeon pea. ISC117 proved to be the best performing genotype in Bagauda, demonstrating high grain yield and overall productivity. In BUK, ISC179 and ISC140 were identified as top performers due to their excellent growth and yield attributes. Further research is recommended to explore the effectiveness of alternative phosphorus sources and soil amendments in promoting pigeon pea growth and yield. The high-performing genotypes identified in this study should be tested in various locations and under diverse growing conditions for further evaluation and potential utilization in breeding programs. Farmers in Kano should consider using the recommended genotypes for improved productivity, considering local conditions and resource availability.

REFERENCES

Adu-Gyamfi, J.J., Fujita, K., and Ogata, S., (2007). Phosphorus fractions in relation to growth in pigeonpea (*Cajanus cajan* (L.) Millsp.) at various levels of P supply. *Soil Science and Plant Nutrition,* 36: 531– 543.

Baboo, R. and Mishra, S.K. (2004). Growth and pod production of cowpea (*Vigna sinensis*) as effected by inoculation, nitrogen and phosphorus application. *Annuals of Agricultural Research,* 25(4): 467-469.

Baldey, A. S. (1988). The plasticity of branching in pigeon pea varieties under different environmental conditions. *Journal of Agronomy*, 15(3): 198-205.

Dasbak, M.A.D., B. C. Echezona and J. E. Asiegbu (2012). Field insect pests and crop damage assessment of pigeonpea (*Cajanus cajan* (L.) Huth) grown under ratoon and in mixture with maize. *Chilean Journal of Agricultural Research*, 72(1): 45-52.

Egbe OM, Kalu BA.(2007) Farming systems study: Participatory rural appraisal of pigeon pea cropping systems in Southern Guinea Savanna Nigeria. *Journal of Environment (Abia State University Environmental Review),* 5(1): 37-47.

Fallah, S. (2008). Effects of planting date and density on yield and its components in chickpea (*Cicer arientinum* L.) genotypes under dryland conditions of Khorram-Abad. *Journal of Science and Technology of Agriculture and Nature Resources Water and Soil Science*, 12; 123-135.

Khatun, A., G. Kabir, and M.A.H. Bhuiyan. (2009). Effect of harvesting stages on the seed quality of lintel (Lens culinaris L.) during storage. *Bangladesh Journal of Agricultural Research,* 34:565- 576.

Mula, M.G. and Saxena, K.B. (2010). Lifting the Level of Awareness on Pigeonpea - A Global.

Ncube, B., T. Manjala, and S. Twomlow (2002). Screening of short duration pigeon pea in Matabeleland. *Field Crop Research*, 1:75-78.

Parihar, C.M., Kaushik, M.M. and Palsaniya, D.R. (2005). Effect of varieties, plant density and phosphorus levels on growth and yield of clusterbean [*Cyamopsis texagonoloba* (L.) taub]. *Annual Agricultural Research New Series*, 26(1): 5-7.

Qiu, J. and Mosjidis, J. A. (1993). Genotype and planting depth effects on seedling vigor in *Sericea lespedeza*. Agr. Exp. Station., Auburn University. Pp 46:309-312

Ram, M. J., Singh, V., & Kumar, A. (2011). Effects of sowing time on growth and yield of pigeon pea. *Indian Journal of Agricultural Sciences*, 81(2): 151-156.

Reddy, L.J. (1990). Pigeon Pea: Morphology. In: Nene Y. L, Hall SD, Sheila VK (Eds). The Pigeon Pea. CAB International, Wallingford, UK. 1990; 47-86.

Remanandan, P., Venkateswarlu, B., & Raghavendra, A. (1988). Effect of phosphorus and potassium on yield and nutrient uptake in pigeon pea (*Cajanus cajan* L.) *Indian Journal of Agronomy*, 33(2), 124-126.

Roberson, M.J., S. Silim, Y.S. Chauhan, and R. Ranganathan. (2001). Predicting growth and development of pigeon pea: biomass accumulation and partitioning. *Field Crop Research*, 70: 89-100.

Serra, A.P., Marchetti, M.E., Dupas, E., Carducci, C.E., da Silva, E.F., Lourente, E.R.P., Alovisi, A.M.T., and Ensinas, S.C., (2018). Phosphorus in forage production http://dx.doi.org/10.5772/intechopen. 70202

Silim, S.N, G. Mergeai, and P. Kimani, editors, Status and potential for pigeon pea in Eastern and Southern Africa. Proceedings of a Regional Workshop, Nairobi, Kenya, 12-15 Sep (2000). International Crops Research Institute for the Semi - Arid Tropics., Patancheru.

Udensi, O and Ikpeme, E.V. (2012). Correlation and Path Coefficient Analyses of Seed Yield and it's Contributing Traits in *Cajanus cajan* (L.) Millsp. *American Journal of Experimental Agriculture*, 2(3): 351-358, 2012

Table 1: Effect of phosphorus on Plant height and Number of leaves of Pigeon Pea genotypes at 4, 8 and 12 weeks after sowing (WAS) in Bagauda and BUK

Treatments	Plant height				Number of leaves				Number of branches			
	8 WAS		12 WAS		8 WAS		12 WAS		8 WAS		12 WAS	
	BGD	BUK	BGD	BUK	BGD	BUK	BGD	BUK	BGD	BUK	BGD	BUK
Phosphorus (P)												
0	75.4	87.0	129.7	139.1	117.9	162.1	436.0b	394.0	6.14	4.62a	12.71	11.67a
40	78.2	84.1	131.4	138.2	121.2	143.7	535.0a	373.0	6.19	3.67b	13.57	9.24b
P-value	0.312	0.880	0.739	0.813	0.757	0.215	0.012	0.510	0.920	0.041	0.555	0.010
SE+	1.88	1.82	3.56	2.66	7.64	10.27	25.6	22.5	0.333	0.314	1.015	1.162
Genotypes (G)												
ISC 203	71.5	75.9[b]	113.8[b]	135.7	114.8	122.8[b]	408	382	6.33	3.50	14.67	8.67
ISC150	82.2	81.7[b]	147.5[a]	132.6	99.20	116.3[b]	498	311	5.00	3.67	12.00	10.00
ISC1	73.1	85.9[a]	127.3[ab]	137.3	123.20	167.5[ab]	534	377	7.00	4.50	12.33	11.67
ISC 117	72.1	76.9[b]	134.0[ab]	129.0	131.50	104.3[b]	511	349	6.00	3.50	11.67	10.50
ISC 179	78.6	92.2[a]	127.3[ab]	145.0	138.80	206.2[a]	462	439	7.33	4.50	15.67	10.17
ISC 140	80.0	93.2[a]	121.6[ab]	145.5	104.70	187.2[ab]	403	442	5.50	4.83	12.67	11.33
ISC 183	80.1	93.0[a]	142.5[ab]	145.3	124.70	166.0[ab]	582	387	6.00	4,50	13.00	10.83
P-value	0.194	0.020	0.020	0.132	0.453	0.005	1.124	0.33	0.161	0.493	0.724	0.633
SE+	3.53	3.40	6.66	4.97	14.300	19.220	47.90	42.10	0.622	0.587	1.898	1.162
Interaction												
P*G	0.581	0.937	0.845	0.476	0.937	0.765	0.455	0.476	0.842	0.766	0.414	0.438

Means followed with same letter(s) within treatment group are not significantly different at 5% level of probability using SNK

Table 2: Effect of phosphorus on yield and yield components of pigeon pea in Bagauda and BUK

Treatments	Days to 1st flowering		Pod length		No. of seeds/pod		Pod weight		Grain yield	
	BGD	BUK	BGD	BUK	BGD	BUK	BGD	BUK	BGD	BUK
Phosphorus (P)										
0	81.90	80.38	5.705	6.27	4.381	4.81	1.38	1.27	378	467
40	81.48	80.24	5.624	6.30	4.33	4.52	1.27	1.19	371	490
P-value	0.714	0.754	0.664	0.880	0.681	0.174	0.656	0.585	0.932	0.725
SE+	0.818	0.319	0.1305	0.330	0.081	0.144	0.180	0.104	57.7	45.1
Varieties (V)										
ISC 203	66.00^{e}	65.00^{e}	4.94^{c}	5.83^{c}	4.167^{bd}	4.00^{b}	1.08	1.15	320	589
ISC150	107.83^{b}	102.50^{b}	7.27^{a}	6.75^{b}	5.33^{a}	5.33^{a}	1.63	1.07	447	464
ISC1	81.33^{c}	87.00^{c}	5.57^{bc}	6.42^{bc}	4.167^{bc}	4.33^{ab}	1.30	1.18	392	425
ISC 117	64.50^{e}	64.17^{e}	4.80^{c}	6.00^{c}	3.833^{c}	4.83^{ab}	2.05	1.13	503	469
ISC 179	73.33^{d}	70.00^{d}	5.50^{bc}	5.87^{c}	4.5^{b}	4.50^{ab}	1.15	1.55	364	469
ISC 140	66.50^{e}	61.17^{f}	5.78^{b}	5.80^{c}	4.5^{b}	4.33^{ab}	0.98	1.42	305	456
ISC 183	112.33^{a}	112.33^{a}	5.83^{b}	7.33^{a}	4.00^{bc}	5.33^{a}	1.07	1.12	291	479
P-value	<0.001	<0.001	<0.001	0.020	<0.001	0.009	0.287	0.535	0.783	0.889
SE+	1.531	0.597	0.244	0.176	0.151	0.270	0.337	0.193	108.0	84.4
Interaction										
P*V	0.268	0.382	0.103	0.937	0.013	0.132	0.597	0.179	0.584	0.344

Means followed with same letter(s) within treatment group are not significantly different at 5% level of probability using SNK

Table 3: Interaction between Phosphorous and Genotypes for Number of Seeds/ Pod in Bagauda

	Phosphorous	
Genotypes	0	40
ISC 203	4.000bc	4.333b
ISC150	5.000ab	5.667a
ISC1	4.333b	4.000bc
ISC 117	4.000bc	3.667c
ISC 179	4.333b	4.667b
ISC 140	5.000ab	4.000bc
ISC 183	4.000bc	4.000bc
SE	0.21	

Means followed with same letter(s) within treatment group are not significantly different at 5% level of probability using SNK

EFFECT OF VEGETATION COVER AND LAND USE ON SOIL WATER RETENTION CHARACTERISTICS IN THE SUDAN SAVVANA OF NIGERIAN

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ABSTRACT

Information on the impact of vegetation and land use on the soil moisture retention characteristics Nigerian Sudan savanna is vital to develop effective and sustainable soil moisture management and conservation practices. To derive such information, a total of 12 samples were collected at 0-20cm depth stratified random sampling technique across four adjacent land uses type at the Research and Teaching Orchard farm of Department of Agronomy, Bayero University Kano; the vegetation and land uses include: mango plantation, citrus plantation, arable land and fallow land. The collected samples were subjected to standard laboratory analysis using standard analytical protocols for the following parameters: pH, electric conductivity (EC), organic matter (OM), exchangeable bases (Mg, Ca, K, and Na), particle size distribution, water retention at field capacity, water retention at permanent wilting point. Base on the results obtained, low organic matter content (> 1.73%) in all the measured land use types in the study area, high sand content in fallow land (73.3%) and high clay content in citrus plantation (15.41%), high Electric conductivity (EC) content in mango plantation (0.7ds/m) than the other land use types were observed. Effective exchangeable cations (ECEC) is generally low (<6 cmol/kg) across the studied land uses. Very strong positive correlation was observed between OM and FC (correlation coefficient = 0.41*). The positive correlation between OM and FC, suggest application of manure and crop residue return to the soil will improve the organic matter content, ECEC and soil moisture retention of the soil.

INTRODUCTION

Soil moisture retention refers to the amount of water a specific soil type can hold, influenced by its pore space distribution and strongly tied to soil structure, texture, and other factors like organic matter (Vereecken *et al.*, 1986). Soil moisture retention plays a vital role in crop growth, significantly affecting yield and the risk of crop failure.

Research has shown that vegetation significantly impacts the temporal and spatial variations in soil moisture (Taf et al., 2017). For instance, English et al. (2017) discovered that varying grassland cover and species affected soil moisture at different depths in semi-arid regions. Similarly, Vivoni *et al.*, (2008) observed that vegetation influenced plant interception and surface soil moisture levels.

Land use and management practices can greatly impact atmospheric factors, such as greenhouse gas emission rates and vapor content, as well as soil physical properties like porosity, hydraulic conductivity (Hotel *et al.*, 2022), infiltration rates, and the amount of water available to plants (Haghighi *et al.*, 2010).

The Nigerian Sudan Savanna Zone lies between latitudes 9°3'N and 12°31'N and longitudes 4°E and 14°3'E, spanning approximately 22.8 million hectares, or about a quarter of Nigeria's land area (Manyong *et al.*, 1995). The region experiences high average annual temperatures (28-32°C), a brief wet season, an extended dry season lasting 6-9 months, and is dominated by short grasses (under 2 meters) with a few scattered trees (Sowunmi and Akintola, 2010). Rainfall patterns in the region are inconsistent, with significant variability impacting water availability. The mean annual rainfall is approximately 1,300 mm, but its distribution can be erratic, exacerbating moisture stress during critical growth periods. The objective of the study is to evaluate the impact of vegetation and land use on soil moisture characteristics and to identify major soil properties influencing soil moisture retention.

MATERIALS AND METHOD

The experiment was conducted at the Teaching and Research Orchard Farm Department of Agronomy, Bayero University Kano, Nigeria located in the Sudan savanna agro ecological zone of Nigeria (Latitude $11^0$58’N and Longitude 8^0 26’E at an Altitude of 460m).

The experiment involved four adjacent land use types as follows: mango plantation, citrus plantation, arable land and fallow land. soil samples in each of the four land use types were conducted using a stratified random sampling technique (Peterson *et al.*, 1986). Where each land use type was divided into three equal sub-divisions (pseudo-replicates). Three random samples were taken using auger from each sub-division (pseudo-replicates) at each depth and bulked to give one composite sample. An infiltration study and undisturbed soil samples were respectively conducted and taken at the center of each sub-division (pseudo-replicates).

Field and Laboratory Analysis

Soil moisture retention characteristics for undisturbed core were measured using pressure plate extractors (Klute, 1986). The moisture content of the soil was evaluated at matric potentials of 0.3 bar (corresponding to Field Capacity (FC) and 15 bar (corresponding to Permanent Wilting Point (PWP). The Plant Available Water (PAW) holding capacity was calculated as the difference between moisture content at FC (0.3bar) and PWP (15bar).

Bulk density was measured using core method (Blake and Hartge, 1986).

Soil pH was measured both in water and in 0.01M KCl using 1:2.5 soil/water solution (Nelson, 1979). The electric rod of the EC meter is inserted into solution and the values were readout in dS/m.

The acid dichromate wet oxidation method of Walkey and Black as describe by Nelson *et al.* (1982) was use in determination of the soil organic carbon content in this study. Then the result obtain is multiplied by 1.72 to obtain the value of the soil organic matter of the soil.

The exchangeable bases (Ca, Mg, K, and Na) of the soil samples were determined by extraction with 1M ammonium acetate (NH_4OAC) procedure (Anderson *et al.*, 1993). The cations content was read on atomic absorption spectrophotometer.

Particle size distribution of the soil less than 2-mm fine earth fraction was analyzed using Bouyoucos (1951) hydrometer method as described by Gee et al. (1986).

Data analysis

The collected data was subjected into a one-way analysis of variance (ANOVA) to test the effect of the land use types using Genstat statistical software. Mean values across the land use types with a significant difference were compared and contrast using Duncan's Multiple Range Test (DMRT). In addition, the relationship between measured soil properties were evaluated using correlation matrix analysis using the same Gentsat statistical software.

RESULTS AND DISCUSSION

The organic matter content of the study was generally low (<1.73%). Despite no statistical difference was observed across land use types, land under citrus and mango plantation recorded higher organic matter content (1.17% and 1.02% respectively) relative to other land uses which have statistically similar values (Table 1). The high organic matter content in citrus and mango plantation is as a result of accumulation of plant root and deposition of leaves falling from the citrus and mango plants. Soil organic carbon forms an integral part of soil organic matter and these can be used to predict amount of soil organic matter in the field. The litter fall from these plantations may have ability to increase soil organic carbon as reported by Yang *et al.*, (2005).

Soil pH

The pH value of the study area was moderately acidic in citrus plantation, mango plantation and arable land with fallow land which being slightly acidic using USDA pH classification method (Table 1). The degree and nature of soil reaction influenced by different anthropogenic and natural activities including leaching of exchangeable bases, acid rains, decomposition of organic farming practices (Brady *et al.*, 2002). This therefore makes the soil pH range for the operating lands to be in the moderately and slightly acidic range and thus suitable for plant growth. United State

Department of Agriculture (USDA) also concluded that too high or too low pH leads to deficiency of many nutrients, decline in microbial activities, decrease in crop yield and deterioration of soil health.

The relative proportion of sand, silt and clay was not affected by the land use types, this is because of the close proximity of the adjacent land areas having similar textures. However fallow land records the high percentage of sand but record low percentage of silt and clay relative to the other land use types (Table 1). Also, citrus plantation records high silt and clay content which might favour more nutrient supply and moisture retention.

The EC value of mango plantation was recorded to have high value (0.7dS/m) than the other three land uses as shown in Table 1. All the EC values fell within safe and low status in relation to salinity/sodicity problems according to the standards of the 1954 handbook of the U.S. Salinity Laboratory.

All the exchangeable bases result statistically shows no significant difference across land use types except in Ca. Lowest calcium content was recorded in fallow land compared with statistically high but comparable values observed in the rest of the land use types (Table 2).

Statistically similar values of soil bulk density were observed across the land use types (Table 4.3). However, lowest bulk density was obtained in the mango plantation land compared to rest of land use types. Bulk density values were less than 1.63 g/cm^3 which According to Arshad et al. (1996) reported as a minimum threshold value above which plant root growth might be retarded due to soil hardiness or compaction.

Water content at field capacity (0.3 bar) was higher in mango and citrus plantation (13.34% and 12.34%, respectively) (Table 3) compared to other two study land use types. The higher moisture retention in mango and citrus plantations is due to the higher clay content (see Table 1) compare to other land uses and also the absence of minimum or no tillage. The use of no-till and residue incorporation has long been used in regions to increase soil moisture retention. Also, at permanent wilting point (15bar), mango plantation and fallow land recorded high values (8.2% and 5.2%, respectively), with citrus plantation and arable land having low but similar result (Table 3)

The plant available water content is high in citrus plantation (7.98%) of which could be due to high clay and organic matter content of citrus plantation (Table 1), there is general phenomenon that high surface area on soil particles and organic matter increase water holding capacity of the soil. And this supported by Kahle et al. (2003) who reported that more carbon is found in soils with smaller particles such as clay due to the binding of carbon to the clay particle protecting it from decomposition.

CONCLUSION AND RECOMMENDATION

The study found out that land uses type affect soil moisture retention as organic matter increases retention of moisture available for plant root hence increases crop production. There is need for further and in-depth study on soil properties and land use types that enhances soil moisture retention as water is a critical factor for plant growth, nutrient adsorption and herbicide mechanism. The overall low content of organic matter will suggest more efforts from the farmers such as addition of manure, residue management and crop rotation to improve the low contents of this important soil parameters. Due to strong positive correlation between OM and FC, application of manure and crop residue return to the soil will improve the organic matter content, ECEC and soil moisture retention of the soil.

REFERENCE

Vereecken, H., Maes, J., Fayen, J., and Darius P. (1989) Estimating the soil moisture retention characteristic from texture, bulk density, and carbon content. *Soil Sci*., *148*, 389-403.

Taf, D.S., de Andrade L.A., Freitas H, Da S.A., (2017) Biological Invasion Influences the outcome of Plant-Soil Feedback in the Invasive Plant Species from the Brazilian Semi-arid, *Microbial Ecology*, 1–11. Doi: 10.1007/s00248-017-0999-6.

English, N.B., Weltzin J.F., Fravolini A., Thomas L., Williams D.G. (2005), The influence of soil texture and vegetation on soil moisture under rainout shelters in a semi-desert grassland, *Journal of Arid Environments*, *63*(1), 324–43. Doi: 10.1016/j.jaridenv.2005.03.013

Vivoni E.R., Rinehart A.J., Méndez-Barroso L.A., Aragón C.A., Bisht G., Cardenas M.B., (2008). Vegetation controls on soil moisture distribution in the Valles Caldera, New Mexico, during the North American monsoon, *Ecohydrology*, *1*(3), pp225–38. doi: 10.1002/eco.11.

Horel, Á., Zsigmond, T., Farkas, C., Gelybó, G., Tóth, E., Kern, A., and Bakacsi, Z. (2022) Climate Change Alters Soil Water Dynamics under Different Land Use Types, *Sustainability*, *14*, 3908.

Haghighi, F.; Gorji, M.; Shorafa, M. A study of the effects of land use changes on soil physical properties and organic matter. Land Degrad. Dev. 2010, 21, 496–502.

Manyong, V.M., G.K. Smith, S.S. Weber, S.S. Jagtab and B. Oyewole, 1995. Macro characterization of agricultural system in West Africa: An overview. Resource and Crop Management Research Monograph No. 21, International Institute of Tropical Agriculture (IITA), Ibadan, pp: 66

Sowunmi, F.A. and J.O. Akintola, 2010. Effect of climatic variability on maize production in Nigeria. Res. J. Environ. Earth Sci., 2: 19-30

Petersen, R.G. and Calvin, L.D. (1986). Sampling. Methods of Soil Analysis 1, Physical and Mineralogical Methods (Soil Science Society of America). *Agronomy*, **9**:33-51. Clemmens, A.J. (1981). Evaluation of infiltration for boarder irrigation. *Agriculture and Water* Management, **3**:251-267.

Klute, A. (1986). Water retention: laboratory method. In: Klute, A. (Ed.). Methods of Soil Analysis, Part 1 *Physical, and Mineralogical Properties*, monograph 9. ASA, Madison, WI, PP. 687-734.

Blake, G.R. and Hartge, K.H. (1986). Bulk density methods of soil analysis, part 1, physical and mineral method (Ed. A Klute). PP. 363 – 382.

Anderson, J.M., and Ingram, J.S.I (Eds.) (1993). Tropical soil biology and fertility: A handbook of methods (2nd edition). Wallingford: CAB international.

Nelson, D.W. & Sommers, L.E. (1982). Total carbon, organic carbon and organic matter. In Methods of soil Analysis. Part 2, *Chemical and microbiological methods*. Agronomy Monograph no. 9 (2nd Edn.). Madison, USA. PP. 539-580.

Bouyoucos, C.A. (1951). A re-calibration of the hydrometer for making mechanical analysis. *Agronomy Journal*, **31**:510-513.

Gee, G.W. and Bauder, J.W. (1986). Particle size analysis in: Klute, A. (Ed), methods of soil analysis part 1, *Physical and mineralogical*, monograph a, ASA, Madison, WI, PP. 383- 412.

Yang F, Yao W Y, Dai W H, et al. (2013) Progress of the water erosion study on the vegetationgal slope [J]. Yellow River, 35(1):72-74

Yang,j.c,huang (2005). Carbon sequestration in rubber plantations established on former arable lands in xishuangbanna china. 29:296303

Brady N.C., Weil R. R., (2002) *The Nature and Properties of Soil*, 13th ed. Springer Netherlands, p.249.

Arshad, M.A., Lowery, B. and Grossman. B. (1996) Physical Tests for Monitoring Soil Quality In: Doran, J.W. and Jones, A.J., Eds., Methods for Assessing Soil Quality, Soil Science Society of America Special Publication 49, SSSA, Madison, WI, 123-142

M. Kahle, M. Kleber, M. Torn, R., (2003) Jahn Carbon storage in coarse and fine clay fractions of illitic soils, *Soil Science Society of America Journal, 67* (6), pp. 1732-1739, 10.2136/sssaj2003.1732

Table 1: Effect of Land Use Type on Soil Organic Matter, pH, Particle Size Distribution and Electric Conductivity (EC)

Land use	Organic Matter (%)	pH	Sand (%)	Silt (%)	Clay (%)	EC (dS/m)
Citrus plantation	1.17	5.71	58.6	26.0	15.41	0.29
Mango plantation	1.02	5.91	62.6	22.7	14.75	0.70
Arable land	0.70	5.97	63.3	24.0	12.75	0.37
Fallow land	0.73	6.10	73.3	16.7	10.08	0.25
Significance level	NS	NS	NS	NS	NS	NS
SED	0.318	0.134	5.68	3.54	2.653	0.355

Table 2: Effect of Land Use Type on Exchangeable Cations (Bases)

Land use	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)
Citrus plantation	3.57a	0.97	0.18	0.27
Mango plantation	3.56a	0.99	0.27	0.39
Arable land	3.52a	1.30	0.25	0.32
Fallow land	1.73b	0.76	0.19	0.24
Significance level	*	NS	NS	NS
SED	0.572	0.165	0.060	0.082

Table: 3 Effect of Land Use on Soil Bulk Density and Soil Moisture Retention

Land use	BD (g/cm^3)	FC (%)	PWP (%)	PAW (%)
Citrus plantation	1.50	12.34	4.4	7.98
Mango plantation	1.42	13.34	8.2	5.16
Arable land	1.56	9.44	4.4	5.00
Fallow land	1.50	9.61	5.4	4.16
Significance level	NS	NS	NS	NS
SED	0.085	2.314	3.13	1.643

Table: 4 Correlation Coefficient across the Studied Soil Characteristics

Correlations

	pH-water	Organic matter (%)	EC(dS/m)	Sand(%)	Silt(%)	Clay (%)	Ca(cmol/kg)	Mg(cmol/kg)	k(cmol/kg)	Na(cmol/kg)	BD (g/cm3)	FC (% vol)	PWP (% vol)	PAW (% vol)	Infiltration Rate(mm/hr)
pH-water	1.0000	-0.2992	0.0891	0.3233	-0.3431	-0.2410	-0.3508	-0.0717	0.1988	-0.1013	-0.1458	-0.0079	0.3951	-0.5924	0.5233
Organic matter (%)	-0.2992	1.0000	0.6692	-0.5730	0.4040	0.7394	0.5795	0.2727	0.3434	-0.2793	-0.1452	0.4098	0.2961	0.1031	-0.5961
EC(dS/m)	0.0891	0.6692	1.0000	-0.3800	0.2350	0.5406	0.5157	0.3703	0.5079	-0.2247	0.0756	0.4397	0.6033	-0.3100	-0.3827
Sand(%)	0.3233	-0.5730	-0.3800	1.0000	-0.9591	-0.9015	-0.8760	-0.4789	-0.3010	0.0925	0.0101	-0.6885	-0.3125	-0.4458	0.5691
Silt(%)	-0.3431	0.4040	0.2350	-0.9591	1.0000	0.7423	0.7897	0.4457	0.2041	-0.0270	0.0194	0.5828	0.2273	0.4323	-0.4240
Clay (%)	-0.2410	0.7394	0.5406	-0.9015	0.7423	1.0000	0.8670	0.4526	0.4009	-0.1779	-0.0535	0.7394	0.3925	0.3948	-0.6995
Ca(cmol/kg)	-0.3508	0.5795	0.5157	-0.8760	0.7897	0.8670	1.0000	0.6845	0.4789	0.0265	0.0875	0.4780	0.1950	0.3418	-0.5425
Mg(cmol/kg)	-0.0717	0.2727	0.3703	-0.4789	0.4457	0.4526	0.6845	1.0000	0.2546	-0.1066	0.1131	0.0300	-0.1212	0.2180	0.0115
k(cmol/kg)	0.1988	0.3434	0.5079	-0.3010	0.2041	0.4009	0.4789	0.2546	1.0000	0.1112	0.2236	0.0551	0.3029	-0.3737	-0.3280
Na(cmol/kg)	-0.1013	-0.2793	-0.2247	0.0925	-0.0270	-0.1779	0.0265	-0.1066	0.1112	1.0000	-0.1539	-0.0434	0.1368	-0.2587	0.0463
BD (g/cm3)	-0.1458	-0.1452	0.0756	0.0101	0.0194	-0.0535	0.0875	0.1131	0.2236	-0.1539	1.0000	-0.1969	-0.0383	-0.2026	0.1354
FC (% vol)	-0.0079	0.4098	0.4397	-0.6885	0.5828	0.7394	0.4780	0.0300	0.0551	-0.0434	-0.1969	1.0000	0.7485	0.2135	-0.5314
PWP (% vol)	0.3951	0.2961	0.6033	-0.3125	0.2273	0.3925	0.1950	-0.1212	0.3029	0.1368	-0.0383	0.7485	1.0000	-0.4881	-0.1598
PAW (% vol)	-0.5924	0.1031	-0.3100	-0.4458	0.4323	0.3948	0.3418	0.2180	-0.3737	-0.2587	-0.2026	0.2135	-0.4881	1.0000	-0.4639
Infiltration Rate(mm/hr)	0.5233	-0.5961	-0.3827	0.5691	-0.4240	-0.6995	-0.5425	0.0115	-0.3280	0.0463	0.1354	-0.5314	-0.1598	-0.4639	1.0000

EFFECT OF CO-INCORPORATION OF FRESH RICE STRAW AND GREEN MANURE APPLIED WITH UREA ON SOIL FERTILITY, GROWTH AND YIELD OF RICE (*Oryza sativa* L.) IN RICE-WHEAT-RICE CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted during 2020 and 2021 wet seasons, at the Irrigation Station, Kadawa Nigeria to determine the effects of co-incorporation of rice straw residue and green manure on rice crop and chemical properties of the soil, in a rice-wheat-rice cropping system, in the Sudan savannah ecological zone of Nigeria. The treatments were: (i) Control, (ii) 100 kg N ha^{-1}, (iii) 150 kg N ha^{-1}, (iv) Green Manure (GM), (v) GM + rice Straw, (vi) wheat straw + 150 kg N ha^{-1}, (vii) Green Manure + Wheat straw. The experiment was laid out in Randomized Complete Block Designs (RCBD) with four (4) replications. The parameter measures include leaf area index, total dry matter, plant height, effective tillers, filled grains panicle $^{-1}$ and green yield. The results showed that the characters improved by simply incorporating cowpea green manure, but further improvement was achieved by co-incorporation of green manure and rice or wheat straw. Therefore, co-incorporation of cowpea green manure and rice or what straw increased rice yield by the average of 58% but was at par with co-incorporation of wheat straw plus GM. The available N, P and K in the first 15.0 cm layer increased by more than15% when compared to plots without any incorporation. The straw incorporated soil increased the CEC and carbon content of the soil by 9% and 17% respectively compared to non-incorporated fields.

INTRODUCTION

Rice is one of the most important staple cereal crops cultivated in Nigeria because of its palatability and ease of preparations and cooking. The rice crop offers variety of uses to the farming community. Rice is also being considered as one of the best and cheapest alternative technology available to farmers for efficient utilization of natural resources. Nigeria rough rice production has now reach 7.4million metric tonnes (USDA, 2019). This rising increase is as a result of rice demand which is largely due to rapid population growth increased urbanization and people's preference for rice as a convenient food (FOA, 2003).

Rice in Nigeria is planted in June and depending on the requirement of a particular variety, it is grown in paddies or in upland. And because the crop responds very well to nitrogenous fertilizers it uses lesser fertilizer compared to other cereals like maize and even sorghum. Kadawa in Kano is one of the main grain producing areas in Nigeria where rice-rice and or rice-wheat rotation is the prevailing cropping system and produces many heaps of crop residues every year. Rice is grown in both wet and dry seasons, because of the availability of irrigation water throughout the year in the area. Highlight on rice production by farmers in this area show that in this area, for the past five (5) years, rice yield harvested has declined to an average of 4.2 t/ha from the 6.2±0.2 – 6.4±0.2 t/ha initially harvested, some decade back with recommended rates of mineral N.P.K and sulfur(s) even when up to 150% of the recommended rate of fertilizers NPK and was used the yield was not much better than what it used to be using the 100% NPK and S rate. Before 2019, for the past ten years the cultivation of rice was done in the wet season while wheat production followed immediately in the harmattan. From the above information, its suggested that the decline in yield might not have been due to low rate of N.P.K and S application. Traditionally in this area rice as well as wheat are manually harvested by cutting and carrying to a central treshing location for separation of grain and straw, with only a small portion of the straw retained in the field. Straw is considered a waist product and was either burned or use for other purposes.

On one hand, decline in yield may have been caused by deficiency of the other nutrients apart from NPK and S not able to sustain initial previous yield or may be due to the manner in which farmers managed their fields for the past years. It has been reported that extensive and inappropriate use of chemical fertilizers is degrading our soils to alarming level. Nutrient recycling by the use of organic manure is referred to restore nutrient removed by crops and organic matter removed or mismanaged by man. Despite the gaps in our knowledge of cropping system involving various long-term options including legumes have generally been found to be beneficial particularly in rice-wheat cropping systems (Abrol and Palaniappan, 1988). The in-situ incorporation of rice straw in the soil has been shown to contribute to recycling of nutrient and increasing soil organic matter (Bijay-Singh *et al.*, 2004; Gupta *et al.*, 2007). Therefore, the objective of the experiment is to shed light on more methods of N management in up-land rice.

MATERIALS AND METHOD

A field experiment was conducted during 2020 and 2021 wet seasons, at the Irrigation Scheme, Kadawa, Kano State ($11^0 29^1$N, $080^0 02^1$E at 500 m above sea level) located in the Sudan savannah ecology of Nigeria, to determine the effect of crop residue management and green manuring on soil organic matter, growth, yield and yield components of rice in rice-rice cropping. The rainfall begins in June and ends in September and has its peak in August. During the crop growing season, average total rainfall was 453.95 over the two years. The mean minimum temperatures over the two years was 16.5 ^{o}C, respectively, while the mean maximum temperature was 35.7^{0}C. The soil is a ferruginous type. Soil samples were collected prior to the experiment at depths of 0-15cm for physical and chemical properties analysis of the soil before and after harvesting from the same plots maintained in the experiment. The soil was sandy clay loam in texture, moderately acidic (5.5), normal electrical conductivity (9.86), low amount of organic carbon (3.4), total nitrogen (1.5) and available P (9.81). The soil was analyzed to determine soil texture, soil pH caution exchange capacity (CEC), total nitrogen, available phosphorus, exchangeable potassium and organic carbon. The results for soil analysis are shown in Table 1. The experiment comprised of seven (7) treatments viz-a-viz (Control, 100 kg N ha^{-1}, 150 kg N ha^{-1}, Green Manure (GM), GM + Rice Straw, GM + Wheat Straw, Wheat Straw + 150 kg N ha^{-1}, the experiment was laid out in Randomized Complete Block design (RCBD) with four (4) replications. Land preparation began in March 3rd of both years after wheat were harvested. The gross size of each plot was 12.90 m^2 (3.84 long and 3.36 m wide) each plot was separated by 0.75 m, while each block was separated by 1.5 m, while a net plot size of 4 m^2 (2m x 2m) was used. The treatment was factorially combined and laid in a randomized complete block design (RCBD) and replicated three times. Land preparation was carried out appropriately on 1/03 in each year while on the 3/03, cowpea seeds were planted on flat basins with raised embankments at the spacing of 20 cm x 20 cm, with irrigation regularly until the 15/04 of each year when uprooted and combined with about 13 t ha^{-1} of rice or wheat straw. The straw was collected and cut into pieces with the help of a knife and co-incorporated at 15 cm depth using a hoe. After the incorporation of green manure and straw materials, rice seeds were sown manually on the 15th of May in each year. Green manure from cowpea at the time uprooting planted after 6 weeks after sowing is reported to add up to 60 kg N ha^{-1} into the soil. About 40 kg N ha^{-1} of urea was added to all GM treatments to make N addition through GM + Urea = 100 kg N ha^{-1}. All inorganic phosphorus, potassium, and gypsum was applied to the various plots receiving the full dose of 100 kg N ha^{-1} and 150 kg N ha^{-1} while the N was applied into 2 splits at half of dose at planting with the remaining dose at 6 WAS. Hand weeding was done at three and six weeks after planting and regular disease control measures was carried out.

Five plants from each net plot were chosen randomly and tagged for measuring plant height, leaf area index, total dry matter, number of filled grains panicle $^{-1}$, effective tillers m^{-2}, and grain yield t ha^{-1} using the standard agronomic procedure. Data collected were subjected to analysis of variance (ANOVA) as described by Cochran (1967) using statistical analysis system (SAS) (Institute, 1997) and Duncan, Multiple Ronge Test was used to separate the treatment means (Duncan, 1955) mean effect of the factors were contained in accordance with the procedure of Gomez and Gomez (1984).

RESULT

The results in Table 2 and 3 shows that averaged over 2020 and 2021 the growth parameter of plant height, yield area index and total dry matter and yield parameters of panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, straw yield and grain yield were significantly increased over the control.

Average over 2020 and 2022 the maximum plant height at harvest was obtained from the treatment of; GM + Rice straw (101.02cm), and GM + Wheat straw (104.9cm), were as control plants showed (70.2cm) as an average plant height. Highest leaf area index at harvest were observed in plots treated with GM + Rice straw (5.04cm) and GM + Wheat straw (4.97cm) and minimum of these was (2.06cm) in the control. At the time of harvesting the Total dry matter in control plots was (501.0 gm^{-2}) while maximum dry matter was observed in plant treated with GM + Rice straw (1426.7 gm^{-2}) and GM + heat straw (1332.9 gm^{-2}).

Panicle length in control plant was (23.4cm) while maximum panicle length was noted in plants treated with GM + Rice straw (28.72cm) and GM + Wheat straw (28.32cm). The data concerning to filled grain $panicle^{-1}$ shows that number of filled grain per panicle significantly decreased in all the treatments except straw + GM and GM incorporated plants as against on-incorporated plants except Wheat straw + 150 kg ha^{-1} that was lower. Maximum number of filled grain per panicle (92.06 cm) was observed in plots incorporated with GM + rice straw and wheat straw + GM (90.48) and GM plots (89.80). Maximum number of effective tillers $hill^{-1}$ was observed in field incorporated with GM + rice straw (326.0) and GM + wheat straw (333.1) whereas control showed (150.6). Maximum Straw yield was identified with plants incorporated with GM + Rice straw (6.89 kg ha^{-1}) and GM + Wheat straw (6.84 kg ha^{-1}) whereas control showed (3.20). Maximum grain yield was observed in plots incorporated with GM + Rice straw (6.88 t ha^{-1}) and GM + Wheat straw (6.45 t ha^{-1}) were as control gave (3.20).

Discussion

The green manure and straw management treatments had significant effect on the plant growth at different growth stages. Plant height reveals the overall vegetative growth of the crops in response to various management practices. It was found that incorporation green manure and crop residue increase the plant height significantly. The increase in plant height in response to incorporation GM + Crop Straw is probably due to enhanced availability of nutrients which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. Inclusion of leguminous green manure in the rice-wheat cropping system enhanced and sustained rice production in the wet sea (IRRI, 1988). The addition of green manure alone can help to make soil fertile but the co-incorporation of green manure and straw for some period in the soil can lead to more increase in the availability of more nutrients. Thus apart from nutrients released by green manure at the early stage of the crop cycle the decomposition of rice or wheat straw at later of the crop cycle may be favoured by soil microbes which may have favoured better nutrient availability and their usage by the crop plants. Organic matter contributes to soil fertility and productivity through its positive effect on different properties.

The addition of rice straw was reported to improve soil pH, soil organic carbon and nutrient content compared to the initial conditions in Vietnam (Thanh *et al.*, 2016) in that study, the incorporation of rice straw resulted in greater increase in soil C, pH and nutrient contents compared to addition of ash from burned straw. Rice straw significantly increases rice yield by the average of 58% compared straw removal. The available N, P and K increased by more than 15% when compared to plots without Green manure and crop straw residue. Residue incorporation not only increases the microbial population but also results in more CO_2 evolution and dehydrogenase activity in the upper most 0-15cm of the soil. The soil CEC and carbon increased by 7% and 22% in incorporation compared to non-incorporation (Liu *et al.*, 2010). Rice straw incorporation significantly affected the soil organic carbon. This might be due to wider C/N (59.1) ratio of straw that takes long to decompose and thus improve soil aggregation soil water retention and reduce bulk density of the soil, promoting crop growth and TN stock. The better nutrient up take capacity of rice plants. The increased microbial activity later helped in mineralization of nutrients especially N and P reported. Higher number of filled grain panicle^{-1} could be attributed to favourable changes in physical and chemical characteristics of the soil which might have enable better filling of grains panicle^{-1}. Therefore full straw incorporation could significantly improve soil fertility and maintain crop yields for the study area.

CONCLUSION

From the experiment, the treatment of rice straw and wheat straw which were at par gave significant yield increases in growth and yield in most of the parameters and chemical properties. Thus, in this regards we find that rice straw and wheat straw were found to be optimum option yield in rice-wheat-rice system. Therefore, full straw incorporation significantly improved soil fertility and maintain crop yields.

REFERENCES

Zhang, P., Chen, X., Weit.; Yang, Z., Yang, B., Han, Q., & Ren, X. (2016). Effects of straw incorporation on the soil nutrient contents, enzyme activities, in a semi-arid region of China. *Soil Tillage Research*, 160, 65-72.

Yang, H., Xu, M., Koide, R. T., Liu, Q., Dai, Y., Liu, L., & Bian, X. (2016). Effects of ditch-buried straw return on water percolation, nitrogen leaching and crop yields in a rice-wheat rotation system. *Journal of the science of food and agriculture*, *96*(4), 1141–1149. https://doi.org/10.1002/jsfa.7196.

Wang, X., Yang, H. S., Liu, J. S., Chen, S. P., Wu, J., Zhy, L. Q., & Bian, X. M. (2015). Effects of ditch-buried straw return on soil organic carbon and Rice-Wheat Rotation System Catena, 127, 56-63.

Zhang Y.; Liu, Y.; Zhang, G.; Guo, X.; Sun, Z.; Li, T. The effects of rice straw and Biochar Applications on the Microbial Community in a soil with a History of Continuous Tomato

USDA. (2019). Soil Health and sustainability. Natural Resources Conservation Service.

USDA (2019). Crop Production Report. National Agricultural Statistics Service.

Food and Agriculture Organization of the United Nations (2003). World Agriculture: Towards 2015/2030.

Abrol, I. P., & Palaniappan, S. P. (1988). Effect of Stubble Incorporation on Soil Properties and Wheat yield/ journal of Agricultural Science, 111(2); 147-153.

Bijay-Singh, et. Al. (2004). Long-term effects of crop reside management on soil fertility and productivity in a rice-wheat rotation. Journal of Agricultural Science, 142 (4), 359-368.

Gupta, et al., (2007). Impact of Straw Incorporation on Soil Physical and Biochemical Properties. Soil and Tillage Research, 96 (1-2), 177-185.

Table 1: Mineral fertilizer, green manure and rice/wheat crop residue management practices averaged over two years 2020 and 2021

Treatment	Description
Control	No fertilizer
NPK[a]	NPK at a rate of 100 – 60 – 30 kg N – P – K ha^{-1}+ S (Sulfur)
NPK[a]	NPK at a rate of 150 – 60 – 30 kg N – P – K ha^{-1}+ S (Sulfur)
GM	Green Manure
GM + Rice Straw	Green Manure + Rice Straw (Fresh weight)
GM+ Wheat Straw	Green Manure + Wheat Straw (fresh weight)
Wheat Straw + 150 kg N ha^{-1}	$N_{150}P_{60}K_{30}$ $ha.^{-1}$ and Rice Straw (fresh weight)

[a]NPK used were urea, triple superphosphate and muriate of potash

Table 2: Impact of rice/wheat residue, green manure and mineral fertilizer on the growth component of rice averaged over two years of 2020 and 2021at Kadawa.

	Plant height			Leave area index			Total dry matter (g m^{-2})		
Treatments	6WAS	9WAS	Harvest	6WAS	9WAS	Harves t			
Control	22.14^{c}	29.80^{c}	70.20^{c}	0.60^{b}	1.62^{c}	2.06^{d}	1.10^{c}	260.2^{d}	501.0^{d}
100 kg N ha^{-1}	24.36^{c}	33.76^{b}	76.21^{c}	0.66^{b}	1.84^{b}	3.07^{c}	130.5^{b}	427.9^{b}	853.0^{c}
150 kg N ha^{-1}	28.11^{b}	55.97	99.38^{b}	0.80^{a}	2.68^{a}	4.71^{b}	148.2^{a}	665.5^{a}	1242.6^{b}
Green Manure (GM)	28.33^{a}	54.35^{a}	100.20^{b}	0.79^{a}	2.67^{a}	4.77^{b}	142.2^{a}	656.2^{b}	1085.7^{b}
GM + Rice Straw	29.72^{a}	56.54^{a}	101.02^{a}	0.83^{a}	2.94^{a}	5.04^{a}	155.8^{a}	709.1^{a}	1426.7^{a}
GM + Wheat Straw	29.87^{a}	56.62^{a}	104.9^{a}	0.83^{a}	2.94^{a}	4.97^{a}	158.9^{a}	717.2^{a}	1332.9^{a}
Wheat straw +150 kg N ha^{-1}	24.00^{b}	35.31^{b}	72.33^{c}	0.66^{b}	1.87^{b}	3.08^{c}	133.3^{b}	474.0^{c}	915.5^{c}
SE (±)	0.5133	0.6447	0.4256	0.0095	0.0885	0.050	7.8495	18.66	27.89

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT. * = significant at 5% probability level **= significant at 1% probability level NS = Non-significant, SE = Standard error, + GM = with green manure, -GM = without green manure

Table 3: Impact of rice residue, green manure and mineral fertilizer on the yield and yield component of rice averaged over two years of 2020 and 2021at Kadawa.

Treatment	Panicle length (cm)	Number of effective tillers hiil^{-1}	Number of filled grains panicle	Grain yield (t ha^{-1})	Straw yield (kg ha^{-1})
Control	23.41^{c}	150.6^{d}	50.91^{d}	2.42^{d}	3.20^{d}
100 kg N ha^{-1}	24.72^{c}	220.8^{c}	56.82^{c}	3.67^{c}	5.28^{c}
150 kg N ha^{-1}	27.22^{b}	302.5^{b}	87.58^{b}	5.82^{b}	5.80^{b}
Green Manure + Rice Straw	28.72^{a}	333.0^{a}	92.06^{a}	6.58^{a}	6.89^{a}
Wheat Straw + 150 kg N	24.32^{c}	214.7^{c}	56.04^{b}	3.68^{c}	5.00^{c}
Green Manure	27.22^{b}	302.5^{b}	89.80^{a}	5.68^{b}	5.70^{b}
Green Manure + Wheat Straw	28.32^{a}	326.1^{a}	90.48^{a}	6.45^{a}	6.84^{a}
SE (±)	0.3364	6.3853	0.9741	0.1931	0.2959

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.* = significant at 5% probability level **= significant at 1% probability level NS = Non-significant, SE = Standard error, + GM = with Green manure, -GM = without green manure

Table 4: Effect of rice residue, green manure and mineral fertilizer on the soil properties of rice averaged over 2020 and 2021 at Kadawa.

Treatment	pH (1:2:5)	CEC (c mol kg^{-1})	Total N (%)	Extr. P (ppm)	Exch. K (ppm)	OM (%)
Control	5.18	10.87	1.76	0.65	9.64	3.80
NPK 150 kg	5.06	10.87	1.79	1.65	13.73	3.06
NPK 120 kg	5.03	10.50	1.74	1.75	13.069	3.10
Green Manure (GM)	6.10	10.87	1.76	1.85	13.67	4.0
GM + Residue	6.17	11.50	1.77	1.93	13.74	4.60
Residue + NPK (150 kg N ha)	6.36	11.25	1.77	1.93	13.72	4.69
Ash + NPK (150 kg N ha)	6.23	10.50	1.77	1.97	13.72	3.99
Initial soil status	5.5	9.86	1.5	0.73	9.81	3.4
SE (±)	NS	NS	NS	NS	NS	NS

NS = Non-significant.

ASSESSMENT OF INDIGENOUS TREE SEEDLINGS PRODUCTION BY PRIVATE PLANT NURSERIES IN TARAUNI LOCAL GOVERNMENT AREA OF KANO STATE

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ABSTRACT

Indigenous tree seedlings are vital for forest restoration, Agroforestry, afforestation, landscaping, and urban greenery initiatives. However, deforestation, urbanization, agricultural expansion, and illegal logging have severely impacted indigenous tree species in Nigeria. This study conducted in Tarauni Local Government Area, Kano State, assessed the production of indigenous tree seedlings by private nurseries. Using a multistage sampling technique, 34 private nurseries were selected, and semi-structured questionnaires were administered to the operators. Data was analyzed using descriptive statistics and diversity indices calculated with PAST software. The results revealed that 59% of the nurseries were not registered with the Corporate Affairs Commission, highlighting their informal status, which could hinder access to finance. The study found a variety of indigenous seedlings being cultivated, with *Moringa oleifera, Parkia biglobosa, Balanite aegyptiaca*, and *Anogeissus leiocarpus* being the most common. A low dominance value (0.06231) indicated a balanced distribution of species, while the Brillouin Index (2.625) and Shannon-Wiener Index (2.847) reflected moderate to high biodiversity. Furthermore, 72% of nurseries reported producing over 1,000 seedlings annually, with 44% sourcing seeds from the market, and none using seed banks. A significant challenge, reported by 52% of nurseries, was inadequate access to water for irrigation. Additionally, 53% of respondents cited a lack of support from government or NGOs, exacerbating their challenges. The study concluded that targeted interventions are needed to support private nurseries, particularly in addressing water access and promoting formal registration. It also recommended establishing seed bank initiatives in collaboration with universities and research institutions to improve the availability of high-quality seeds for indigenous species propagation.

Keywords: Agroforestry, Deforestation, Tree Diversity, Native Trees, and Plant Nurseries

INTRODUCTION

Nigeria is home to a wide variety of indigenous tree species that are vital for maintaining ecological stability and offering numerous benefits to local communities (Agbelade *et al.*, 2021). However, the rapid depletion of these natural resources, driven by deforestation, urban expansion, and unsustainable land-use practices, is a growing concern (Akindele and Adebo, 2004; Wali *et al.*, 2024). These native trees are integral to the Nigerian ecosystem, providing ecological, economic, and socio-cultural value. They are well-adapted to the local climate and play key roles in soil preservation, water regulation, and biodiversity protection (Wali *et al.*, 2024). In addition, they offer local communities essential resources, such as food, medicine, fuel, timber, and cultural significance (Eko *et al.*, 2021; Wali *et al.*, 2024).

The conservation and sustainable management of indigenous tree species are essential for safeguarding Nigeria's natural heritage and enhancing the well-being of local communities (Agbelade *et al.*, 2021). A key component of this effort is the production of high-quality seedlings, crucial for reforestation, afforestation, and agroforestry initiatives (Olajide *et al.*, 2008). Private nurseries play a pivotal role in producing these seedlings, complementing the efforts of government bodies and non-governmental organizations (Babalola, 2008). Typically run by individuals or community groups, these nurseries contribute to both the local economy and environmental conservation (Olajide *et al.*, 2008). Indigenous tree seedlings serve various purposes, such as landscaping, agriculture, reforestation, and urban greening. In cities like Tarauni, private nurseries are vital in fulfilling the demand for seedlings. However, several challenges may limit their ability to produce enough high-quality seedlings.

Nigeria's diverse indigenous tree species face significant threats due to various human activities and environmental pressures. The decline of these valuable trees has serious consequences for the country's ecological balance, biodiversity, and the well-being of local communities (Agbelade *et al.*, 2021; Orwa *et al.*, 2009). Deforestation is a major global concern, and growing population pressure on limited forest and land resources has caused traditional tree-based methods of restoring vegetation to fail (Abdullahi *et al.*, 2022). The clearing of forests for agriculture, settlements, and infrastructure has led to the destruction of natural habitats, fragmenting and reducing tree populations (Idris *et al.*, 2021), while also releasing the carbon stored in these trees (Mustafa and Wali, 2020). Furthermore, unsustainable harvesting practices, such as overexploitation for fuelwood, timber, and other forest products, have exacerbated the issue (Larinde and Ruth, 2014; Suleiman *et al.*, 2017). The lack of effective management and conservation strategies has further degraded indigenous tree populations, hindering their natural regeneration and growth (Agbelade *et al.*, 2021).

In Tarauni LGA, the decline in indigenous tree diversity is particularly concerning. The region has experienced severe deforestation and environmental degradation due to urbanization, unsustainable harvesting, and agricultural expansion (Idris *et al.*, 2021). This loss of valuable tree species has harmed both the local ecosystem and the communities that depend on it. The production of indigenous tree seedlings by private nurseries in Tarauni offers significant potential for supporting reforestation efforts, restoring degraded areas, and promoting sustainable land-use practices (Olajide *et al.*, 2008; Agbelade *et al.*, 2021). Furthermore, growing these species can strengthen the local economy by creating income-generating opportunities and ensuring continued access to natural resources for local communities (Babalola, 2008). Tackling the decline in indigenous tree diversity requires a coordinated effort from government agencies, non-governmental organizations, and local communities. A key element of these efforts is the production of high-quality seedlings of endangered species for reforestation and restoration initiatives.

Private nurseries have the potential to significantly contribute to agroforestry and forest restoration by growing and supplying indigenous tree seedlings. However, assessing their current status, practices, and challenges is crucial to developing strategies that enhance their role in conserving and sustainably managing Indigenous tree species. This study examines the annual seedling production capacity, and the variety of indigenous tree seedlings produced by private nurseries in the Tarauni Local Government Area.

METHODOLOGY

Description of the Study Area

Tarauni Local Government Area, located in Kano State, northern Nigeria, boasts a rich history dating back to the pre-colonial era when it was part of the larger Kano Emirate, serving as a key agricultural and trade center. Positioned between 11°58'N - 12°13'N latitude and 8°25'E - 8°40'E longitude, the area had a population of 367,458 according to the 2006 Nigerian Population Census, a number that is now estimated to have exceeded 500,000 due to rapid urbanization and population growth. The region has a diverse economy, with agriculture (including crops like millet, sorghum, cowpea, and vegetables), commerce (notably in markets such as Tarauni Central Market), and small-scale industries (like furniture making and metal fabrication) playing vital economic roles (Asani, 2022).

Tarauni LGA experiences a tropical savanna climate typical of the semi-arid regions of northern Nigeria, characterized by two distinct seasons: the dry season and the wet season. The dry season, lasting from November to April, sees little to no rainfall, with daytime temperatures reaching up to 40°C (104°F) and cooler nights. During this period, the harmattan-a dry, dusty wind from the Sahara Desert is common, often reducing visibility and causing respiratory problems. The wet season, from May to October, brings moderate to heavy rainfall, peaking between July and September. The area receives an average annual rainfall of 600 to 800 millimeters (24 to 31 inches). Temperatures during the wet season are generally lower, ranging from 25°C (77°F) to 35°C (95°F). The climate in the Tarauni Local Government Area significantly influences agricultural activities, water availability, and the growth and survival of indigenous tree species (Dantani, *et al*., 2024).

The predominant soil type in Tarauni LGA is sandy loam, characterized by a high sand content with moderate levels of silt and clay. These soils are generally well-drained but can be prone to erosion and nutrient depletion if not properly managed. Soil fertility in the area varies depending on factors such as topography, organic matter content, and agricultural practices. In some parts, the soil is relatively fertile, supporting crop cultivation and tree growth, while in others, the soil may be less productive and require additional inputs or management strategies (Mshelia *et al*., 2020). The vegetation in Tarauni LGA reflects the typical savanna ecosystem, featuring a mix of grasses, shrubs, and scattered trees. Dominant tree species include Acacia (such as *Acacia nilotica* and *Acacia senegal*), *Balanites aegyptiaca*, *Ziziphus mauritiana*, and *Faidherbia albida* (Mshelia *et al*., 2020). These indigenous trees provide significant economic and ecological benefits, offering timber, fuelwood, fodder, and various non-timber forest products. However, due to human activities like overgrazing, unsustainable harvesting, and land-use changes, the natural vegetation in some areas has been deforested or degraded, leading to soil erosion, loss of biodiversity, and reduced land productivity.

Sampling Technique

For this study, a multistage sampling technique was used. Initially, a purposive sampling method was employed to select the area surrounding Aminu Kano Teaching Hospital (AKTH). In the second stage, convenient sampling was used where 34 private plant nurseries that are engaged in Indigenous tree seedling production were selected. The location was chosen because AKTH is surrounded by private nurseries extending to Zaria Road within Tarauni LGA, making it the primary area where private plant nurseries are concentrated within the LGA. This approach aims to capture a representative sample of nurseries that produce indigenous tree seedlings, providing valuable insights into the current practices, challenges, and opportunities related to indigenous tree seedling production in the area.

Data Collection and Analysis

A carefully designed semi-structured questionnaire was administered to the selected private nursery operators to gather data on indigenous tree seedling production practices, challenges, and opportunities. The questionnaire included sections on the operator's profile, nursery characteristics, indigenous tree species cultivated, seedling production practices, challenges encountered, and opportunities for improvement, along with the support needed. A total of 34 questionnaires were distributed to the respondents for data collection. The collected data was then cleaned and analyzed using descriptive statistics, with demographic information presented in terms of frequency and percentages. Furthermore, PAST Software was used in analyzing the seedlings' diversity, using the Shannon-Wiener Index which is mathematically expressed as:

$$H' = -\sum_{i=1}^{s} p_i \ln(p_i)$$

Where: H′= Shannon-Wiener diversity index; S = total number of species (species richness) p_i= proportion of individuals belonging to species *i* (calculated as $p_i = \frac{n_i}{N'}$ Where n_i is the number of individuals in species i and N is the total number of individuals in the sample); $ln(p_i)$ =natural logarithm of the proportion of species *i*

RESULTS AND DISCUSSION

The results presented in Table 1 indicate that most respondents (38%) are aged between 36 and 45 years, followed by 27% who are over 46, and 26% in the 26-35 age range. Only 9% of the respondents are between 18 and 25 years old. This distribution suggests that nursery owners and operators are predominantly middle-aged or older, with fewer young individuals represented. The age factor was found to be significant in nursery enterprises, with younger people being more open to new ideas and practices compared to older individuals, who tend to be more conservative and less likely to adopt new methods (Eko *et al.*, 2021).

The results reveal that all respondents (100%) are male, with no female representation in the sample. This finding may reflect the gender dynamics or cultural norms within the nursery industry in the study area, where ownership and management appear to be predominantly male. Additionally, the entire sample (100%) consists of respondents from the Hausa/Fulani tribe, with no other tribal affiliations represented in the data. This outcome may be due to the demographic makeup of the study area or the dominance of the Hausa/Fulani tribe in the regional nursery industry. This aligns with the findings of Olaleye et al. (2008), who noted that men predominantly own nursery enterprises in Sokoto State. The lack of female participation may stem from ongoing debates and discussions surrounding the status and role of women in society worldwide. The data in Table 1 reveals that a majority of respondents (65%) are married, while 35% are single, with no respondents indicating they are divorced or widowed. This distribution suggests that most nursery owners and operators in the study area are married, potentially highlighting the significance of family support in the nursery business. Half of the respondents (50%) have a non-formal education, while 27% have completed secondary education, and 23% have achieved a tertiary level of education. This distribution reflects a range of educational backgrounds among nursery owners and operators, with a notable portion possessing non-formal education. However, the study by Eko et al. (2021) suggests that higher education levels may negatively impact nursery productivity, making it statistically insignificant. This could be attributed to the fact that operating a nursery business is accessible to anyone, regardless of their academic specialization or educational attainment. Table 1 further indicates that most respondents (59%) are primarily involved in business activities, while 29% are students. A smaller percentage includes artisans (9%) and civil servants (3%). This finding suggests that nursery ownership and management are frequently pursued as a business venture or as a supplementary source of income for students.

A significant majority of respondents (97%) identify as Muslims, while only 3% are Christians. This distribution likely reflects the religious demographics of the study area and the predominance of Islam within the region's nursery industry. These findings align with Fodiyo (2023), who reported that most respondents engaged in nursery operations in the Sokoto metropolis are also Muslims. The table also displays a relatively even distribution of respondents across various experience levels in the nursery industry. The largest group, comprising 32%, has 11-15 years of experience, followed by 29% with 6-10 years, 26% with over 15 years, and 12% with less than 5 years. This differs from Fodiyo's (2023) findings, which indicated that plant nursery owners typically have a minimum of 9 years of experience in the field. The diversity in experience levels in this study suggests a mix of both established and emerging nursery operators in the area.

The results from Table 2 indicate that 59% of nurseries are not registered with the Corporate Affairs Commission (CAC), while only 41% have formal registration. This suggests that most nursery operations in the study area function as informal or unregistered businesses. This lack of formal registration may affect their ability to comply with regulations, access resources or financing, and sustain long-term growth. These findings align with Fakayode *et al.* (2008), who identified the inability to secure adequate funding as a major limitation for operators in the ornamental plant nursery business.

Most nurseries (62%) measure 20x30 square meters, followed by 32% at 20x20 square meters. Only a small percentage (6%) have a size smaller than 20x20 square meters, and none exceed the 20x30 square meter size. This distribution suggests that the majority of nurseries in the study area are small to medium-sized operations, possibly reflecting resource limitations or operational choices.

Table 2 indicates that 61% of the nurseries employ both full-time and part-time staff, while 23% rely solely on part-time workers, and 16% employ only full-time staff. This suggests that a mixed labor system of full-time and part-time workers is the most common in the nursery industry, likely due to the seasonal nature of the work or resource constraints. Among nurseries with full-time employees, 45% have fewer than 5 workers, 19% have between 6 and 10, and 35% employ more than 10 full-time staff. This distribution indicates that most nurseries maintain a relatively small full-time workforce, with a smaller number employing larger teams.

Regarding silvicultural practices, 53% of nurseries engage in seed sowing, while 47% utilize both seed sowing and vegetative propagation methods. Notably, none of the nurseries reported exclusively using vegetative propagation. This finding suggests that seed sowing is the primary silvicultural practice in the study area, possibly due to its simplicity, cost-effectiveness, or cultural preferences.

Table 3a reveals the Composition of Indigenous Seedlings Produced in the Surveyed Nurseries, it shows a diverse range of Indigenous seedlings produced by the surveyed nurseries, with Moringa (*Moringa oleifera*), locally known as Zogale, being the most prevalent species, cultivated by 38% of the nurseries. Other commonly produced species include African locust bean (*Parkia biglobosa* or Dorawa), Desert date (*Balanite aegyptiaca* or Aduwa), African birch (*Anogeissus leiocarpus* or Marke), African myrrh (*Commiphora africana* or Dashi), and Doum palm (*Hyphane thebeca* or Goruba), each represented in 32-35% of the nurseries. Species such as Heart leaved fig (*Ficus polita* or Durmi), Acacia (*Acacia nilotica* or Bagaruwa), Tamarind (*Tamarindus indica* or Tsamiya), Date (*Phoeniex dactylifera* or Dabino), Apple-ring acacia (*Faidherbia albida* or Gawo), Gum arabic (*Acacia senegal* or Dakwara), and Mango (*Mangifera indica* or Mangwaro) are also produced, though with slightly lower frequencies ranging from 21-26%. The study of Danjuma *et al*., 2014 reported that most plant nurseries prefer producing exotic seedlings that grow within a short period and are more preferred by local buyers.

The table further highlights the presence of several other indigenous species being cultivated, although at lower frequencies. These include Sycomore tree (*Ficus sycomorus* or Baure) and Catch thorn (*Ziziphus abyssinica* or Magarya) at 18% each, Shea butter (*Vitellaria paradoxa* or kadanya) at 15%, Ditax (*Ditarium senegalenses* or Taura) and Sea lemon (*Ximenia americana* or Tsada) at 6% each, and Baobab (*Adonsonia digitata* or Kuka) and African grapes (*Lannea microcarpa* or Faru) at 3% each. This diversity in the composition of Indigenous seedlings produced by the nurseries reflects the rich biodiversity of the region and the potential demand for various indigenous species for different purposes, such as food, medicine, timber, cultural significance, or agroforestry purposes.

Table 3b presents the ecological indices derived from Table 3a, which evaluate biodiversity, species richness, and evenness within a plant community. A low dominance value of 0.06231 indicates that no single species predominates among the indigenous tree seedlings, suggesting a well-balanced distribution. The Brillouin index, which is particularly effective for smaller sample sizes, shows a value of 2.625, indicating a moderately diverse community of indigenous tree seedlings.

The Shannon-Wiener Index, another biodiversity measure, yields a value of 2.847, suggesting moderate to high diversity with a more even distribution of species. Additionally, the Evenness index, which assesses how evenly individuals are spread across species, has a value of 0.8616, indicating a fairly even distribution. This aligns with the equitability measure, which has a value of 0.9503, close to 1, suggesting a highly equitable community where species are similarly abundant.

Margalef's Index assesses species richness and has a value of 3.792, indicating moderate species richness. Fisher's Alpha, which is sensitive to the presence of rare species, shows a value of 6.198, reflecting moderate diversity with a balanced mix of both common and rare species. Lastly, the Chao-1 estimator of species richness has a value of 20.33, which is very close to the actual number of observed species (20), suggesting that the sampling effort was adequate and that there are likely few undiscovered species within the community.

Table 4 shows that no nurseries exclusively produce indigenous species. Instead, 47% focus solely on exotic species, while 53% cultivate a mix of indigenous and exotic species. This suggests a greater emphasis on growing exotic species, possibly due to market demand, familiarity, or ease of propagation, which aligns with the findings of Danjuma *et al.* (2014).

Among nurseries producing indigenous seedlings, a significant majority (72%) generate more than 1,000 seedlings annually. Additionally, 22% produce between 100 and 500 seedlings, and 6% produce between 501 and 1,000 seedlings. This distribution indicates that most nurseries involved in indigenous seedling production operate on a relatively large scale.

The primary source of seeds for the nurseries is the market (44%), followed by a combination of forest and market sources (28%). Only 22% obtain seeds directly from the forest, while 6% source them from farmlands. Notably, none of the nurseries reported using a seed bank as a source. This finding underscores the significance of market channels, the reliance on natural sources for seed acquisition, and the absence of a seed bank or conservation and research institutions for accessing viable seeds.

The majority of nurseries (88%) utilize a blend of traditional and acquired knowledge in their production processes. Only 6% rely exclusively on conventional knowledge, while another 6% use only acquired knowledge. This distribution indicates that most nurseries effectively combine traditional practices with modern techniques, potentially benefiting from the integration of indigenous knowledge and contemporary methods. The primary challenge faced by nurseries is access to water for irrigation, as reported by 52% of respondents. Other significant challenges include various issues related to seeds and marketing (21%), low seedling demand (9%), and a combination of challenges involving seeds, low demand, and low profits (12%). Additionally, 3% of respondents cited difficulties with access to seeds, while another 3% mentioned challenges related to water and land access. These findings highlight the need for improved water management and marketing strategies to tackle these critical issues. Furthermore, the results indicate that 53% of nurseries do not receive any support from government or non-governmental organizations (NGOs), whereas 47% do receive some form of assistance. Among those who receive support, it primarily takes the form of technical training or workshops. This shows the significance of capacity-building and knowledge-transfer initiatives to improve the skills and capabilities of nursery operators. These efforts could potentially contribute to the overall sustainability and productivity of the industry.

CONCLUSION AND RECOMMENDATION

The study found that plant nurseries produce a diverse range of Indigenous seedlings, with Moringa (*Moringa oleifera*), African locust bean (*Parkia biglobosa*), Desert date (*Balanite aegyptiaca*), African birch (*Anogeissus leiocarpus*), African myrrh (*Commiphora africana*), and Doum palm (*Hyphane thebeca*) being the most commonly cultivated species. A notable percentage of nurseries reported producing over 1,000 indigenous seedlings annually, demonstrating their significant role in propagating these species. These findings highlight the need for targeted interventions and support to address the specific issues faced by private nurseries in the area.

REFERENCES

Abdullahi, S., Barau, A. A., and Lawal, A. I. (2022). Assessment of Trees Outside Forest (TOF) Benefits in Wamakko Local Government Area of Sokoto state, Nigeria. Proceedings of the 8th Biennial conference of the Forests and Forest Products Society, Held at the Forestry Research Institute of Nigeria, Ibadan, Nigeria. 14th - 20th August, 2022 *3*, 305–309. https://www.ffps.org.ng/proceedings/august_14th_20th_2022/

Agbelade, A. D., Onyekwelu, J. C., Akindele, S. O., and Adekunle, V. A. J. (2021). Indigenous tree species conservation in Nigeria: Current practices, challenges, and strategies for improvement. *Journal of Forestry Research*, 32(4), 1219-1235.

Akindele, S. O., and Adebo, G. M. (2004). Growth and nutrient allocation relations of selected precipitation woody species in response to soil moisture stress in outer Southern Nigeria humid rainforest. Ekó, 1, 297-310.

Asani, M. A. (2022). Vulnerabilities among Informal Economic Operators in Kano Metropolis. *African Scholar Journal of Built Env. and Geological Research* (JBEGR-4) 24 (4) 2-16

Babalola, F.D. (2008): Assessment of Small-Scale Private Nursery Enterprise in Ibadan, Oyo State Nigeria. Small Scale Forestry 7:263- 273. DOI:10.1007/s11842-008-9054-2

Danjuma, M. N., Bindawa, A. A., Maiwada, B., Shittu, U., and Adamu, I. (2014). Challenges and Prospects of Tree Seedlings Production in Katsina State of Nigeria. *IOSR Journal of Humanities and Social Science*, *19*(4), 74–80. https://doi.org/10.9790/0837-19447480

Dantani, A., Khalil, A. M., Abanikanda, J. O., Magaji, U. A., Dantani, M., Abubakar, A., ... and Yunus, A. (2024). Problems and Prospects of Tree Planting in Kano Metropolis, Kano State, Nigeria. *World News of Natural Sciences*, *53*, 186-202.

Eko, O.D., Adedokun, M.O., Soaga, J.A., Okojie, L.O., Atanda, T.A., Abisoye, T.R. (2021). Socio-Economic Importance of Tree Nursery Enterprises in Lagos State, Nigeria. *Journal of Applied Science and Environmental Management* 25 (1):21-28.

Fakayode, B. S., Adewumi, M.O., Rahji, M.A.Y., and Jolaiya J.A. (2008). Viability and Resource Use in Ornamental Plants Nursery Business in Nigeria; *European Journal of Social Sciences* – Volume 6 (4). Pp 263-273

Fodiyo, B. (2024). Assessment of Selected Small Scale Nursery Enterprises in Sokoto Metropolis, Sokoto State, Nigeria. Unpublished project submitted to Department of Forestry and Environment, Faculty of Agriculture, Usmanu Danfodiyo University Sokoto, Sokoto State Nigeria.

Idris, H. A., Mohammed, U. K., Tanko, A. I., Ahmed, M., and Mohammed, M. U. (2021). Land Use/Land Cover Change, Population and Urban Dynamics in Kano Metropolis. *African Journal of Earth and Environmental Sciences*, 3(1), 925-941.

Keay, R. W. J. (1989). Trees of Nigeria. A Revised Version of Nigerian Trees (1960, 1964). Clarendon Press, Oxford, UK.

Larinde, S.L. and Ruth S. (2014): Assessment of Small-Scale Private Plant Nursery Enterprise in Port Harcourt, Rivers State; *Global Journal Bioscience and Biotechnology;* Vol.3 (3); pp: 301-311.

Mustafa, H. F., and Wali, B. R. (2020). Estimation of carbon dioxide assimilated in shoot biomass of mature Acacia seyal (Del.) Brenan and Eucalyptus microtheca (F.) Muell. *Tropical Plant Research 7(1):* 14–19

Mshelia, S. S., Mbaya, A. Y., and Galkaye, E. (2020). Municipal Solid Waste Management Practices in Tarauni Local Government Area, Kano State, Nigeria. *International Journal of Geography and Environmental Management*, *6*(3), 1-12.

Olajide, O., Akinsanmi, F. A., and Adewunmi, A. B. (2008). Response of Fruit Trees to Irrigation at the Nursery Stage: Growth and Nutrient Uptake. *Journal of Plant Nutrition*, 31(4), 617-628.

Olaleye, A. S., Akpabio, I.A., Esu, B.B., and Adedire, M.O (2008). Gender perception on constraints affects agroforestry practice in Sokoto state, Nigeria *Agricultural Journal*,3(5),375-381).

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., and Simons, A. (2009). Agroforestry Database: A Tree Reference and Selection Guide Version 4.0. World Agroforestry Centre, Kenya.

Suleiman, M. S., Wasonga, V. O., Mbau, J. S., Suleiman, A., and Elhadi, Y. A. (2017). Non-timber forest products and their contribution to households' income around Falgore Game Reserve in Kano, Nigeria. *Ecological Processes*, *6*, 1-14.

Wali B. R., A. G Bello., Shamaki S. B. (2024), Forest Ownership Distinctiveness across the Globe: A Review. *African Journal of Environment and Natural Science Research* 7(3), 100- 109. DOI: 10.52589/AJENSRGN3WOOFI

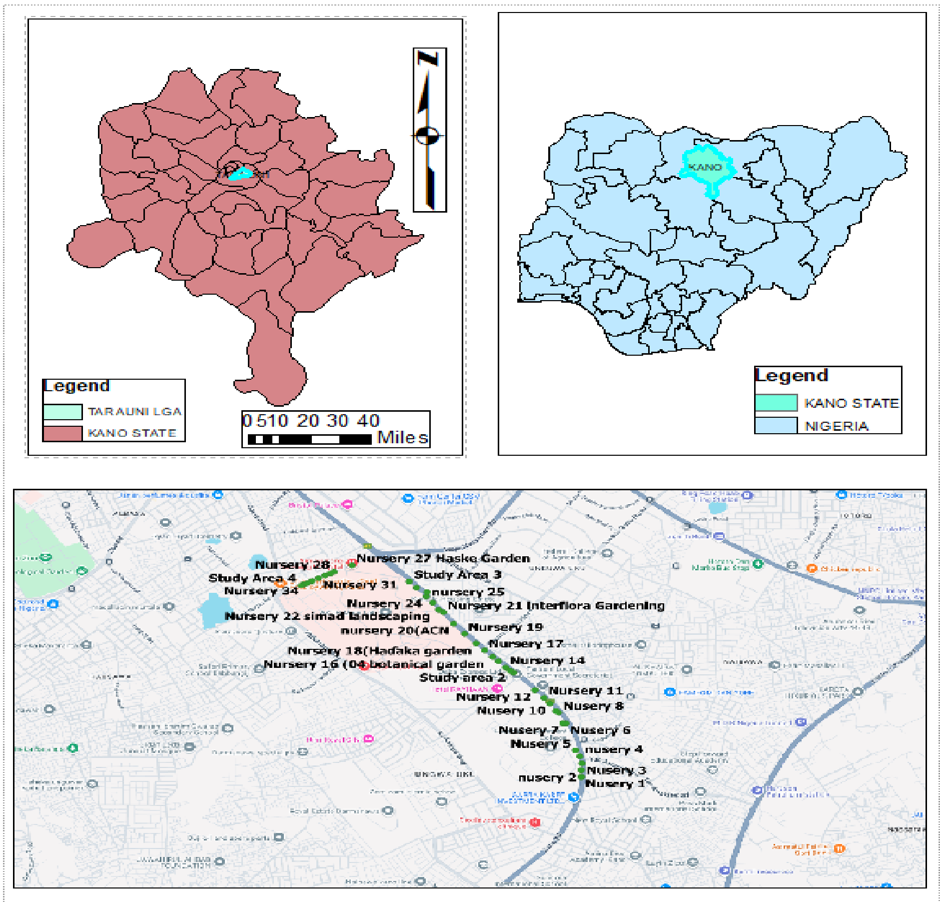

Figure 1. Map of the study area (Source; Fieldwork, 2024)

Table 1: Demographic Characteristics of Respondents

S/N	Variable	Frequency	Percentage %
	Age		
1	18-25	3	9
	26-35	9	26
	36-45	13	**38**
	>46	9	27
2	**Gender**		
	Male	34	**100**
	Female	0	0
3	**Tribe**		
	Hausa/Fulani	34	**100**
	Yoruba	0	0
	Igbo	0	0
	Other	0	0
4	**Marital Status**		
	Single	12	35
	Married	22	**65**
	Divorce	0	0
	Widowed	0	0
5	**Educational Level**		
	Non-Formal	17	**50**
	Secondary	9	27
	Tertiary	8	23
	Total	34	100
6	**Primary Occupation**		
	Civil Servant	1	3
	Business	20	**59**
	Artisan	3	9
	Student	10	29
7	**Religion**		
	Islam	33	**97**
	Christianity	1	3
8	**Years of Experience**		
	<5 Years	4	12
	6-10 Years	10	29
	11-15 Years	11	**32**
	>15 Years	9	26

Source: Fieldwork, 2024

Table 2: Nursery identification and operational information

S/N	Variable	Frequency	Percentage %
1	**CAC Registration**		
	Registered	14	41
	Not Registered	20	**59**
2	**Nursery Size (square meters)**		
	<20x20m	2	6
	20x20m	11	32
	20x30m	21	**62**
	>20x30m	0	0
3	**Employment System**		
	Full Time	5	16
	Part-Time	7	23
	Both	19	**61**
4	**Full-Time Employees**		
	<5 Persons	14	**45**
	6-10 Persons	6	19
	>10 Person	11	35
5	**Silvicultural Practice**		
	Seed Sowing	18	**53**
	Vegetative Propagation	0	0
	All of Above	16	47

Source: Fieldwork, 2024

Table 3a: Composition of Indigenous Seedlings Produced in the Surveyed Nurseries

S/N	Local Name	Common Name	*Scientific Name*	Frequency	Percentage%
1	Zogale	Moringa	*Moringa oleifera*	13	38
2	Dorawa	African locust bean	*Parkia biglobosa*	12	35
3	Aduwa	Desert date	*Balanite aegyptiaca*	12	35
4	Marke	African birch	*Anogeissus leiocarpus*	12	35
5	Dashi	African myrrh	*Commiphora africana*	11	32
6	Goruba	Doum palm	*Hyphane thebeca*	11	32
7	Durmi	Heart-leaved fig	*Ficuss polita*	9	26
8	Bagaruwa	Acacia	*Acacia nilotica*	9	26
9	Tsamiya	Tamarind	*Tamarindus indica*	8	24
10	Dabino	Date	*Phoeniex dactylifera*	8	24
11	Gawo	Apple-ring acacia	*Faidherbia albida*	8	24
12	Dakwara	Gum Arabic	*Acacia senegal*	7	21
13	Mangwaro	Mango	*Mongifera indica*	7	21
14	Baure	Sycomore tree	*Ficus sycomorus*	6	18
15	Magarya	Catch thorn	*Ziziphus abyssinica*	6	18
16	Kadanya	Shea butter	*Vitellaria paradoxa*	5	15
17	Taura	Ditax	*Ditarium senegalenses*	2	6
18	Tsada	Sea lemon	*Ximenia americana*	2	6
19	Kuka	Baobab	*Adonsonia digitata*	1	3
20	Faru	African grapes	*Lannea microcarpa*	1	3

Source: Fieldwork, 2024

Table 3b: Seedling Diversity Indices in Private Plant Nurseries

SN	Indices	Values
1	Dominance_D	0.06231
2	Brillouin	2.625
3	Shannon_H	2.847
4	Evenness_e^H/S	0.8616
5	Margalef	3.792
6	Equitability_J	0.9503
7	Fisher_alpha	6.198
8	Chao-1	20.33

Table 4: Indigenous Trees Seedling Production

S/N	Variable	Frequency	Percentage %
1	**Species Produced**		
	Indigenous Only	0	0
	Exotic Only	16	47
	Both	18	**53**
2	**Indigenous Seedlings Produced Annually**		
	<100	0	0
	100-500	4	22
	501-1000	1	6
	>1000	13	**72**
3	**Major Seed Sources**		
	Seed Bank	0	0
	Farm Lands	1	6
	Forest	4	22
	Market	8	**44**
	Forest and Market	5	28
4	**Production Knowledge**		
	Traditional	1	6
	Acquired	1	6
	Both	16	**88**
5	**Major Challenges**		
	Access to seeds	1	3
	Access to water for irrigation	18	**52**
	Low seedlings Demand	3	9
	Seeds and Marketing	7	21
	Seeds, Low Demand, and Low Profit	4	12
	Access to Water and Land	1	3
6	**Govt or NGO Support**		
	Yes	16	47
	No	18	**53**

Source: Fieldwork, 2024

EFFECT OF WEEDING REGIMES ON THE GROWTH RESPONSE OF SOME SELECTED SOYBEAN (*Glycine max* [L.] MERRILL) VARIETIES IN GUSAU NORTHERN GUINEA SAVANNAH AGROECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

A field experiment was conducted during 2020 rainy season at the Teaching and Research Farm of the Department of Agricultural Science Education, Federal College of Education (Technical), Gusau to study the performance of four soybean varieties (three improved varieties 'TGX 1448-2E', 'TGX 1904' and 'SAMSOYA 2' and one local variety '*Danbulagi*') to different weeding regimes. The experiment was a factorial combination of variety and weeding regimes in a split-plot design in a randomized complete block arrangement with three replications. The three weeding regimes (no weeding (control), one hoe weeding at 3 WAS and two hoe weeding interventions one at 3 WAS and one at 6 WAS) were allocated to main plot and four varieties of soybean to subplot. The results showed the summed dominance ration of broadleaves, grasses and sedges at the experimental site at harvest were 73.05, 23.22% and 3.73 respectively. The results also showed significant ($P<0.05$) differences among weeding regimes on canopy spread at 8 and 12 WAS, the number of branches at harvest. The varieties differ significantly on canopy spread at all sampling periods and a number of branches at 8 and 12 WAS. The results showed that weeded once produced the widest (56.45 cm and 62.75 cm) canopy spread at both 8 and 12 WAS respectively while weedy check plots and weeded twice had the highest growth reduction in all the varieties except 'TGX 1904' variety that performed similarly across the weeding regimes. SAMSOYA 2 recorded the tallest (73.44 cm) plants with more (28.94) number of leaves. TGX 1448-2E weeded once recorded the widest (64.67 cm) canopy spread. It can be concluded that weeding 'TGX 1904' and 'SAMSOYA 2' varieties once is recommended for growth improvement of the crop in the northern Guinea Savanna agro-ecological zone of Nigeria.

Keywords: Growth, weeding regime, variety

INTRODUCTION

Soybean (*Glycine max* (L.) Merril) known as Chinese beans belongs to the family Fabaceae, subfamily Faboideae, genus Glycine and subgenus Soja and is an annual *herbaceous* leguminous crop (Asiegbu and Okpara, 2002; Singh *et al*., 2003). It originated from North-eastern China and has been cultivated for the past three millennia (Simmond *et al*., 1999). Soybean is the most important grain legume crop in the world in terms of total production and international trade (Simmond *et al*., 1999). The crop has the highest protein content of 30-50% of all food crops. It is equivalent to a protein of animal products and is used to fortify various foods to improve their nutritional quality (Kwarteng and Towler, 1994; IITA, 1990). It is second only to groundnut in terms of oil content (20%) among food legumes on a dry matter basis which is 85% unsaturated and cholesterol-free (Fouilleux *et al*., 1996; Dugje *et al*., 2009).

Soybean performance is a function of crop genetic composition and environmental factors; hence both abiotic and biotic factors must be optimum. One of the most important aspects of soybean production is weed management. Uncontrolled weeds could reduced yield of soybean by up to 5% depending on the density and variety (Nathanael *et al*., 2013). Uncontrolled weeds not only reduce soybean yields through their competition for light, nutrients, and moisture, but they can also severely reduce harvest efficiency (Norris, 1999). The most effective weed management programs in soybeans uses a combination of cultural, mechanical, and chemical control strategies (Grichar *et al*., 2004). Cultural practices improved weed control by enhancing the competitive ability of the crop. Hand weeding has remained the most widely practiced cultural weed control technique in the tropics perhaps because of the fear of toxic residues and lack of knowledge about their use. It is unethical to cultivate soybeans without a weeding operation carried out from the time of sowing to harvest, or engage in daily weeding. Some farmers weed their plots twice before crop maturity, considering the cost of labor, others, three times, all to ensure optimum yield. However, the frequency and sequence of such weeding are usually at the farmer's discretion and may not be economical (Iremiren, 1988). Aggressive cultivars can be effective cultural practices for weed growth suppression (Wicks *et al*., 2004; Mennan and Zandstra, 2005). A potential method for reducing herbicide application is the development of competitive crop cultivars. Lemerle *et al*. (1996) suggested that these crop cultivars can act to increase the efficiency of partially weed suppressive like mechanical weeding or reduced-rate of herbicide applications and achieve better performance from integrated control. The competitive ability of crops can be expressed in two ways. First is the ability of the crop to compete with weeds, reducing weed seed and dry matter production. The second possibility is having crops tolerate competition from weeds while maintaining high yields. Numerous crops exhibited cultivars differences in competitive ability (Munger *et al*., 1987). The objective of the study, therefore, was to evaluate the growth performance of some varieties of soybean cultivated under different weeding regimes to ascertain which treatment or treatment combinations would suppress weed and enhances growth of soybean in this agro ecology.

MATERIALS AND METHOD

Field experiment was conducted during 2020 rainy season at the teaching and research farm of the Department of Agricultural Science Education, School of Secondary Education (Vocational), Federal College of Education (Technical), Gusau in the Northern Guinea Savanna ecological zone of Nigeria. The farm is located on latitude 12º 9' 46.25" N and longitude 6º 40' 28.22" E and at an altitude of about 495.98 m above sea level (asl). The area is characterized by moderate annual rainfall distribution and total of 1160 mm most of which fall between May and October in the year 2020 (ZADP, 2020).

Three varieties of improved soybean (TGX 1448-2E, TGX 1904 and SAMSOY 2) seeds were obtained from seed unit of (Institute for Agricultural Research, Ahmadu Bello University (IAR, ABU) Samaru, Zaria and one local variety (*Danbulagi*) from a farmer in the locality were used in this study. The experiment was a factorial combination of variety and weeding regimes in a split plot design in randomized complete block arrangement with three replications. The three weeding regimes (no weeding (control), one hoe weeding at 3 WAS and two hoe weedings at 3 WAS and one at 6 WAS) were allocated on the main plot level and four varieties of soybean (*Danbulagi*, TGX 1448-2E, TGX 1904 and SAMSOY 2) on the subplot level.

Land preparation was done by working the existing vegetation mechanically into the soil using a tractor implement plough followed by harrowing to achieve a good soil tilth. Plots measuring 2.5 m × 4.5 m (11.25 m^2) were demarcated and ridged at 75 cm inter-row spacing with 1.0 m spacing between blocks and 0.50 m spacing between plots.. The gross plot sizes were 4.5 m × 2.5 m (11.25 m^2) and net plot sizes were 2.0 × 3.0 m (6.0 m^2). Each gross plot consisted 6 ridges of 2.5 m length and 4 ridges of 2 m length as net plot In order to protect the seeds from soil borne diseases and pests, the seeds were dressed with Apron- star at the rate of 10 g of the chemical per 2.0 kg of seed before sowing. Sowing was done on 6th July 2020 at the spacing of 75 cm inter-row and 25 cm intra-rows. Six soybean seeds were sown at the depth of 3-5 cm by dibbling.

Weeding was carried out manually using a hoe according to treatments. Compound fertilizer (NPK 15:15:15) was applied uniformly at the rate of 250 kg ha^{-1} in split doses at 3 and 6 weeks after sowing by burying the fertilizer material in trenches dug at 5 cm away from the hill. Insecticide Sharp Shooter (Profenofos 40% + Cypermethrin 4% EC) was applied at the rate of 660 g a.i. ha^{-1}. Fungicide (Mancozeb) was applied at the rate of 2.5 kg a.i. ha^{-1} to curtail insect attack and disease incidence on young plants.

Data were collected on stand establishment count at 14 DAS and at harvest, summed dominance ratio, plant height (cm), number of leaves, branches $plant^{-1}$ and canopy spread at 4, 8 and 12 WAS and harvest. Five soybean hills from each net plot were randomly sampled, their height were measured from the ground level of each plant to the tip of the longest leaf at 4, 8 12 WAS and harvested using a graduated meter ruler. The number of leaves and branches were counted manually following the same interval. Canopy spread was measured through taking the dimension of the spread from the center (radius) using meter ruler.

Data were subjected to Analysis of Variance (ANOVA) using GLM procedure in SAS statistical software (SAS 2004), where significance at 0.05 probability level was observed among treatment means for the main effect they were separated using Duncan Multiple Range Test (DMRT) as described by Duncan (1955).

RESULTS AND DISCUSSION

The summed dominance ration of broadleaves, grasses and sedges at the experimental site at harvest were 73.05, 23.22% and 3.73 respectively (Figure 1).

The effect of weeding regimes, variety and interactions of weeding regime × variety on stand establishment count and canopy height in 2020 cropping seasons is presented in Table 1. The results show that there was no significant (P>0.05) effect of weeding regimes, variety and interactions of weeding regimes and variety on stand establishment count of soybeans. The effect of weeding regimes, variety and interactions of weeding regimes × variety on canopy height during 2020 cropping season is presented in Table 1.

Weeding regimes had a significant effect on the canopy height of soybean varieties at various growing stages when the plants were subjected to different weeding regimes. This implied that all the varieties responded equally to height under the various weeding regimes. This is in agreement with the work of Odeleye *et al*. (2007) where the two-soybean used did not vary in stem height under varying weeding regimes.

The results show a significant (P<0.01) variation among the varieties for canopy height at both 4 and 8 WAS and significant (P<0.05) at harvest. At 12 WAS, there was no significant (P>0.05) different effect of variety on canopy height of soybean plants. TGX 1904 recorded the tallest (33.98 cm and 85.36 cm) plants at 4 and 8 WAS respectively comparable with the other varieties at 4 WAS except TGX 1448-2E (29.29 cm) but performed differently from the other varieties at 8 WAS. At harvest, SAMSOYA 2 recorded the tallest (73.44 cm) plants comparable with the other varieties except TGX 1448-2E which recoded the shortest plants at 4, 8 and harvest respectively. This is probably due to genetic difference in the varieties in their ability to trap sunlight or nutrient absorption which promote their vegetative growth and made the plants taller. The differential performance of the varieties can be attributed to the inherent genotypic variation (Aduloju *et al*., 2009; Mudibu *et al*., 2011) among them as well as their specific responses to environmental factor like soil nutrients as witnessed in cowpea and soybean (Sanginga *et al*., 2000; Osodeke, 2001).

Table 2 shows the interaction between soybean variety and weeding regimes on canopy height at 8 and 12 WAS. The four soybean varieties responded differently to the weeding regimes on canopy. TGX 1904 weeded twice recoded the tallest (37.27 cm) plant which was at par with SAMSOYA

2 weeded twice (34.67 cm) and SAMSOYA 2 weedy check (34.20 cm). TGX 1448-2E weeded twice recorded the shortest (27.40 cm) plants which was comparable with TGX 1448-2E weedy check (27.80 cm). This indicates that the three soybean varieties responded differently to the weeding regimes in this trait. However, Odeyele *et al*. (2007) reported that interactions between variety × weeding regimes were not significant on all the parameters. Ayeni and Oyenka (1992) and Lamptey *et al*. (2015) had earlier reported that the longer the period of weed infestation the stronger the suppressive influence on the stem height of soybean. This could be likened to the pressure caused by weeds and their competition for nutrients, photosynthate, light, space and water. This is because weeds have the strength to cause a depressive effect on soybean plant height relatively.

The effect of weeding regimes, variety and interactions of weeding regimes × variety on number of leaves during 2020 cropping season is presented in Table 3. The results shows no significant (P>0.05) effect on number of leaves of soybean when the plants were subjected to different weeding regimes at all growing stages. This disagreed with that by Halford *et al*. (2001) who observed the suppressive ability of weeds on soybean vegetative characters such as the number of leaves produced by each plant.

The soybean variety has no effect on canopy spread at all sampling periods and number of branches at harvest (Table 4). Weeding regimes significantly affected canopy spread and the number of branches at harvest. Weeding two times at 3 and 6WAS, significantly supported wide canopies and the number of branches per plant at all sampling periods while weedy check was the lowest. This might be due to the presence of weeds which compete with crops for environmental resources necessary for growth reported by Akobundu (1987). Frequent weddings reduce weed growth and make the environmental resource available for crop growth. This agreed with the findings of Dugie *et al*. (2009) who reported that weeding suppresses or minimizes growth, and development.

The interaction between variety and weeding regimes on canopy spread was significant at

6 and 12 WAS.ng periods. The *Danbulagi and* TGX 1448-2E weed once significantly produced wider canopy than weeded two times and weedy check at 8WAS (Table 5). At 12 WAS, TGX 1448-2E weeded once recorded the widest (64.67 cm) canopy spread comparable with the other varieties across various weeding regime except *Danbulagi* weeded twice and weedy check, SAMSOYA 2 weedy check, TGX 1448-2E weedy twice and weedy check. TGX 1448-2E weedy check recorded the narrowest (53.33 cm) canopy spread at par with *Danbulagi* weeded twice and weedy check, SAMSOYA 2 weedy check, TGX 1448-2E weedy twice.

CONCLUSION

This study has given significant information on the effect of variety and weeding regimes on soybean growth. The results indicated that weeding regimes at various levels influenced growth parameters of soybeans, the optimum weeding regime was weeded once. Based on the results of a study it may be concluded that weeding 'TGX 1904' and 'SAMSOYA 2' varieties once is recommended for optimum soybean performance in the study area.

REFERENCES

Aduloju, M. O., J. Mahamood and Y. A. Abayomi (2009). Evaluation of soybean (*Glycine max* [L.] Merrill) genotypes for adaptability to a southern Guinea savanna environment with and without P fertilizer application in north central Nigeria. *African Journal of Agricultural Research*, 4 (6): 556-563.

Akobundu, I. O. and J. A. Poku (1987). Weed control in soybean in the tropics. In: Singh, S. R., Rachie, K. O., Dashiell, K. E. (Eds.) *Soybean for the tropics*. New York: John Wiley & Sons, 69-77.

Asiegbu, J. E. and D. A. Okpara (2002). Soybean production in marginal soils of southeastern Nigeria. In: *Proceedings of 36th Annual conference of the Agricultural Society of Nigeria*. Owerri, Nigeria, 20th-24th October, Federal University of Technology, 104-107.

Ayeni, A. O. and P. O. Oyekan (1992). Weed control in soybean (*Glycine max* [L.] Merrill) in Nigeria. *Tropical Oil Seed Journal*, 1: 43-52.

Dugje, I. Y., L. O. Omoigui, F. Ekeleme, R. Bandyopadhyay, P. Lava Kumar and A. Y. Kamara (2009). *Farmers' guide to soybean production in northern Nigeria*. Ibadan, Nigeria: International Institute of Tropical Agriculture.

Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics* 11: 142.

Fouilleux, G., C. Revellin, A. Hartman and G. Catroux (1996). Increase of *Bradyhizohium japanicum* numbers in soils and enhanced nodulation of soybeans (*Gycine max* [L] Merrill) using granular inoculants amended with nutrients. FEMS. *Microbiology Ecology*, 20: 173-183.

Grichar, W. J., B. A. Bessler and K. D. Brewer (2004). Effect of row spacing and herbicide dose on weed control and grain sorghum yield. *Crop Protection*, 23: 263-267.

Halford, C., A. S. Hamill, J. Zhang and C. Doucet (2001). Critical period of weed control in no-till soybean and corn. *Weed Technology*, 15 (4): 737-744. DOI: https://doi.org/10.1614/0890037X(2001)015[0737:CPOWCI]2.0.CO;2.

Harder, D. B., C. L. Sprague and K. A. Renner (2007). Effect of soybean row width and population on weeds, crop yield, and economic return. *Weed Technology*, 21 (3): 744-752. DOI: https://doi.org/10.1614/WT-06-122.1.

IITA (1990). International Institute of Tropical Agriculture. Annual report of the International Institute of Tropical Agriculture. Ibadan Nigeria, 45-47.

Iremiren, G. O. (1988). Frequency of weeding okra (*Abelmoschus esculentus* [L.] Moench) for optimum growth and yield. *Experimental Agriculture*, 24 (2): 247-252. DOI: https://doi.org/10.1017/S0014479700015994.

Kwarteng, J. A. and M. J. Towler (1994). *West Africa Agriculture. A textbook for schools and colleges*. Published by Macmillan Press Ltd. 144-116 pp.

Lamptey, S., S. Yeboah, K. Sakodie and A. Berdjour (2015). Growth and yield response of soybean under different weeding regimes. *Asian Journal of Agriculture and Food Sciences*, 3 (2): 155-163.

Lemerle, D., B. Verbeek and N. E. Coombes (1996). Interaction between wheat (*Triticum aestivum*) and diclofop to reduce the cost of annual ryegrass (*Lolium rigidum*) control. *Weed Science*, 44: 634-639.

Mennan, H. and B. H. Zandstra (2005). Effect of wheat (*Triticum aestivum*) cultivars and seeding rate on yield loss from *Galium aparine* (cleavers). *Crop Protection*, 24: 1061-1067.

Mudibu, J., K. K. C. Nkongolo and A. Kalonji-Mbuyi (2011). Morphovariability and agronomic characteristics of soybean accessions from the Democratic Republic of Congo (DR-Congo) gene pool. *Journal of Plant Breeding and Crop Science*, 3 (11): 260-268.

Munger, H. M., J. C. Chandler and F. M. Hons (1987). Soybean (*Glycine max*) velvetleaf (*Abutilon theophrasti*) interspecific competition. *Weed Science*, 35: 647-653.

Nangju, D. (1980). Effect of plant density, spatial arrangement, and plant type on weed control I cowpea and Soybean. In: I. O. Akobundu (Ed.), Weeds and their control in the humid and sub-humid tropic, p. 188-199. International Institute of Tropical Agriculture, Ibadan.

Nathanael, D. F., M. B. Chris and E. S. David (2013). Soybean yield loss potential associated with early-season weed competition across 64 site-years. *Weed Science Society of America*, 61 (3): 500-507. DOI: https://doi.org/10.1614/WS-D-12-00164.1.

Norris, R. F. (1999). Ecological implications of using thresholds for weed management. p. 31–58. In D. D. Buhler (Ed.) *Expanding the context of weed management. Food Products*. Press, New York. http://dx.doi.org/).

Odeleye, F. O., O. M. O. Odeleye and O. A. Dada (2007). The performance of soybean (*Glycine max* [L.] Merrill) under varying weeding regimes in south western Nigeria. *NotulaeBotanicaeHortiAgrobotanici Cluj-Napoca*, 35 (1): 27-36. DOI: https://doi.org/10.15835/nbha351247.

Osodeke, V. E. (2001) Yield performance, N2-fixation and fertilizer requirement of soybean (*Glycine max* [L.] Merrill) in some soils of the forest zone of Southeastern Nigeria. Ph.D thesis. Umudike: Department of Soil Science and Agro climatology, Michael Okpara University of Agriculture.

Sanginga, N., O. Lyasse and B. B. Singh (2000). Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. *Plant and Soil*, 220 (1/2): 119-128. DOI: https://doi.org/10.1023/A:1004785720047.

SAS (2004). *The SAS system for windows*, Version 9.4. SAS Inst. Inc., Cary, NC, USA.

Simmonds, N. W., J. Smartt, S. Millen and W. Spoor (1999). *Principles of crop improvement, 2nd edition*. Published Longman Group Ltd. Pp 252-256.

Singh, C., P. Singh and R. Singh (2003). *Modern techniques of raising field crops*. New Delhi: Oxford and IBH publishing Co. PVT Ltd.

Wicks, G. A., P. T. Nordquist, P. S. Baenziger, R. N. Klein, R. H. Hammons and J. E. Watkins (2004). Winter wheat cultivar characteristics affect annual weed suppression. *Weed Technology*, 18: 988-998.

ZADP (2020). Zamfara Agricultural Development Project, Gusau. Meteorological data unit.

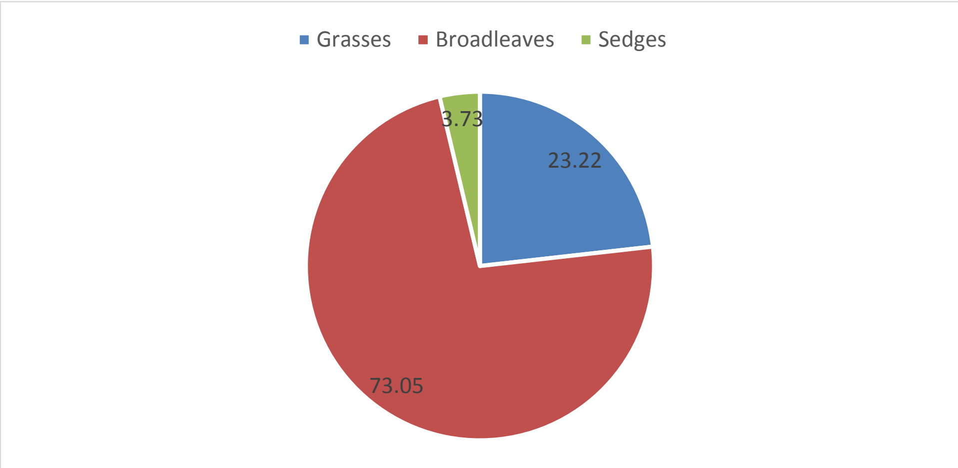

Figure 1: Relative contribution of grasses, broadleaves and sedges to the weed species composition at the experimental site during 2020 rainy season

Table 1: Effect of weeding regimes, variety and interactions of weeding regimes × variety on stand establishment count and canopy height of soybean in Gusau northern guinea savannah zone of Nigeria

Treatments	Stand establishment count (plants ha^{-1})	Canopy height (cm)			
		4 WAS	8 WAS	12 WAS	At harvest
Weeding (W)					
Weeded once	51944.40a	32.40a	71.57a	94.48a	71.73a
Weeded twice	52638.90a	33.10a	68.50a	89.07a	67.60b
Weedy check	52361.10a	31.72a	72.98a	90.87a	68.20ab
Significance level	ns	Ns	ns	Ns	Ns
SE (±)	253.575	0.796	4.405	1.489	0.997
Variety (V)					
Danbulagi	52407.40a	32.82a	66.98b	92.09ab	69.93a
TGX 1904	52222.20a	33.98a	85.36a	93.91ab	70.20a
SAMSOYA 2	52407.40a	33.53a	70.76b	95.18a	73.44a
TGX 1448-2E	52222.20a	29.29b	60.98b	84.71b	63.13b
Significance level	ns	**	**	ns	*
SE (±)	521.048	0.781	4.194	3.036059	2.172
Mean	52314.81	32.41	71.02	91.47	69.18
CV (%)	2.99	7.23	17.72	9.93	9.42
Interaction (W × V)					

Significance level	Ns	*	ns	ns	Ns
SE (±)	902.481	1.352	7.265	5.259	3.763

Means in a column for each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, ** represent significant at P≤0.05 and P≤0.01 respectively, ns = not significant at P>0.05, WAS = weeks after sowing

Table 2: Interaction effect of weeding regimes × variety on canopy height of soybean at 4 weeks after sowing in Gusau northern guinea savannah zone of Nigeria

	Weeding regimes		
Variety	Weeded once	Weeded twice	Weedy check
Danbulagi	32.40b	33.07b	33.00b
TGX 1904	32.80b	37.27a	31.87b
SAMSOYA 2	31.73b	34.67a	34.20a
TGX 1448-2E	32.67b	27.40c	27.80c
SE (±)	0.781		
LSD	4.017		

Means within row and column followed by the same letter are not significantly different at P=0.05 using least significant difference (LSD)

Table 3: Effect of weeding regimes, variety and interactions of weeding regimes × variety on number of leaves of soybean in Gusau northern guinea savannah zone of Nigeria

Treatments	4 WAS	8 WAS	12 WAS
Weeding (W)			
Weeded once	6.23a	18.55a	25.83a
Weeded twice	6.28a	18.88a	25.68a
Weedy check	6.04a	16.60a	22.62a
Significance level	ns	ns	Ns
SE (±)	0.126	1.201	2.051
Variety (V)			
Danbulagi	6.69a	18.47a	23.80b
TGX 1904	6.11ab	17.69a	22.11b
SAMSOYA 2	6.13ab	17.71a	28.94a
TGX 1448-2E	5.81b	18.18a	23.98b
Significance level	ns	ns	**
SE (±)	0.216	0.784	1.140
Mean	6.19	18.01	24.71
CV (%)	10.46	13.05	13.84
Interaction (W × V)			
Significance level	Ns	Ns	Ns
SE (±)	0.374	1.358	1.974

Means in a column for each factor followed by the same letter are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), ** represent significant at P≤0.01, ns = not significant at P>0.05, WAS = weeks after sowing

Table 4: Effect of weeding regime, variety and interactions of weeding regimes × variety on canopy spread (cm) and number of branches plant^{-1} at harvest of soybean

Treatments	4 WAS	8 WAS	12 WAS	Number of branches plant^{-1} at harvest

Weeding (W)				
Weeded once	28.98a	56.45a	62.75a	2.95a
Weeded twice	29.30a	54.90a	59.31a	2.53ab
Weedy check	27.52b	51.95b	55.13b	1.97b
Significance level	ns	*	*	*
SE (±)	0.371	0.650	0.974	0.165
Variety (V)				
Danbulagi	28.98	52.98	57.56	2.38
TGX 1904	28.38	56.44	61.27	2.44
SAMSOYA 2	28.49	55.53	59.58	2.73
TGX 1448-2E	28.56	52.78	57.86	2.38
Significance level	ns	Ns	Ns	ns
SE (±)	0.462	1.611	1.193	0.156
Mean	28.6	54.43333	59.06389	2.48
CV (%)	4.85	8.88	6.06	18.90
Interaction (W × V)				
Significance level	ns	*	*	ns
SE (±)	0.801	2.791	2.067	0.271

Means in a column for each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), * represent significant at P≤0.05, ns = not significant at P>0.05, WAS = weeks after sowing

Table 5: Interactions effect of weeding regimes × variety on canopy spread of soybean at 8 and 12 WAS in Gusau northern guinea savannah zone of Nigeria

Variety	Weeding regimes		
	Weeded once	Weeded twice	Weedy check
		8 WAS	
Danbulagi	57.73a	51.73b	49.47b
TGX 1904	51.40b	61.87a	56.07a
SAMSOYA 2	56.67a	55.93a	54.00a
TGX 1448-2E	60.00a	50.07b	48.27b
SE (±)	2.791		
LSD	8.293		
		12 WAS	
Danbulagi	64.33a	55.67b	52.67b
TGX 1904	60.47a	64.00a	59.33a
SAMSOYA 2	61.53a	62.00a	55.20b
TGX 1448-2E	64.67a	55.57b	53.33b
SE (±)	2.067		
LSD	6.141		

Means within row and column under each parameter followed by the same letter are not significantly different at P=0.05 using least significant difference (LSD)

EFFECT OF WEEDING REGIME AND BIOFERTILIZER ON PHYSIOLOGICAL CHARACTERISTICS, GROWTH AND BIOMASS YIELD OF WEEDING REGIME AEROBIC RICE

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ABSTRACT
An experiment was carried out to study the influence of weeding regime and biofertilizer on productivity, species composition of weed communities in aerobic rice under glass house conditions. It consisted of two weeding regimes (weed free and weedy check) and five biofertilizer treatments (namely: control chemical fertilizer recommended rate (CFRR) 100% (150 N; 60 P_2O_5; 60 K_2O kg ha^{-1}), biofertilizer 1 ton + 75% CFRR, biofertilizer 2 tons + 50% CFRR, biofertilizer 3 tons + 25% CFRR and biofertilizer 4 tons). Results revealed that a total of sixteen weed species were identified. Broad-leaves weeds were the most dominant (91.77%) compared to the grass (5.88%) and sedges (2.35%). Among the broad leaves, *Eleutheranthera ruderalis* (55.62%), *Phyllatus niruri* (15.48%) and *Ageratum houstonianum* (7.22%) were the most dominant. Weed biomass decreases with increase in biofertilizer while weed density increases with increase in biofertilizer. Application of biofertilizer 3 tons + 25% CFRR gave the tallest (90.92 cm) plant. The highest (3.08 mg cm^{-2}) chlorophyll-a was significantly produced from biofertilizer 2 tons + 50% CFRR while the highest (2.93, 5.47 and 6.38 mg cm^{-2}) chlorophyll-b, total chlorophyll and actual chlorophyll respectively was significantly produced from biofertilizer 3 tons + 25% CFRR. Plants in biofertilizer 4 tons gave the heaviest (1.75 g $plant^{-1}$ and 8.77 g pel^{-1}) crop biomass. These results concluded that biofertilizer 4 tons was optimum for increased plant biomass. It also increased the rice weed's competitiveness in a glasshouse under aerobic conditions and weedy environment compared to sole chemical fertilizer.
Keywords: Biofertilizers, Weeding regime, Aerobic rice

INTRODUCTION

Weed is a unique collection of plant species that can absorb and thrive in intensive disrupted habitats (Murphy and Lemerle, 2006). In the fields, weeds compete with plants for the most abundant abiotic resources that affect growth, such as nutrients, light, and water, and their presence usually results in drastic decline in crop yields and quality (Kennedy *et al*., 2011; Odero *et al*., 2011; Vollmann *et al*., 2010). Hence, farmers work hard to control weeds with herbicides to eliminate risks associated with crop production decline despite the adverse effects of weeds and the positive effects of weeds on agro ecosystems are usually ignored (Wilson *et al*., 2009). In agriculture, crop production practices such as cultivation, weed management, and fertilizer applications influence weeds growth and development (Barberi *et al*., 1997).

The availability of nutrients affects the competition of weeds with plants (Evans *et al*., 2003), but the responses differ from species of weed, crop, and soil nutrient status. Weaver *et al*. (1992) reports the availability of nutrients as a dynamic approach that can influence the duration and level of competition. As suggested by DiTomaso (1995), fertilizer controlling strategies reduce weed disturbances in crops. Changing the dose of fertilizer (Cathcart and Swanton, 2003), time of application (Blackshaw *et al*., 2004) and techniques (Mesbah and Miller, 1999) can alter the competition of weeds with the crop.

Application of fertilizer at a moderate rate (150 kg N ha^{-1}) combined with integrated weed management is proven to assist the aerobic rice system to achieve the highest grain yield, economic returns, and water productivity. Usman *et al*. (2001) recommended the use of N fertilizer in two fractions while maintaining weed free environment in crops for at least 6 weeks. This management helps in increasing the nutrient absorption of rice plants rather than weeds. Crop fertilization can indirectly affect the composition of weeds by affecting the nutrient and radiation competition between plants and weeds (Pyšek and Lepš, 1991). Differences in the ability of different plant species to compete for nutrients, and thus to respond to fertilization in terms of growth, can alter the proportion of active photosynthetic active radiation (PAR) occurring in the soil and thus the availability of light for weed communities. A stable fertilizer treatment (optimal N, P and K fertilizers for plant growth and yield) will encourage crop growth, resulting in closed crop cultivation and mild restrictions for weed communities growing below, and affecting the diversity of weed species. Suppression of weeds in the treatment of balanced fertilization through increased competition for light has been regarded as one of the most important determinants of crop yield advantage (Yin *et al*., 2006).

As ARPS is an emerging production system, information on the integrated effect of biofertilizer and weed management on aerobic rice may be helpful to achieve higher yield and to reduce production cost. The scientific information on the effect of biofertilizer and weed management on aerobic rice is limited and warrants research attention for augmenting the crop yield. It was hypothesized that weed species composition would be markedly influenced by biofertilization, reduce the growth potential of weeds, reduce their responses to nutrient availability and appropriate biofertilization patterns would be feasible to maintain a high crop yield while also maintaining a diverse weed community. The present experiment was carried out to determine the influence of weeding regimes and biofertilizer in combination with chemical fertilizer on aerobic rice productivity and species composition of weed communities in aerobic rice under glasshouse condition.

MATERIALS AND METHODS

Pot experiment was conducted in the glasshouse Field 2 of Universiti Putra Malaysia (UPM) (latitude 3^0 02'N; longitude 101^0 42' E and on the altitude of 31 m above sea level) Selangor, Malaysia during July to November 2017. Topsoil collected from Field 10 was used as the growing medium.

The experiment consisted of two weeding regimes (weed free and weedy check) and five (5) biofertilizer combinations (namrly: control chemical fertilizer recommended rate 100% (CFRR) (150 N; 60 P_2O_5; 60 K_2O kg ha^{-1}), biofertilizer 1 ton ha^{-1} + 75% CFRR, biofertilizer 2 tons ha^{-1} + 50% CFRR, biofertilizer 3 tons ha^{-1} + 25% CFRR and biofertilizer 4 tons ha^{-1} were factorially combined giving a total of 10 treatments combinations and 40 buckets that were used for this experiment. The aerobic rice genotype MR219-9 was used for this experiment. The treatments were arranged in a Randomized Complete Block Design (RCBD), in four replicates.

Buckets (diameter top and bottom 98 cm, and depth 32 cm) arranged in rows spaced 30 cm × 30 cm were used for this experiment. Topsoil collected from field 10 was pulverized, inert materials and plant debris were removed. The soil was then crushed, mixed thoroughly and air dried under the shade at field 10 prior to transportation to the glasshouse field 2. Fourteen (14) kg of the dry soil was placed in each pot. Three (3) dry treated rice seeds on each spot were directly dibbled in the bucket which was later thinned down to 1 seedling $hill^{-1}$ 14 days after sowing. The plants were spaced 15 cm × 15 cm 5 plants $bucket^{-1}$. Hand weeding was carried out regularly to keep the weed-free treatments weed free and weedy check plots were kept un-weeded throughout the crop growing period.

Prior to sowing, biofertilizer was mixed thoroughly with the soil. Compound fertilizer (NPK 15:15:15) was applied at the rate of 400 kg ha^{-1} as basal; and Urea at the rate of 196 kg ha^{-1} in two split doses by side placement at 30 and 60 DAS to supply total recommended nutrients of 150 N; 60 P_2O_5; 60 K_2O kg ha^{-1}. Both were applied according to treatments.

The biofertilizer used constituted a consortium of nitrogen fixing bacteria (*Bacillus sp.* Sb35 and 42) and phosphate solubilizing bacteria (*Bacillus sp.* PSB16). One liter of each inoculum was diluted in 4 liters of distilled water (dH_2O) + molasses in the soil microbiology laboratory (bacteria) Department of Land Management, Faculty of Agriculture, UPM. The biofertilizer was then prepared in the biofertilizer processing laboratory at glasshouse Field 2 using empty fruit bunch (EFB) and peat moss in a ratio of 1:1:1. The inocula (prepared biofertilizer) was transferred into plastic bags, sealed and stored at ambient room temperature for one month for the bacteria to multiply before application.

The rice plants were allowed to compete with the weeds up to ripening period. Watering was done 6, 4 and 2 days interval at seedling, vegetative and reproductive stages. Weeds were removed regularly during the experimental period in the weed free treatment. Pests and disease control was done as and when necessary. The crop biomass was recorded at harvest.

Data collection

At harvest, all weed species in each bucket were cut at the base, separated into categories of grasses, broadleaves and sedges and their intensity of occurrence (density in m^2 $bucket^{-1}$) was recorded. The samples were cleaned, sun-dried and then oven dried at 75^0 C for 72 hours to a constant weight. The dry weight was taken by weighing on a weighing balance. Plant height was measured from the ground level of each plant to the tip of the longest leaf/tallest panicle at 4, 8 and 12 WAS. Number of tillers were counted manually following the same inter. These were determined at harvest. One rice plant cut and washed to remove all soil particles adhering on the shoot. The samples were then brought to the laboratory for leaf area measurement using leaf area meter (MODEL: LI-3100 AREA METER, USA). After the measurement, the samples were oven dried at 70 ^{0}C for 72 hours until a constant weight was achieved and the crop biomass was recorded.

Leaf samples were collected at 80 days after sowing from each treatment. Leaf samples were collected at 70 days after sowing from each treatment. Three cm^2 fresh leaves cut using scissors were transferred into small vials containing 20 ml of 80% acetone, quickly corked airtight, covered with aluminum foil, and kept in the dark for 9 days to ensure the release of all the chlorophyll from the tissues. A 3.5 ml of the supernatant was then sampled to measure the absorbance using a scanning spectrophotometer (Model UV-3101PC, UV-VIS NIR) at 664 nm and 647 nm wave lengths. The chlorophyll content was calculated using the following formulae (Coombs *et al.*, 1987):

Chlorophyll-a (mg/cm^2) = $3.5/3(13.19A_{664}-2.57A_{647})$; Chlorophyll-b ($mg/cm^2$) = $3.5/3(22.10A_{647}-5.26A_{664})$

Total chlorophyll = 3.5 × (chlorophyll-a + chlorophyll-b)/3; Actual chlorophyll = (3.5 × Total chlorophyll)/3

Where A_{664} = Absorbance of the solution at 664 nm wave length;A_{647} = Absorbance of the solution at 647 nm wave length; 3.5 = total of chlorophyll extraction in vial; 3 = area of leaves for chlorophyll extraction; 13.19, 2.57, 22.10 and 5.26 are absorption coefficient

Photosynthesis (µmol CO_2 m^{-2} s^{-1}) and transpiration (mmol H_2O m^{-2} s^{-1}) were measured from the youngest fully expanded leaf of rice at 85 DAS using a portable photosynthesis system (LI-6400XT, LI-COR Inc. Lincoln, Nebraska, USA). Transpiration (mmol H_2O m^{-2} s^{-1}) and photosynthesis (µmol CO_2 m^{-2} s^{-1}) were measured from the youngest fully expanded leaf of rice at 75 using a portable photosynthesis system (LI-6400XT, LI-COR Inc. Lincoln, Nebraska, USA). Measurements were carried out under full sunlight and at constant CO_2 of 380 µmol CO_2 mol^{-1} in the chamber. Measurements were made in a region of one-third the distance from leaf tip. Once the leaf was within the chamber, the program commenced with a 3 min dark period. At the end of each light period, gas exchange parameters were recorded. The light-saturated rate of photosynthesis was taken as the rate at 1000 µmolm^{-2} s^{-1}.

Stems and leaves of both the crop and weeds were harvested oven dried at 70 ^{0}C for 72 hours and weighed to obtain shoot biomass.

RESULTS AND DISCUSSION

Analysis of the weed vegetation indicated a mixed weed composition spreading over in 13 families (Table 1). A total of 16 weed species were identified. The weed flora dominantly consisted of 11 kinds of broadleaves with total relative density of 90.36% and relative dry weight of 93.18%, followed by grasses 4 with total relative density of 6.06%; and then sedge 1 with a relative density of 3.58%. In terms of their relative density, about 73.83% (relative density) of the weed species were represented by 3 species all broadleaves. Based on their relative density, these 3 species were found to dominate the site. These were *Eleutheranthera ruderalis* (Swartz) Sch.-Bip., *Phyllatus niruri* L. and *Ageratum houstonianum* Mill. Compared to other species, the present *Eleutheranthera ruderalis* (Swartz) Sch.-Bip. had the highest relative density (46.42%), followed by *Phyllatus niruri* L. with a relative density (20.66%) then followed by *Ageratum houstonianum* Mill. with a relative density (6.75%). The least dominant species were also broadleaves *Physalis minima* Linn. With 0.83% relative density, *Euphorbia hirta* L. with relative density 0.69 %, *Ipomoea vagans* Baker with relative density 0.41% and *Mitracarpus villosus* (Sw.) DC. with relative density 0.41%.

Weed density was significantly ($p \le 0.05$) influenced by biofertilizer (Figure 1). Biofertilizer 4 tons significantly produced the maximum (21.63 no. m^{-2}) density while CFRR 100% significantly produced the minimum (14.13 no. bucket^{-1}) weed density at par with the 3 other biofertilizer treatments.

Weed dry weight was significantly ($p \le 0.05$) influenced by biofertilizer (Figure 1). CFRR 100% significantly produced the heaviest (26.79 g bucket^{-1}) weed dry weight while biofertilizer 4 tons significantly produced the lightest (9.15 g bucket^{-1}) weed dry weight at par with biofertilizer 3 tons + 25% CFRR.

Weeding regime, biofertilizer and interaction between weeding regime × biofertilizer had significant ($p \le 0.05$) effects on plant height (Table 2). In weeding regime, weed free significantly produced the tallest (89.37 cm) plants than the weedy check. In biofertilizer treatments, biofertilizer 3 tons + 25% CFRR significantly produced the tallest (90.88 cm) plants while the shortest (79.04 cm) plants were significantly produced from CFRR 100% at par with biofertilizer 1 ton + 75%

CFRR. The interaction effect between weeding regime × biofertilizer on plant height is presented in Table 3. Plant height was significantly influenced by biofertilizer in weedy check only. Biofertilizer 3 tons + 25% CFRR gave the highest (90.92 cm) plant height while CFRR 100% gave the lowest (71.00 cm) plant height.

Weeding regime and interaction between weeding regime × biofertilizer had significant ($p \leq .05$) effects on leaf area but the effect of biofertilizer was not significant ($p > 0.05$) (Table 6.2). Weed free significantly produced the largest (393.95 cm^2 $plant^{-1}$) leaf area than the weedy check.

The interaction effect between weeding regime × biofertilizer on leaf area is presented in Table 4. Leaf area was significantly influenced by biofertilizer in all the weeding regime treatments. In weed free treatment, CFRR 100% gave the highest (454.92 cm^2 $plant^{-1}$) leaf area, while biofertilizer 4 tons gave the lowest (337.92 cm^2 $plant^{-1}$) leaf area. In weedy check, biofertilizer 4 tons gave the highest (163.33 cm^2 $plant^{-1}$) leaf area, while biofertilizer 1 ton + 75% CFRR gave the lowest (63.26 cm^2 $plant^{-1}$) leaf area.

Weeding regime and interaction between weeding regime × biofertilizer had significant ($p \leq 0.05$) effects on both crop biomass $plant^{-1}$ and pel^{-1} but the effect of fertilizer was not significant ($p > 0.05$) (Table 2). Weed free significantly produced the heaviest (3.33 g $plant^{-1}$ and 19.17 g pel^{-1}) crop biomass $plant^{-1}$ and pel^{-1} respectively than the weedy check. The interaction effect between weeding regime × biofertilizer on crop biomass $plant^{-1}$ and pel^{-1} is presented in Table 5. Crop biomass was significantly influenced by biofertilizer in weedy check only. Plants in biofertilizer 4 tons gave the heaviest (1.75 g $plant^{-1}$ and 8.77 g pel^{-1}) crop biomass, while biofertilizer 1 ton + 75% CFRR gave the lowest (0.99 g $plant^{-1}$ and 4.09 g pel^{-1}) crop biomass at par CFRR 100%.

Weeding regime, biofertilizer and interaction between weeding regime × biofertilizer had significant ($p \leq 0.05$) effects on chlorophyll-a chlorophyll-b, total chlorophyll and actual chlorophyll (Table 6). In weeding regime treatments, weed free significantly produced the heaviest (3.48, 2.90, 6.38 and 7.44 mg cm^{-2}) chlorophyll-a, chlorophyll-b, total chlorophyll and actual chlorophyll respectively than the weedy check. In biofertilizer treatments, the heaviest (3.08 mg cm^{-2}) chlorophyll-a was significantly produced from biofertilizer 2 tons + 50% CFRR, the heaviest (2.93, 5.47 and 6.38 mg cm^{-2}) chlorophyll-b, total chlorophyll and actual chlorophyll respectively was significantly produced from biofertilizer 3 tons + 25% CFRR while the lightest (2.18 mg cm^{-2}) chlorophyll-b was significantly produced from biofertilizer 1 ton + 75% CFRR, the heaviest (2.24, 4.50 and 5.24 mg cm^{-2}) chlorophyll-a, total chlorophyll and actual chlorophyll respectively was significantly produced from CFRR 100%. The interaction effect between weeding regime × biofertilizer on chlorophyll-a, chlorophyll-b, total chlorophyll and actual chlorophyll is presented in Table 7. Chlorophyll-a, chlorophyll-b, total chlorophyll and actual chlorophyll was significantly influenced by biofertilizer in weedy check only. Biofertilizer 2 tons + 50% CFRR gave the highest and the least (2.46 and 1.06 mg cm^2) chlorophyll-a and chlorophyll-b while biofertilizer 1 ton + 75% CFRR gave the least (1.06, 2.47 and 2.89 mg cm^2) chlorophyll-a, total chlorophyll and actual chlorophyll respectively. Biofertilizer 3 tons + 25% CFRR gave the highest (3.06, 4.80 and 5.60 mg cm^2) chlorophyll-b, total chlorophyll and actual chlorophyll respectively.

Weeding regime, biofertilizer and interaction between weeding regime × biofertilizer had significant ($p \leq 0.05$) effects on photosynthesis and transpiration rate (Table 6). In weeding regime treatments, weed free significantly produced the highest (18.13 µmol CO_2 m^{-2} s^{-1} and 5.24 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively than the weedy check. In biofertilizer treatments, the highest (17.15 µmol CO_2 m^{-2} s^{-1} and 5.62 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate was significantly produced from CFRR 100% and biofertilizer 2 tons + 50% CFRR respectively, while the lowest (15.74 µmol CO_2 m^{-2} s^{-1} and 3.94 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively was significantly produced from biofertilizer 4 tons ha^{-1} different from the other biofertilizer treatments.

The interaction effect between weeding regime × fertilizer on photosynthesis and transpiration rate is presented in Table 8. Photosynthesis and transpiration rate were was significantly influenced by biofertilizer in all weeding regime treatments. In weed free treatment, CFRR 100% gave the highest (19.93 µmol CO_2 m^{-2} $s^{-1}$and 6.08 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively, while biofertilizer 1 ton + 75% CFRR and biofertilizer 4 tons gave the least (15.46 µmol CO_2 m^{-2} $s^{-1}$and 5.04 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively. In weedy check treatment, biofertilizer 2 tons + 50% CFRR gave the highest (16.91 µmol CO_2 m^{-2} $s^{-1}$and 5.62 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively, while biofertilizer 4 tons and CFRR 100% gave the least (11.73 µmol CO_2 m^{-2} $s^{-1}$and 3.41 mmol H_2O m^{-2} s^{-1}) photosynthesis and transpiration rate respectively.

DISCUSSION

Weed species observed in the glasshouse varied. Broadleaves were dominant where *Eleutheranthera ruderalis* (Swartz) Sch.-Bip., *Phyllatus niruri* L. and *Ageratum houstonianum* Mill. showed more than 78.32% of the SDR. Contrary to what was reported by Sunyob *et al*. (2015) that about 75.84% of the total weed community in glasshouse was grassy. In aerobic rice, the high weed pressure can be associated with soil dry-tillage as well as alternating wet and dry condition at the time of crop growth that were favourable for the weeds' sprouting and development (Elliot *et al*., 1984; Fujisaka *et al*., 1993; Rao *et al*., 2007).

Emergence and growth of weeds were found to be influenced by biofertilizer. Maximum weed population and decreased in weed biomass were obtained with the application of biofertilizer 4 tons in comparison to application of chemical fertilizer alone or combination of chemical fertilizer and biofertilizer. This might be due to a high number of nitrogen fixing bacteria which help in trapping the moisture and nutrients from the soils. Ghosh *et al*. (2016) reported that application of biofertilizer had neither positive nor negative outcome on the total weed population. Blackshaw (2005) studied that fresh manures and compost release nitrogen slowly that benefits the weeds more than crop plant, therefore more weeds are present in fields where manures and compost are applied. Weed seed bank was highest in fresh manures followed by broadcasted nitrogen fertilizer and then banded nitrogen fertilizers. Maintenance of crop residues or addition of nitrogen influences the weed seed mortality. That may be due to indirect action, alteration in seed germination patterns and seed fate (more germination, less mortality) or by direct stimulatory or inhibitory action of microbial predators of weed seeds (Davis, 2007). Some studies elucidated that composted manure may reduce weed seed bank in soil (Menalled *et al*., 2009). Furthermore, compost limits weed growth by releasing phytotoxic substances in the immediate environment of weed seeds (Ozores-Hampton *et al*., 1999), as well reduces weed seed bank and competitive ability.

Plants in a weed-free situation were taller, produced larger leaf area, took more days to flowering and produced higher biomass than plants in weedy condition. The possible reason might be that intensive weeds and rice plants competitions probably caused somewhat short rice plants, narrow leaf area, fewer days to flowered and matured; and lighter biomass in the weedy situation than in weed-less conditions. Weeds usually absorb mineral nutrients faster than many crop plants and accumulate them in their tissues in relatively larger amounts. Similarly, sole and integrated application of biofertilizer with chemical fertilizer led to a significant increase in plant height. Plants in biofertilizer 3 tons + 25% CFRR were taller and took lesser days to flowering than those in CFRR 100% and biofertilizer 1 ton + 75% CFRR. The positive effects of biofertilizers on improving crop growth might be due to increase in nitrogenase activity and synthesis of growth-promoting substances by phosphate solubilizing (PS) and N fixing bacteria. Phosphorus solubilizing bacteria play a strong role in phosphorus nutrition by enhancing its availability to plants through release from inorganic and organic soil P pools through solubilization and mineralization processes (De *et al*., 2012). Alnoaim and Hamad (2004) reported that biofertilizers along with chemical N fertilizer (180 $kg.ha^{-1}$) application, the highest plant height, number of tillers and grain yield of rice (*Oryza sativa*) were achieved. Tan *et al*. (2012) also reported liquid biofertilizer containing rhizobia and PGPR increased rice vigor and growth.

Weeds significantly influenced chlorophyll contents, leaf photosynthesis rate and transpiration rate, plants in weed free conditions recorded the highest values than the plants in weedy check. Increasing integration of biofertilizer with chemical fertilizer increased chlorophyll content. Increased in chlorophyll content might be due to higher availability of nitrogen to the growing tissue and organs supplied by nitrogen fixing *Azotobacter species* (Chandrasekhar *et al*., 2005), which also produced growth promoting substances resulting in more efficient absorption of nutrients through photosynthetic pigments and consequently the chlorophyll content increased (Hassan, 2009). The positive effect of N supply on the formation of chloroplasts during leaf growth also enhances chlorophyll content of leaves (Singh *et al*., 2014). CFRR 100% and biofertilizer 2 tons + 50% CFRR seemed to be more effective than the other fertilizer treatments in increasing photosynthesis and transpiration rate. This can be attributed to the larger surface area for light interception by plants on these treatments. Mondal *et al*. (2015) reported that greater light interception by the NPK (75% of full dose) + vermicompost (2.5 ton ha^{-1}) treated plants leads toward a higher rate of photosynthesis or photosynthetic rate which contributed significantly toward the vegetative growth of crop plants of B9 variety leading to higher LAI value.

CONCLUSION

This study has shown that lesser weeds dry weights with comparatively greater accumulation of dry matter recorded in biofertilizer 4 tons showed the rice plants in this treatment had greater weeds' competitiveness and toleration capability. The results of this study, therefore, conclude that biofertilizer 4 tons was optimum for the growth characters studied and increased in plants weed's competitiveness and toleration capability as compared to sole chemical fertilizer.

REFERENCES

Barberi, P., Silvestri, N., & Bonari, E. (1997). Weed communities of winter wheat as influenced by input level and rotation. *Weed Res*, *37*, 301–313.

Blackshaw, R. E. (2005). Nitrogen fertilizer, manure and compost effects on weed growth and competition with spring weed. *Agron. J*, *97*, 1612–1621.

Blackshaw, R. E., Molnar, L. J., & Janzen, H. H. (2004). Nitrogen fertilizer timing and application method affect weed growth and competition with spring wheat. *Weed Sci.*, *52*, 614–622.

Cathcart, R. J., & Swanton, C. J. (2003). Nitrogen management will influence threshold values of green foxtail (Setaria viridis) in corn. *Weed Sci*, *51*, 975–986.

Chandrasekhar, B. R., Ambrose, G., & Jayabalan, N. (2005).). Influence of biofertilizer and nitrogen source level on the growth and yield of *Echinochloa frumentacea* (Roxb.) Link. *J. Agric. Technol.*, *1*, 223–234.

Coombs, J., Hall, D. O., Long, S. P., & Scurlock, S. M. O. (1987). *Chlorophyll determination. Techniques in bioproductivity and photosynthesis*. Oxford: Pergamon Press.

Davis, A. S. (2007). Nitrogen fertilizer and crop residue effects on seed mortality & germination of eight annual weed species. *Weed Sci.*, *55*, 123–128.

De, T., Sarkar, T., De, M., Maity, T., Mukherjee, A., & Das, S. (2012). Abundance and occurrence of phosphate solubilizing bacteria and phosphatase in the sediment of Hooghly estuary, north

east coast of bay Bengal. *India. J Coastal Develop*, *13*(1), 9–16.
DiTomaso, J. M. (1995). Approaches for improving crop competitiveness through the manipulation of fertilization strategies. *Weed Sci.*, *43*, 491–497.
Elliot, P. C., Navarez, D. C., Estario, D. B., & Moody, K. (1984). Determining suitable weed control practices for dry-seeded rice. *Philipp. J. Weed Sci*, *11*, 70–82.
Evans, S. P., Knezevic, S. Z., Shapiro, C., & Lindquist, J. L. (2003). Nitrogen level affects critical period for weed control in corn. *Weed Sci.*, *51*, 408–417.
Fujisaka, S., Moody, K., & Ingram, K. T. (1993). A descriptive study of farming practices for dry seeded rainfed lowland rice in India, Indonesia, and Myanmar. *Agric. Ecosyst. Environ*, *45*, 115–128.
Ghosh, S., Malik, G. C., & Mahua, B. (2016). Weed management and biofertilizer effects on productivity of transplanted rice. *Ind. J. Weed Sci.*, *48*(2), 148–151
Hassan, F. (2009). Response of *Hibiscus sabdariffa* L. plant to some biofertilizer treatments. *Ann. Agric. Sci. Ain Shans Univ. Cairo*, *54*, 437–446.
Kennedy, K. J., Boyd, N. S., Nams, V. O., & Olson, A. R. (2011). The impacts of fertilizer and hexazinone on sheep sorrel (*Rumex acetosella*) growth patterns in lowbush blueberry fields. *Weed Sci*, *59*, 335–340.
Menalled, F. D., Buhler, D. D., & Liebman, M. (2009). Composted swine manure effects on germination and early growth of crop and weed species under greenhouse conditions. *Weed Technol*, *19*(4), 784–789.
Mesbah, A. O., & Miller, S. D. (1999). Fertilizer placement affects jointed goatgrass (*Aegilops cylindrica*) competition in winter wheat (*Triticum aestivum* L.). *Weed Technol*, *13*, 374–377.
Mondal, T., Datta, J. K., & Mondal, N. K. (2015). Chemical fertilizer in conjunction with biofertilizer and vermicompost induced changes in morpho-physiological and bio-chemical traits of the mustard crop. *J. Saudi Soc. Agric. Sci*, *xxx*, xxx–xxx.
Murphy, C., & Lemerle, D. (2006). Continuous cropping systems and weed selection. *Euphytica*, *148*, 61–73.
Odero, D. C., Mesbah, A. O., Miller, S. D., & Kniss, A. R. (2011). Interference of redstem filaree (*Erodium cicutarium*) in sugarbeet. *Weed Sci*, *59*, 310–313.
Ozores-Hampton, M., Stoffella, P. J., Bewick, T. A., Cantliffe, D. J., & Obreza, T. A. (1999). Effect of age of composted MSW and biosolids on weed seed germination. *Compost Sci. Util.*, *7*, 51–57.
Pyšek, P., & Lepš, J. (1991). Response of a weed community to nitrogen fertilization: a multivariate analysis. *J. Veg Sci*, *2*, 237–244.
Rao, A. N., Johnson, D. E., Sivaprasad, B., Ladha, J. K., & Mortimer, A. M. (2007). Weed management in direct-seeded rice. *Adv. Agron*, *93*,153–257.
Singh, M., Khan, M. M. A., & Naeem, M. (2014). Effect of nitrogen on growth, nutrient assimilation, essential oil content, yield and quality attributes in Zingiber officinale Rosc. *J. Saudi Soc. Agric. Sci*. Retrieved from http://dx.doi.org/10.1016/j.jssas.
Sunyob, N. B., Juraimi, A. S., Hakim, M. A., Azmi, M., Selamat, A., & Amirul, A. (2015). Competitive Ability of some Selected Rice Varieties against Weed under Aerobic Condition. *Int. J. Agric. Biol*., 61–70.
Tan, K. Z., Shamsuddin, Z. H., Radziah, O., Halimi, M. S., & Abdul Rahim, K. B. (2012). Development and application of liquid biofertilizer inoculums for increased rice vigor and growth. In *International Agriculture Congress 2012*. Marriot Putrajaya.
Usman, A., Elemo, K., Bala, A., & Umar, A. (2001). Effect of weed interference and nitrogen on yields of a maize/rice intercrop. *Int. J. Pest Manag*, *47*, 241–246.
Vollmann, J., Wagentristl, H., & Hartl, W. (2010). The effects of simulated weed pressure on early maturity soybeans. *Eur. J. Agron*, *32*, 243–248.
Wilson, R. S., Hooker, N., Tucker, M., LeJeune, J., & Doohan, D. (2009). Targeting the farmer

decision-making process: a pathway to increased adoption of integrated weed management. *Crop Prot*, *28*, 756–764.

Yin, L. C., Cai, Z. C., & Zhong, W. H. (2006). Changes in weed community diversity of maize crops due to long-term fertilization. *Crop Prot*, *25*, 910–914.

Table 1: Weed species relative density, relative dry weight and summed dominance ratio at the UPM glass house field 2 at Universiti Putra Malaysia

Scientific names of weed species	Family	Relative density
Grasses		
*Digitaria horizontalis*Willd.	Poaceae	1.10
Eleusine indica (L) Gaertn	Poaceae	2.07
Paspalum scrobiculatum L.	Poaceae	1.24
Seteria barbata (Lam.) Kunth	Poaceae	1.65
Broad leaves		
Ageratum houstonianum Mill.	Asteraceae	6.75
Cleome rutidosperma DC.	Cleomaceae	1.65
Eleutheranthera ruderalis (Swartz) Sch.-Bip.	Asteraceae	46.42
Euphorbia hirta L.	Euphorbiaceae	0.69
Ipomoea vagans Baker	Convolvulaceae	0.41
Jussiaea linifolia Vahl	Onagraceae	4.68
Lindernia dubia (L.) Pennell	Linderniaceae	3.44
Mimosa pudica L.	Fabaceae	4.41
Mitracarpus villosus (Sw.) DC.	Rubiaceae	0.41
Phyllatus niruri L.	Phyllathaceae	20.66
Physalis minima Linn.	Solanaceae	0.83
Sedges		
Cyperus iria L.	Cyperaceae	3.58

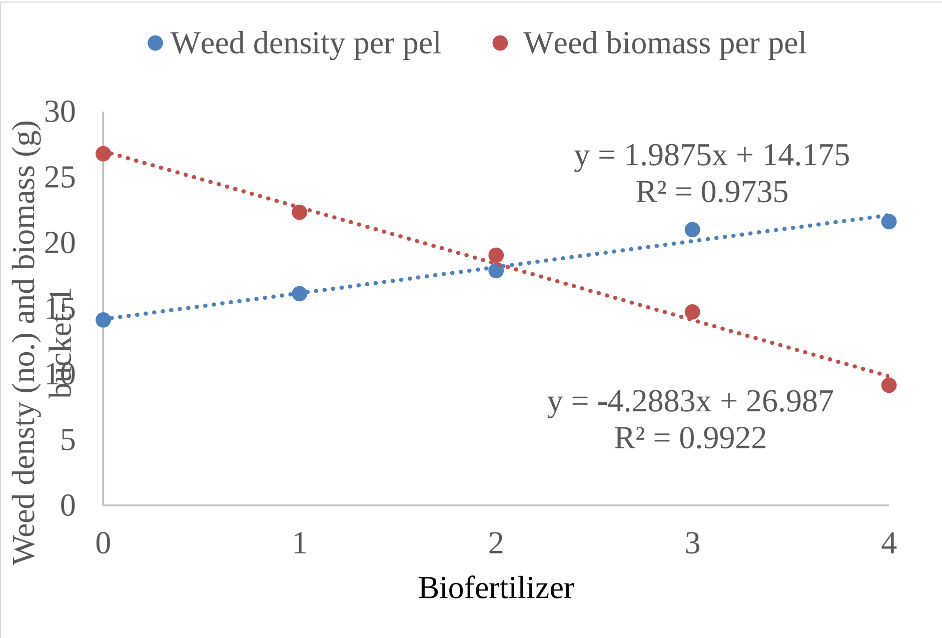

Figure 1: Weed density (blue) and weed dry weight (red) as influenced by biofertilizer at the UPM glass house field 2 Universiti Putra Malaysia.

Table 2: Plant height at harvest, leaf area, days to flowering, crop biomass of aerobic rice as influenced by weeding regime and biofertilizer and their interactions Universiti Putra Malaysia

Treatment	Plant height at harvest (cm)	Leaf area at harvest (cm^2 $plant^{-1}$)	Crop biomass (g $plant^{-1}$)	Crop biomass (g $bucket^{-1}$)
Weeding regime (W)				
Weed free	89.37a	393.95a	3.83a	19.17a
Weedy check	81.63b	108.93b	1.38b	6.90b
Biofertilizer (ha^{-1}) (B)				
CFRR 100%	79.04c	269.62a	2.63a	13.10a
Biofertilizer 1 ton + 75% CFRR	81.23bc	238.84a	2.51a	12.56a
Biofertilizer 2 tons + 50% CFRR	86.88ab	260.65a	2.51a	12.54a
Biofertilizer 3 tons + 25% CFRR	90.88a	237.44a	2.72a	13.58a
Biofertilizer 4 tons	89.46a	250.62a	2.68a	13.40a
Significance level				
W	***	***	***	***
B	**	ns	Ns	Ns
W × B	*	**	**	**
Mean	85.4958	251.437	2.61	13.0375
CV	7.63569	21.4729	17.41	17.4078
SE				
W	1.4597493	12.072721	0.10149	0.50748
B	2.3080663	19.088648	0.16048	0.80240
W × B	3.2640987	26.995425	0.22695	1.13477

Means in a column for each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, DAS = days after sowing

Table 3: Plant height of aerobic rice at harvest (cm) as influenced by interaction between weeding regime × biofertilizer at Universiti Putra Malaysia

Biofertilizer (ha^{-1})	Weed free	Weedy check
CFRR 100%	87.08a	71.00b
Biofertilizer 1 ton + 75% CFRR	89.25a	73.21b
Biofertilizer 2 tons + 50% CFRR	91.00a	82.75ab
Biofertilizer 3 tons + 25% CFRR	90.83a	90.92a
Biofertilizer 4 tons	88.67a	90.25a

Means in a column followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), CFRR = chemical fertilizer recommended rate

Table 4: leaf area of aerobic rice at harvest (cm^2 $plant^{-1}$) as influenced by interaction between weeding regime × biofertilizer at Universiti Putra Malaysia

Biofertilizer (ha^{-1})	Weed free	Weedy check
CFRR 100%	454.92a	84.33bc
Biofertilizer 1 ton + 75% CFRR	414.43ab	63.26c
Biofertilizer 2 tons + 50% CFRR	413.31ab	108.00abc
Biofertilizer 3 tons + 25% CFRR	349.17ab	125.71ab
Biofertilizer 4 tons	337.92b	163.33a

Means in a column followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), CFRR = chemical fertilizer recommended rate

Table 5: Crop biomass $plant^{-1}$ and $bucket^{-1}$ (g) of aerobic rice as influenced by interaction between weeding regime × biofertilizer at Universiti Putra Malaysia

Biofertilizer (ha^{-1})	Crop biomass $plant^{-1}$		Crop biomass pel^{-1}	
	Weed free	Weedy check	Weed free	Weedy check
CFRR 100%	4.23a	1.01b	21.167a	5.04b
Biofertilizer 1 ton + 75% CFRR	4.03a	0.99b	20.173a	4.09b
Biofertilizer 2 tons + 50% CFRR	3.61a	1.41a	18.03a	7.06a
Biofertilizer 3 tons + 25% CFRR	3.70a	1.74a	18.48a	8.69a
Biofertilizer 4 tons	3.60a	1.75a	18.02a	8.77a

Means in a column followed by the same letter are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), CFRR = chemical fertilizer recommended rate

Table 6: Chlorophyll-a, chlorophyll-b, total chlorophyll, actual chlorophyll, photosynthesis, transpiration rate of aerobic rice as influenced by weeding regime and biofertilizer and their interactions at Universiti Putra Malaysia

Treatments	Chlorophyll-a (mg cm^{-2})	Chlorophyll-b (mg cm^{-2})	Total chlorophyll (mg cm^{-2})	Actual chlorophyll (mg cm^{-2})	Photosynthesis (µmol CO_2 m^{-2} s^{-1})	Transpiration rate (mmol H_2O m^{-2} s^{-1})
Weeding regime (W)						
Weed free	3.48a	2.90a	6.38a	7.44a	18.13a	5.24a
Weedy check	1.68b	1.85b	3.53b	4.12b	14.88b	4.20b
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	2.24c	2.25c	4.50c	5.24c	17.15a	4.74c
Biofertilizer 1 ton + 75% CFRR	2.40bc	2.18c	4.57c	5.34c	15.67b	4.24d
Biofertilizer 2 tons + 50% CFRR	3.08a	2.02d	5.10b	5.95b	16.85a	5.62a
Biofertilizer 3 tons + 25% CFRR	2.54b	2.93a	5.47a	6.38a	17.12a	5.06b
Biofertilizer 4 tons	2.62b	2.50b	5.12b	6.00b	15.74b	3.94e
Significance level						
W	***	***	***	***	***	***
B	***	***	***	***	***	***
W × B	***	***	***	***	***	***
Mean	2.58	2.38	4.95	5.78	16.51	4.72
CV	8.25	6.26	6.12	5.78	2.95	5.19
SE						
W	0.04749957	0.03329155	0.06778026	0.07907696	0.10891	0.05483
B	0.07510342	0.05263856	0.10716999	0.12503166	0.1722	0.08669
W × B	0.10621227	0.07444217	0.15156126	0.17682147	0.24353	0.1226

Means in a column for each factor followed by the same letter are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *** represent significant at P≤0.001, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate

Table 7: Chlorophyll-a, chlorophyll-b, total chlorophyll, actual chlorophyll, photosynthesis and transpiration of aerobic rice as influenced by interaction between weeding regime × biofertilizer at Universiti Putra Malaysia

Treatment	Chlorophyll-a (g cm^{-2})	Chlorophyll-b (g cm^{-2})	Total chlorophyll (g cm^{-2})	Actual chlorophyll (g cm^{-2})
Weed free				
BF0	3.35a	3.00a	6.35a	7.41a
BF1	3.73a	2.95a	6.68a	7.80a
BF2	3.70a	2.98a	6.68a	7.80a
BF3	3.34a	2.79a	6.13a	7.15a
BF4	3.26a	2.77a	6.03a	7.03a
Weedy check				
BF0	1.14d	1.50c	2.64d	3.08d
BF1	1.06d	1.41c	2.47d	2.89d
BF2	2.46a	1.06d	3.52c	4.10c
BF3	1.74c	3.06a	4.80a	5.60a
BF4	1.98b	2.24b	4.22b	4.93b

Means in a column for each biofertilizer followed by the same letter are not significantly different at P=0.05 using Duncan's multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate

Table 8: Photosynthesis (µmol CO_2 m^{-2} s^{-1}) and transpiration (mmol H_2O m^{-2} s^{-1}) as influenced by interaction between weeding regime × biofertilizer

Biofertilizer (ha^{-1})	Photosynthesis (µmol CO_2 m^{-2} s^{-1})		Transpiration rate (mmol H_2O m^{-2} s^{-1})	
	Weed free	Weedy check	Weed free	Weedy check
CFRR 100%	19.93a	14.37d	6.08a	3.41d
Biofertilizer 1 ton + 75% CFRR	15.46d	15.89b	4.33d	4.15c
Biofertilizer 2 tons + 50% CFRR	16.80c	16.91a	5.63b	5.62a
Biofertilizer 3 tons + 25% CFRR	18.73b	15.50c	5.13c	4.99b
Biofertilizer 4 tons	19.75a	11.73e	5.04c	2.84e

Means in a column followed by the same letter are not significantly different at 5P=0.05 using Duncan's new multiple range test (DNMRT), CFRR = chemical fertilizer recommended rate

ECOLOGICAL EFFECTS ON THE GROWTH OF CASTOR (*Ricinus communis* L.) AS INFLUENCED BY FERTILIZATION AND INTRA-ROW SPACING

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ABSTRACT

Field trials were conducted during two successive rainy seasons of 2019 and 2020 at two locations. The locations were the Teaching and Research Farm of the Faculty of Agriculture, Bayero University Kano (BUK) in Sudan savannah zone of Nigeria and the Research Field of the National Cereals Research Institute, Badeggi in southern guinea savannah zone of Nigeria. The study evaluated the effects of two primary (N and P) and one secondary mineral element (S) and intra-row spacing on the growth and development of Castor (*Ricinus communis* L.). The treatments consisted of factorial combinations of N, P and S at three levels of each (0, 15 and 30 kg ha^{-1}) and three intra-row spacings of 0.50, 0.75 and 1.0 m. The experiment was laid out in Split-split plot design replicated three times. N was assigned to the main plot, factorial combination of P and intra-row spacing were assigned to sub plots and S was allocated to Sub-sub plots. Data was collected on plant height, number of leaves, and number of branches, leaf area index, crop growth rate, and days to 50% flowering. The data collected was subjected to analysis of variance (ANOVA) using Statistics Analysis System (SAS). Means were separated using Students-Newman-Keuls (SNK) test at 5% level of probability. The results showed that application rate of N, P, and S at 30 kg ha^{-1}, contributed to the highest mean plant height, number of leaves, and number of branches, leaf area index, crop growth rate and days to 50 % flowering at Badeggi and BUK during the two successive seasons. The tallest plant and highest crop growth rate of castor were obtained with the N application rate of 30 kg ha $^{-1}$and narrow spacing of 0.5 m. The results from this study indicated that increase in growth characters of castor plant could be achieved with the application of N, P and S at the rate of 30 kg ha^{-1} and intra-row spacing of 0.75 m in these ecologies.
Key words: Ecological, Effects, Growth, Castor, Application, Fertilizer, Spacing

INTRODUCTION

Castor bean (*Ricinus communis* L.) is an important non-edible oilseed crop belonging to the family Euphorbiaceae, known for its oil-rich seeds containing hydroxyl fatty acid. It has been cultivated for thousands of years and is believed to have originated in Ethiopia due to its high diversity (Anjani, 2012). Castor was domesticated in various tropical and subtropical regions, including ancient Egypt where it was used in lamps and found in ancient tombs. Currently, India is the largest producer of castor, accounting for approximately 90% of global production, followed by China, Myanmar, Vietnam, Indonesia, Cambodia, Pakistan, Thailand, Bangladesh, and the

Philippines (Molly Moore, 2020). The economic significance of castor is evident, with predictions that its oil and derivatives could contribute a significant amount, up to USD 1.81 billion, to the world economy (James, 2016). In Nigeria, the economic viability of castor has also been highlighted, with potential contributions of up to 25 billion Naira to the country's economy (Ibeagha and Onwualu, 2015). The revival of industrial crops, including castor, has caught the attention of the Nigerian government, leading to a focus on diversifying the economy and increasing the GDP (Salihu *et al*., 2013a). However, despite its economic potential and environmental benefits, castor has yet to be fully utilized as a valuable resource (Malik *et al*., 2018). To unlock its full potential, scientists, farmers, and the government must work tirelessly to achieve higher yields and develop cost-effective technologies for castor production (Cesar and Batalha, 2010). Exploiting Nigeria's agricultural potential, including the production of castor for food and feed, is crucial for achieving economic balance in the country (Cesar and Batalha, 2010). Castor mostly grows wildly in Nigeria but is currently produced in small holdings of one to four hectares per farmer with mean yield of 500 – 600kg ha^{-1} annually (Denovan and Landsberge, 1999). Production hectarage was estimated about 6,000 ha^{-1} and the major producing States are Cross River, Ebonyi, Niger, Kwara and Kogi (Field Survey, 2009). More states were identified to be major castor producers in Nigeria during Germ Plasm collection (Salihu *et al*., 2022b)

MATERIALS AND METHODS

The trials were conducted for two years during the raining seasons of 2019 and 2020 at two locations; Faculty of Agriculture, teaching and research field Bayero University Kano, located at $11^{0}58^{0}$N 8^{0},25E and 457m above sea level in the Sudan Savanna Zone of Nigeria which is characterized by two seasons the wet season (June-October) and the dry season (November-May) with annual rainfall of 800-1000 mm (FFD, 2012) and National Cereals Research Institute Badeggi Niger State located at 9^{0},45N and 06^{0}'07'E and 70m above sea level in the Southern Guinea Savanna Agro-Ecological Zone of Nigeria (FDALR 1985) with rainy season lasts for about 180-210 days. The area has an average annual rainfall of 1100-1124mm unevenly distributed. The mean temperature is 23-33 ^{0}C (Gana, 2014). The mean annual potential monthly relative humidity is about 40% (Ojanuga, 2006).

Treatments and Experimental Design

The treatment consisted of a factorial combination of three levels of Nitrogen (0, 15 and 30 kg ha^{-1}), phosphorus (0, 15 and 30 kg ha^{-1}) and Sulfur (0, 15 and 30 kg ha^{-1}), and three intra-row spacing

(0.50, 0.75, and 1 m). The treatments were laid in a split-split plot, design with nitrogen allocated to the main plots, combination of phosphorus and intra-row spacing allocated to sub plots while Sulphur was allocated to sub-sub plots.

Data collection

Soil samples were collected randomly from twelve (12) points from each of the sites and 6 composite samples were made from each of the fields (location I and II). The soil samples were collected from the depth of 0-30 cm using a soil auger, bulked, dried and processed. The samples were analyzed for determination physic-chemical properties using standard procedures as described by Black (1965). Data were further collected on plant height, number of branches per plant and days to 50% flowering using standard agronomic procedures. The data collected were subjected to analysis of variance (ANOVA) using Statistics Analysis System (SAS) 9.1 version and means were separated using Students-Newman-Keuls (SNK) at 5% level of probability.

RESULTS AND DISCUSSION

The results of the physicochemical properties of soils at the experimental sites showed that BUK had sandy loam soil, while Badeggi had sandy soil (Table 1). Both sites had low nutrients and cation exchange capacity (CEC), which is typical of savanna soils due to intensive land use and inherent parent materials (Dudal, 2002). The soil pH was satisfactory, with BUK averaging 6.4 and Badeggi 5.8, aligning with Samson (2012). Organic carbon and total nitrogen were higher at BUK than at Badeggi, while available phosphorus, effective CEC, and potassium levels were low at both sites, indicating below-critical fertility levels.

Significant differences were observed in plant height between treatments at Badeggi and Kano during the 2019 (Table 2) and 2020 (Table 3) rainy seasons. BUK recorded taller castor plants with the application of nitrogen, phosphorus, and sulfur (N, P, and S), with higher fertilizer dosages producing taller plants, consistent with Shinde *et al.* (2018). Taller plants were observed at wider spacing (1 m) compared to closer spacing (0.5 and 0.75 m), contrasting Shinde *et al.* (2018). The number of branches per plant also increased with higher fertilizer rates, agreeing with Umesha *et al.* (2019). Fertilizer rates significantly affected the leaf area index and number of leaves (Table 4), with increased nitrogen leading to larger leaf areas, as reported by Araujo *et al.* (2009). This relationship between leaf area and photosynthesis is crucial for plant development.

The relative growth rate of castor plants was significantly influenced by location, fertilizer types, and application rates, with BUK showing a higher relative growth rate than Badeggi under all fertilizer treatments. Among the fertilizers, nitrogen application resulted in the highest relative growth rate, aligning with findings by Antonio *et al.* (2020) that nitrogen is crucial for plant metabolism, as it contributes to the formation of proteins and hormones essential for growth (Mengel & Kirkby, 2000). Consequently, higher nitrogen doses positively impacted plant height, stem diameter, number of leaves, and leaf area, optimizing biochemical processes like photosynthesis (Marschner, 2002). Additionally, the days to maturity of castor plants decreased with higher doses of nitrogen, phosphorus, and sulfur across both locations and seasons. Notably, sulfur application at 30 kg ha^{-1} reduced the number of days to flowering (Table 5), thereby shortening the overall time to maturity.

REFERENCES

Anjani, A.K., Mamza, P.A.P., Ahmed, A.S. and Agunwa, U. (2012). Extraction and characterization of castor seed oil from wild *Ricinus communis* Linn. *International Journal of Science, Environment and Technology,* 4(5):1392-1404.

Antonio R. Cavalcante1, Washington B. de Lima1, Lucia H. G. Chaves1, Josely D. Fernandes1, Felipe G. de Souza1 & Simone A. Silva (2020) Mineral fertilization with macronutrients in castor bean, lineage UFRB 222 *Revista Brasileira de Engenharia Agrícola e Ambiental* v.24, n.2, p.106-114,

Araujo, D. L. de; Chaves, L. H. G.; Mesquita, E. F. de; França, C. P. (2009) Crescimento da mamoneira cultivar BRS-149 Nordestina adubada com nitrogênio, fósforo e potássio. Engenharia Ambiental: Pesquisa e Tecnologia, v.6, p.685-702

Black, C. A (1965). *Methods of Soil Analysis. Part 1*, American society of agronomy, Madison, Wisconsin, USA 1572p.

Cesar, A.S. and Batalha, M.O. (2010). Biodiesel production from castor oil in Brazil, a different reality. *Energy Policy*, 38:4031-4039. Doi:http:/x.doi.org10.108ijempol 2010.0 3027

Dudal, R. (2002). Forty years of soil fertility work in sub-Saharan Africal. In: Valauwe, B.; Dield, J.; Sanginga, N.; Merckx, R.(eds). Integral plant nutrient management in sub-Saharan Africa: from concept to practice. CAB International, Wallimgford, UK, pp 7-21

Federal Department of Agricultural Land Resources (FDALR) (1985). The Reconnaissance soil survey of Imo State, Nigerian (1: 250,000). Soils report 133PP.

FFD (2012). Fertilizer Use and Management Practices for Crops in Nigeria (4th Edition). Abuja, Nigeria: Federal Ministry of Agriculture and Rural Development.

Field Survey (2009). Collection of Castor germ plasm by National cereal's research Institute, Badeggi

Gana, A.K. (2014). Soil amendment agent for the Sandy Upland Sugarcane ecology in Nigeria. *Journal of Agricultural Technology*, 7(2): 497-505.

James, S. (2016). Castor oil and derivatives market trend growth research and analysis to 2020. http://www.linkedin.com/pulse/castor-oil-derivatives-market-trend-growth-research-anaiysis-james. Accessed 18 Apr 2016.

Malik, M.Y., Muhammad, M.R., Muhammad, Z. and Kazim, A. (2018). Yield Response of Castor (*Ricinus commnnis* L.) to NPK fertilizers under Arid climatic conditions. *Pakistan Journal of Agricultural Research*. Doi,10.17582/journal.pjar/2018/31.21.80. 185

Marschner, H. (2002) Mineral nutrition of higher plants. San Diego: Academic Press, 889p.

Molly, R.T., Kuo, C.C. and Yoon, J.Y. (2020). Breeding and Seed Production of Root crops in the Tropics and Subtropics. Technical Bulletin 17, AVRDC, 97.

Ojanuga, A.G (2006). Agroecological zones of Nigerian Manual. National Special Programme for Food Security. Food and Agriculture Organization of United Nation (FAO), 124-230.

Salihu, B. Z., Gana, A. and Apuyor, B. (2013a). Castor oil plant *(Ricinus communis L.):* botany, ecology and uses. *International Journal of Scientific Research* (Ahmedabad, India), 3(5): 1334-1341.

Samson Foli (2012) Farm characterizations in the southern and northern Guinea savannah zones of Nigeria MSc thesis Plant Production Systems Wageningen University

Table 1: Physical and Chemical Properties of Soils of the Experimental Sites at Bayero University, Kano and Badeggi During the 2019 and 2020Rainy Seasons.

	BUK		Badeggi	
	2019	2020	2019	2020
Physical Properties (g kg^{-1})				
Sand	607.4	617.1	921.3	921.8
Silt	257.0	234.8	24.8	34.9
Clay	135.6	148.1	53.9	43.3
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy
Chemical properties				
pH (H_2O)	6.4	6.0	5.84	5.75
pH ($CaCl_2$)	6.0	5.8	5.44	5.43
Organic carbon (g kg^{-1})	4.68	4.57	1.26	1.30
Total nitrogen (g kg^{-1})	2.45	2.16	0.15	0.14
Available phosphorus (mg kg^{-1})	17.10	16.40	26.22	22.45
Exchangeable bases (Cmol kg^{-1})				
Ca	4.88	4.72	8.84	8.90
Mg	0.41	0.80	4.46	4.53
K	0.12	0.13	1.89	1.85
Na	0.07	0.13	0.23	0.22
C.E.C.	5.48	5.78	15.42	15.50

Table 2: Effect of Nitrogen, Phosphorus, Sulphur and Intra-row Spacing on Plant Height (cm) of Castor Plant at Badeggi and BUK During the 2019 Rainy Season.

Treatment	Badeggi				BUK			
	Weeks After Sowing (WAS)							
	4	8	12	16	4	8	12	16
Nitrogen (kg N ha^{-1})								
0	16.96	39.26	64.46	99.25	17.21	41.09	46.6	87.1
15	17.97	39.58	66.54	97.45	17.36	38.11	49.3	88.7
30	18.14	42.44	67.04	98.69	17.64	39.21	58.8	89.8
SE±	0.019	0.011	0.013	0.010	0.028	0.008	0.031	0.009
P-value	0.2021	0.0511	0.1041	0.1419	0.5035	0.0670	0.067	0.2214
Phosphorus (kg P ha^{-1})								
0	17.87	39.08b	63.49c	98.51ab	17.45	39.56	376b	83.2
15	17.86	40.99a	65.77b	96.88b	17.77	40.51	370b	88.9
30	17.35	41.21a	68.37a	100.00a	16.99	38.38	380a	89.9
SE±	0.019	0.011	0.012	0.010	0.028	0.008	0.013	0.009
P-value	0.2501	0.0003	0.0001	0.0002	0.1522	0.2965	0.0001	0.2214
Sulphur (kg S ha^{1})								
0	16.28c	32.08c	58.30c	86.89c	17.38c	34.18c	52.78c	96.56
15	17.73b	40.99b	66.45b	96.25b	17.64b	38.18b	63.88b	108.20
30	19.07a	48.21a	72.89a	112.24a	19.61a	46.23a	74.63a	132.90
SE±	0.002	0.001	0.002	0.001	0.016	0.004	0.008	0.006
P-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.9076
Intr-Spacing (m)								
0.5	17.72	39.83	65.28	98.50	16.72b	39.50	37.3	81.6
0.75	17.47	40.50	65.89	98.53	17.44a	38.75	38.2	82.0
1.0	17.89	40.96	66.47	98.36	18.07a	40.20	39.0	85.7
SE±	0.022	0.013	0.015	0.011	0.005	0.002	0.003	0.002
P-value	0.4837	0.2601	0.2002	0.9833	0.0042	0.2011	0.1553	0.0798
Interactions								
N x P	0.2055	0.1091	0.1060	0.2150	0.1354	0.1955	0.0004 **	0.0002 **
N x S	0.1618	0.1602	0..3053	0.2216	0.2132	0.1022	0.1727	0.2012
P x S	0.1022	0.2013	0.1523	0.1032	0.1180	0.2030	0.0003 **	0.1010
N x Intr-Sp	0.1030	0.1623	0.3019	0.1090	0.1028	0.1915	0.0004 **	0.0001 **
P xIntr-Sp	0.2511	0.4011	0.2308	0.1051	0.1321	0.1543	0.0002 **	0.2404
S x Intr-Sp	0.3010	0.2324	0.1052	0.2010	0.1035	0.2208	0.6781	0.2023
N x P x Intr-Sp	0.1612	0.1044	0.1146	0.1185	0.2234	0.2562	0.0003 **	0.1213
N x P xS x Intr-Sp	0.1001	0.2014	0.2146	0.2144	0.3151	0.2001	0.2518	0.2522

Means with the same letter are not significantly different at 5% level of Probability using SNK. NS= Not significant, **=Significant at 1%.

Table 3: Effect of Nitrogen, Phosphorus, Sulphur and Intra-row Spacing on Plant Height (cm) of Castor Plant at Badeggi and Kano in 2020 Rainy Season

Treatment	Badeggi				Kano			
	Weeks After Sowing (WAS)							
	4	8	12	16	4	8	12	16
Nitrogen (kg N ha^{-1})								
0	15.96b	40.40	65.31	97.06	15.41c	40.94c	63.08	96.50
15	17.19a	40.57	65.63	98.17	15.64b	42.36b	63.64	96.82
30	17.43a	40.83	65.64	98.28	15.95a	43.72a	63.88	97.52
SE±	0.029	0.011	0.013	0.011	0.056	0.019	0.014	0.012
P-value	0.0002	0.1900	0.2856	0.4090	0.0001	0.0001	0.2884	0.1859
Phosphorus (kg P ha^{-1})								
0	16.56	40.22	64.83	98.14a	15.63	42.18	63.40	96.33
15	16.84	40.58	65.69	96.47b	15.64	42.34	63.51	96.56
30	17.18	41.04	66.06	98.89a	15.75	42.51	63.62	96.95
SE±	0.024	0.013	0.015	0.012	0.073	0.024	0.019	0.016
P-value	0.2475	0.3146	0.2679	0.0003	0.2971	0.5596	0.2507	0.3942
Sulphur (kg S ha^{-1})								
0	14.04c	32.57c	56.87c	85.49c	10.81c	30.52c	50.78c	78.69c
15	17.19b	40.97b	66.33b	96.67b	16.06b	43.44b	65.13b	96.87b
30	19.36a	48.29a	73.39a	11.35a	20.14a	53.07a	74.69a	115.28a
SE±	0.004	0.002	0.002	0.002	0.006	0.002	0.002	0.012
P-value	0.0001	0.0001	0.0001	0.0001	.0.0001	0.0001	0.0001	0.0001
Intr- Spacing (m)								
0.5	16.59	39.71	65.89	98.45	15.64	42.27	63.12b	96.62
0.75	16.64	41.34	64.99	98.69	15.67	42.53	63.05b	96.91
1.0	17.35	40.80	65.70	98.35	15.69	42.23	64.42a	97.31
SE±	0.024	0.013	0.015	0.012	0.068	0.023	0.018	0.029
P-value	0.1760	0.1365	0.4780	0.1492	0.8535	0.5805	0.0003	0.4793
Interactions								
N x P	0.1523	0.1765	0.1049	0.1370	0.1234	0.4735	0.1735	0.2836
N x S	0.2819	0..1372	0.1832	0.2074	0.0003**	0.1734	0.1734	0.2967
P x S	0.1033	0.1632	0.3565	0.1623	0.2645	0.1382	0.1382	0.3815
N x Intr-Sp	0.1012	0.1052	0.2123	0.2051	0.0002**	0.0002**	0.2620	0.0005**
P xIntr-Sp	0.1103	0.2272	0.1756	0.1539	0.4856	0.0003**	0.0001**	0.4358
S x Intr-Sp	0.1023	0.3958	0.1234	0.1070	0.5232	0.1615	0.1615	0.1045
N x P x Intr-Sp	0.3118	0.2345	0.3520	0.3052	0.7145	0.0001**	0.4813	0.1465
N x P xS x Intr-Sp	0.1015	0.3325	0.1134	0.1410	0.5367	0.2845	0.2845	0.1602

Means with the same letter are not significantly different at 5% level of Probability using SNK.
NS= Not significant **=Significant at 1

Table 4: Effect of Nitrogen, Phosphorus, Sulphur and Intra-row spacing on Number of Branches of Castor Plant at Badeggi and BUK During the 2019 Rainy Season.

Treatment	Badeggi			BUK		
	Weeks After Sowing			Weeks After Sowing		
	8	12	16	8	12	16
Nitrogen (kg N ha^{-1})						
0	5.65	7.58	8.20b	13.33	10.73b?	59.11
15	5.63	7.58	8.42b	13.42	10.95a	59.80
30	5.63	7.58	9.38a	13.75	11.25a	62.47
SE±	0.012	0.092	0.050	0.042	0.002	0.064
P-value	0.3836	0.5653	0.0037	0.5993	0.0001	0.1596
Phosphorus (kg P ha^{-1})						
0	5.62	7.48	8.63	13.17	10.78b	59.37
15	5.63	7.63	8.67	13.35	11.05a	60.71
30	5.67	7.63	8.70	13.98	11.10a	61.34
SE±	0.069	0.091	0.049	0.042	0.102	0.064
P-value	0.2681	0.1047	0.2823	0.3847	0.0001	0.3359
Sulphur (kg S ha^{-1})						
0	4.24c	5.42c	6.71c	9.85	8.98c	60.47
15	5.77b	7.63b	8.64b	13.50	10.58b	59.72
30	6.91a	9.69a	10.64a	17.23	13.43a	61.24
SE±	0.013	0.011	0.006	0.025	0.061	0.038
P-value	0.0001	0.0001	0.0001	0.2367	0.0001	0.3379
Intr-Sp (m)						
0.5	5.65	5.51	8.58	12.83	10.90	59.17
0.75	5.75	5.65	8.64	13.43	10.98	59.90
1.0	5.81	5.75	8.78	14.25	11.05	62.31
SE±	0.058	0.108	0.130	0.008	0.019	0.012
P-value	0.1001	0.4679	0.3955	0.1731	0.2339	0.2522
Interactions						
N x P	0.3743	0.0443	0.1702	0-.2715	0.2345	0.9680
N x S	0.0754	0.0126	0.6513	0.2512	0.5542	0.3822
P x S	0.1013	0.1887	0.3581	0.1243	0.3907	0.7248
N x Intr-Sp	0.1235	0.1217	0.1051	0.1603	0.2019	0.2203
P xIntr-Sp	0.4017	0.7765	0.2915	0.4910	0.1618	0. 6061
S x Intr-Sp	0.3012	0.1620	0.2265	0.3111	0.6011	0.5951
N x P x Intr-Sp	0.3042	0.3273	0.8665	0.2976	0.1315	2.2842
N x P xS x Intr-Sp	0.1490	0.1932	0.2229	0.2212	0.2323	0.2415

Means with the same letter are not significantly different at 5% level of Probability using SNK
NS= Not significant.

Table 5: Effect of Nitrogen, Phosphorus, Sulphur and Intra-row Spacing on Days to 50% flowering at Badeggi and BUK During the 2019 and 2020 Rainy Seasons.

	Badeggi		Kano	
Treatment	2019	2020	2019	2020
Nitrogen (kg N ha^{-1})				
0	73.70	73.63	109.23	73.74
15	74.16	74.31	110.19	73.94
30	74.16	74.47	110.51	74.70
SE±	0.007	0.007	0.007	0.005
P-value	0.9391	0.5750	0.4244	0.7804
Phosphorus (kg P ha^{-1})				
0	69.54b	70.68	108.66	72.75
15	75.37a	75.38	110.13	74.79
30	77.10a	76.17	110.16	74.84
SE±	0.007	0.008	0.007	0.007
P-value	0.0001	0.0601	0.2684	0.2525
Sulphur (kg S ha^{-1})				
0	68.26c	67.60c	109.21	71.45ab
15	73.48b	73.92b	109.72	73.00b
30	80.28a	80.90a	109.98	77.92a
SE±	0.001	0.003	0.004	0.001
P-value	0.0001	0.0001	0.5491	0.0001
Intr-Sp (m)				
0.5	71.95	71.67c	108.85	73.31
0.75	74.98	73.44b	109.91	74.07
1.0	75.00	77.30a	110.15	74.99
SE±	0.008	0.008	0.001	0.006
P-value	0.0617	0.0001	0.5344	0.5003
Interactions				
N x P	0.2369	0.2540	0.2511	0.2291
N x S	0.1491	0.2951	0.1406	0.1324
P x S	0.1826	028.97	0.1335	0.1689
N x Intr-Sp	0.1261	0.1216	0.2311	0.1142
P xIntr-Sp	0.1730	0.1109	0.2517	0.1613
S x Intr-Sp	0.2394	0.1735	0.2055	0.1346
N x P x Intr-Sp	0.1809	0.2223	0.1039	0.2054
N x P xS x Intr-Sp	0.1987	0.1296	0.1229	0.1758

Means with the same letter are not significantly different at 5% level of Probability, SNK. NS= Not significant.

RESPONSE OF GROWTH PARAMETERS OF MAIZE (*Zea mays* L.) TO RABBIT COMPOST TEA AND NPK FERTILIZER

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ABSTRACT

This study evaluates the response of growth parameters of maize (*Zea mays* L.) to rabbit compost tea and NPK (15-15-15) fertilizer at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti. The treatments were laid out in a randomized *c*omplete block design (RCBD) with three replicates. Each replicate consisted of four (4) treatments. The treatments and application rate were the control, rabbit compost tea at 400 l ha^{-1}, a combination of NPK at 100 kg ha^{-1} and rabbit compost tea at 200 l ha^{-1}, and the application of NPK (15-15-15) fertilizer at the rate of 200 kg ha^{-1}. In the experiment, growth parameters of maize (*Zea mays* L.) were monitored and evaluated. Findings showed that the application of rabbit compost tea and NPK (15-15-15) fertilizer significantly ($p < 0.05$) increased the plant height, stem girth, number of leaves, and leaf area when compared with the control, especially when combined. According to this study, rabbit compost tea is an effective and sustainable organic amendment that smallholder maize farmers should consider using to improve growth and output.

Keywords: Rabbit compost tea, NPK fertilizer, growth parameters, maize, and effect.

INTRODUCTION

Worldwide, maize, sometimes known as corn, is a crop that is cultivated in large quantities. According to Badu-Apraku & Fakorede (2017), maize (*Zea mays* L.) is a member of the grass family. Around the world, maize is a major grain crop that is planted in both temperate and tropical regions with a range of soil types and climates. But to have the best yields, maize needs careful fertility management because it uses a lot of nutrients. One excellent, nutrient-packed fertilizer that has numerous nutrients for crop growth is rabbit manure (also known as rabbit poop or pellets) (Adi *et al.*, 2020). Adi et al. (2020) found out that rabbit manure contains high levels of nitrogen. Applying rabbit manure straight to plants is safe and will not burn them (Ame, 2021). In terms of nutrients, rabbit manure is twice as rich as chicken manure and four times richer than cow or horse manure (Ame, 2021). Rabbit manure is considered “cold” manure; that is, it can be added directly to plants immediately after collecting from the rabbit hutch without burning the splants.

Rabbit compost tea is a natural, organic fertilizer made from rabbit manure. It is a rich source of nutrients, such as nitrogen, phosphorus, and potassium. Other minerals contained in rabbit manure, including calcium, sulphur, magnesium, and other micronutrients, are also abundant. Compost tea is a nutrient-rich solution obtained by fermenting compost in water to extract soluble organic matter, beneficial microorganisms, and nutrients (Ramírez-Gottfried *et al.*, 2023). Little or no attention has been drawn to the use of rabbit compost tea for the growth of crops. However, this study will help to evaluate the effects of rabbit compost tea and compare the combined use of rabbit compost tea and NPK fertilizer on the growth parameters of maize.

MATERIAL AND METHODS

Description of Experimental Site and Land Preparation

The research work was conducted at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti, Nigeria. At an elevation of roughly 542 meters, this study region is situated between latitude 15^o 39' N and longitude 70^o 12' E. It is located in the southwest of Nigeria, in a rainforest agroecological zone. The experimental field was harrowed and cleared mechanically. After completion, the experimental layout was divided into plots and blocks.

Source of Material

An improved maize hybrid (Ife Hybrid-5) was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan station.

Preparation of Rabbit Compost Tea

The rabbit compost tea was prepared by adding 5 kg of rabbit pellet to 20 liters of water, and it was placed under the sun for four days with an enclosed lid. The mixture was stirred twice a day. Finally, the liquid strained from the mixture was known as compost tea, and it was sprayed onto the foliar part of the maize plants.

Experimental Design

Each treatment was replicated three times over the ten-week trial, which was set up using a randomized complete block design (RCBD). There were four (4) treatments in each replicate. With 12 plots measuring 2 m by 3 m (6 m^2) and 1 m of alleyways separating the plots and replicates, the total land area was 88 m^2 (11 m by 8 m).

Planting and Cultural Practices

In an experimental field that had already been set up, the maize (*Zea mays* L.) seeds were manually planted with a spacing of 75 cm x 45 cm (29,630 plants/ha). Hand-pulling and hoeing were the manual methods used to control weeds.

Treatment Application

NPK fertilizer was applied by side placement, while rabbit compost tea application was achieved by foliar spray. The treatments were split into two levels of applications, as illustrated in Table 1.

Agronomic Data Collection

Plant height was measured with the use of the meter rule (cm), and the number of leaves was determined by counting the leaves. At ten weeks after planting, stem girth was measured via vernier caliper (cm), and leaf area (cm^2) was calculated (Elings, 2000).

Leaf Area = Leaf length x maximum leaf width x 0.75 ---------eqn. 1

Data Analysis

The data obtained on the growth parameters were statistically analyzed through analysis of variance. Data were analyzed using the Statistical Tool for Agricultural Research (STAR) and Tukey's HSD test was used to compare the treatment means.

RESULTS AND DISCUSSION

Figure 1 shows rabbit compost tea has a high N content of 4.2%. However, NPK fertilizer had a K content of 14.88%, which was far greater than rabbit compost tea. The highest P level was found in NPK fertilizer, with 14.80%. Rabbit compost tea had a 1.75% P content. Calcium and magnesium were the other elements that were analyzed. Rabbit compost tea contained the highest Ca and Mg content of 1.60 and 1.40 mg/kg, respectively.

Throughout the maize growing period, all treatments produced significantly higher plant heights than the control (Table 2). NPK had the tallest plants (26.33) at four weeks after planting (WAP), with rabbit compost tea coming in second (25.50). The combination of rabbit compost tea (RCT) at 200 l/ha and NPK fertilizer at 100 kg/ha could reasonably compete with NPK fertilizer on maize height at five weeks after planting. However, from eight weeks after planting until the end of the research project, the combination of NPK fertilizer at 100 kg/ha and rabbit compost tea at 200 l/ha produced the tallest plants, whereas the control had the shortest plants during the whole growth period of maize in this study.

Table 3 shows that the number of leaves was significantly ($p < 0.05$) enhanced by both the NPK fertilizer and the combination of NPK and RCT fertilizer used as treatments. Throughout the field study, the rabbit compost tea treatment produced more leaves than the control. The NPK and NPK plus RCT fertilizer treatments did not differ significantly ($p > 0.05$).

In Table 4, all the treatments significantly ($p < 0.05$) increased the maize leaf area when compared with the control at 10 WAP. There are no significant differences ($p > 0.05$) among the rest of the treatments, but there were variations in leaf area in their response to treatments at 10 WAP, with values of 406.00, 396.75, and 409.00, respectively, for the NPK fertilizer, RCT, and NPK plus RCT. **As** measured at 10 WAP, there were significant ($p < 0.05$) differences in stem girth among the treatments. The combined application of NPK and RCT manifested the highest stem girth. The application of NPK and RCT to maize resulted in a significant increase in stem girth, indicating that RCT is a great source of mineral nutrients required for plant growth.

This study has been able to show that compost tea obtained from rabbit pellets or manure contains a considerable amount of macro- and micronutrients. The use of rabbit compost tea as a fertilizer makes nutrients and beneficial microorganisms available for maize plant growth. The results of this study showed that rabbit compost tea, which is prepared under anaerobic condition, contains soluble nutrients and beneficial microorganisms that interact to fight phytopathogenic organisms and promote the growth of maize plant.

CONCLUSION AND RECOMMENDATION

This study demonstrated the benefits of using rabbit compost tea as a fertilizer for cultivating maize. The pattern of maize growth in this study infers that rabbit compost tea could compete positively with inorganic fertilizers. Preferably, the combination of rabbit compost tea at 200 l/ha and 100 kg/ha of NPK performed better when compared with the use of 200 kg/ha of NPK. Rabbit compost tea is an effective and sustainable organic amendment that smallholder maize farmers should consider using to improve growth and output.

REFERENCES

Adi, I. P. T. S., Yuliartini, M. S., & Udayana, I. G. B. (2020). Effect of rabbit compost and NPK on the growth and yield of Zucchini (Cucurbita pepo L.). *SEAS (Sustainable Environment Agricultural Science)*, *4*(2), 151-156. https://doi.org/10.22225/seas.4.2.2624.151-156

Ame, V. (2021). How to use rabbit poop as fertilizer. Available from: https://www.morningchores.com/rabbit-fertilizer/

Badu-Apraku, B., & Fakorede, M. A. B. (2017). Morphology and physiology of maize. *Advances in genetic enhancement of early and extra-early maize for sub-Saharan Africa*, 33-53. https://doi.org/10.1007/978-3-319-64852-1_3

Elings, A. (2000). Estimation of leaf area in tropical maize. *Agronomy Journal*, *92*(3), 436-444. https://doi.org/10.2134/agronj2000.923436x

Ramírez-Gottfried, R. I., Preciado-Rangel, P., Carrillo, M. G., García, A. B., González-Rodríguez, G., & Espinosa-Palomeque, B. (2023). Compost Tea as Organic Fertilizer and Plant Disease Control: Bibliometric Analysis. *Agronomy*, *13*(9), 2340. https://doi.org/10.3390/agronomy13092340

Table 1: List of treatment combinations

Acronym	Treatment description
T_1	0 RCT + 0 NPK
T_2	100 kg ha^{-1} of NPK applied at 2 WAP + 100 kg ha^{-1} of NPK applied at 4 WAP
T_3	200 l ha^{-1} of RCT applied at 2 WAP + 200 l ha^{-1} of RCT applied at 4 WAP
T_4	200 l ha^{-1} of RCT applied at 2 WAP + 100 kg ha^{-1} of NPK applied at 4 WAP

RCT = Rabbit Compost Tea, WAP = Weeks after Planting
T_1 = Control, T_2 = NPK (15-15-15) fertilizer at 200 kg ha^{-1}, T_3 = Rabbit compost tea at 400 l ha^{-1} T_4 = NPK (15-15-15) fertilizer at 100 kg ha^{-1} plus rabbit compost tea at 200 l ha^{-1}.

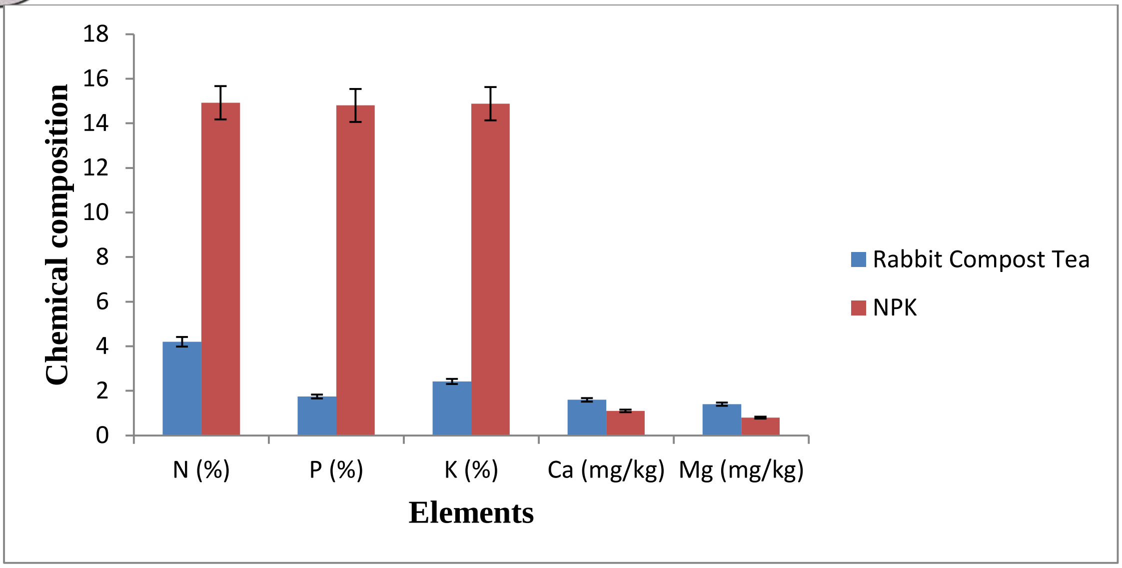

Figure 1: Chemical composition of rabbit compost tea and NPK (15-15-15) fertilizer

Table 2: Effect of rabbit compost tea and NPK fertilizer on plant height at different stages of maize growth

Treatments	Plant height (cm)							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	14.67a	18.83c	23.27c	34.67c	47.80c	58.63c	60.03c	60.33c
NPK (15-15-15)	14.83a	26.33a	37.87a	54.53a	69.27a	74.00b	79.20ab	79.66ab
Rabbit compost tea (RCT)	13.13a	25.50ab	32.50b	48.57b	61.77b	71.37b	75.67b	76.17b
NPK + RCT	13.03a	20.93bc	35.26ab	54.07a	71.33a	81.63a	83.07a	83.30a
S.D	1.668	4.238	7.432	9.295	11.877	9.692	10.308	10.331
SEM	0.482	1.224	2.145	2.683	3.428	2.798	2.976	2.982

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test. S.D = Standard Deviation, SEM= Standard Error of the Mean

Table 3: Effect of rabbit compost tea and NPK fertilizer on the number of leaves at different stages of maize growth

Treatments	Number of leaves							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	6.67bc	9.00b	9.00b	11.00b	11.67c	12.33c	13.00c	12.67c
NPK (15-15-15)	7.67a	10.33a	11.67a	13.00a	14.00ab	15.33a	15.67a	15.67a
Rabbit compost tea (RCT)	6.00c	9.67ab	11.00a	12.67a	13.3b	14.00b	14.33b	14.33b
NPK + RCT	7.00ab	9.33b	11.33a	12.33a	14.33a	15.67a	16.00a	15.67a
S.D	0.835	0.792	1.215	0.866	1.231	1.435	1.288	1.379
SEM	0.241	0.229	0.351	0.251	0.355	0.414	0.372	0.398

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 4: Effect of rabbit compost tea and NPK fertilizer on leaf area and stem girth of maize

Treatment	Leaf area (cm^2)	Stem girth (cm)
	10 Weeks after planting	
Control		
Mean ± SEM	305.00 ± 28.645^b	1.63 ± 0.057^d
Mean ± S.D	305.00 ± 49.615^b	1.63 ± 0.098^d
NPK (15-15-15)		
Mean ± SEM	406.25 ± 30.973^a	2.05 ± 0.038^b
Mean ± S.D	406.25 ± 53.646^a	2.05 ± 0.066^b
Rabbit compost tea (RCT)		
Mean ± SEM	396.75 ± 17.250^a	1.86 ± 0.059^c
Mean ± S.D	396.75 ± 29.878^a	1.86 ± 0.102^c
NPK + RCT		
Mean ± SEM	409.00 ± 22.426^a	2.12 ± 0.045^a
Mean ± S.D	409.00 ± 38.843^a	2.12 ± 0.078^a

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test

IN VITRO ANTIOXIDANT SCREENING OF DIFFERENT MAIZE VARIETIES

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ABSTRACT

The extracts of different maize varieties SAMMAZ 18, SAMMAZ 24, SAMMAZ 52, SAMMAZ 55 and SAMMAZ 66 were screened for *in vitro* antioxidant activities. The antioxidant capacity were assessed via *in vitro* assay models which include 2, 2-diphenyl-1-picryalhydrazil (DPPH) radical scavenging assay using ascorbic acid as standard. Total antioxidant capacity and as well as total phenolic content which was determine using ammonium molybdate method, while total phenolic content was determine according to folin-Ciocalteu's method. The results showed that, among the five tested maize extract varieties, SAMMAZ55 exhibit a significant (P>0.05) DPPH scavenging activity followed by SAMMAZ24 with the value of 27.81±1.4 and 20.62±0.5 respectively at concentration of 0.5mg/ml. Total antioxidant capacity was found to be higher in SAMMAZ55 with the value of 0.651±0.04 at concentration of 500µg/ml while SAMMAZ 66 shows the least total antioxidant capacity with the value of 0.506±0.012 also at concentration of 500µg/ml. the results of the total phenolic content shows that SAMMAZ 55 exhibit the highest total phenolic content (26.16±0.56mg/TAE extract) while SAMMAZ18 has the least total phenolic content(18.80±0.59mg/TAE extract). This indicate that the antioxidant potentials observed can be attributed to the presence of polyphenolic compounds present in the extracts. The results of the present work demonstrated the presence of phenolic content and antioxidant properties of the maize varieties which can serve as good natural antioxidant agents.

Key words: Antioxidants, DPPH, SAMMAZ, oxidative stress

INTRODUCTION

Free radicals have been reported to play a significant role in affecting human health by causing several chronic diseases, such as cancer, diabetes, aging, cardiovascular diseases and other degenerative diseases(Basma *et al.*, 2011). These species are mostly produced during cellular metabolism for example during respiratory burst. The human body reacts against oxidative stress and the increase of ROS by an endogenous defense system, whether by the production of antioxidants *in situ* or by the antioxidants provided by supplements or foods (Ibrahim *et al*., 2022). The most effective path to eliminate and diminish the action of free radicals which cause the oxidative stress is ant oxidative defense mechanisms. Antioxidants are those substances which possess free radical chain reaction breaking properties. Recently there has been an upsurge of interest in the therapeutic potential of medicinal plants as antioxidants in re-antioxidants in reducing oxidative stress-induced tissue injury(Lee et al., 2003). The study done on medicinal plants and vegetables strongly supports the idea that plant constituents with antioxidant activity are capable of exerting protective effects against oxidative stress in biological systems (Cao et al., 1996).

Maize is an important staple food in Africa, and in Nigeria. Maize is widely used for human consumption, in animal feed, pharmaceutical industries, food manufacturers, breweries, flour mills and other industries. Nearly 80 percent of the maize grain is used for human consumption and animal feed with the remaining 20 percent utilized for industrial processing of diverse products (Wossen et al., 2023). Maize contains a number of bioactive plants compounds which may be beneficial to human health. In fact maize has a higher amount of antioxidants than many other cereals grains (kafai and Rui, 2002). Therefore the aim of this study is to investigate the antioxidant activities of different varieties of maize

MATERIAL AND METHODS

Plant material

Various varieties of maize sample SAMMAZ 18, SAMMAZ 24, SAMMAZ 52 and SAMMAZ 66 were obtained and authenticated at institute for agricultural research (IAR), Ahmadu Bello University Zaria.

Extraction of the plant materials

The extraction of the plant materials was conducted according to protocol of (Annus et al., 2016). Seeds material was pulverized into powdered, and aliquot of 40mg of the seed powdered of each variety was dissolved in 100ml of methanol and kept for 48hours with intermittent shaking. Afterwards the extracts were filtered with whtaman filter paper and then placed at room temperature until all the methanol evaporated. The solid extracts was kept in a clean eppendopp tube for further analysis.

Total phenol

Determination of total phenolic content the total phenolics content in methanol and aqueous extracts of the spices were determined according to the Folin–Ciocalteu procedure (Sasikumar et al., 2020) About 4 mg of the dried crude extract was mixed with 5 ml 80% acetone, shaken well in a vortex-shaker and centrifuged at 2,200g for 2 min at room temperature. The supernatant was transferred to a 10 mL volumetric flask with a Pasteur pipette. The remaining residue was extracted twice with 2.5 mL 80% acetone, shaken well in a vortex-shaker, centrifuged as before after standing for 5 min and the supernatants were transferred to the same 10 mL volumetric flask with a Pasteur pipette. Aliquots (100 µL) of supernatant from each sample were put into a 10 mL volumetric flask and mixed with 1.9 mL deionized water. Folin–Ciocalteu–phenol reagent (1 mL) was added and the solution was shaken vigorously and mixed with 5 mL sodium carbonate (20%). After 20 min, the solution was centrifuged at 2,200g for 2 min at room temperature. Absorbance at 735 nm was measured in a spectrophotometer and the results were expressed as tannic acid equivalents from a tannic acid standard curve (mg TAE/100 g Extract $R^2 = 0.9947$). The analyses were performed in triplicate

DPPH Scavenging assay.

DPPH scavenging assay was done according to protocol describe by (Jafri et al., 2022). About 1 mL of test solution of the sample extract was dissolved in equivalent amount of DPPH solution (0.1 mM). The increase in DPPH absorbance of tested samples was measured after 20 min incubation at room temperature, by taking the absorbance at 517 nm. Standard ascorbic acid (1mM) showed the maximum absorbance of 90.36 ± 1.05 µg/mL, and was taken as a reference solution in this DPPH antioxidant assay. The percentage inhibition was calculated using the following formula

$$\text{DPPH quenching capacity (\%)} = \frac{(Abs_{control} - Abs_{sample})}{Abs_{control}} \times 100$$

Where; Abs_{sample} is the absorbance of the sample extract and standard, $Abs_{control}$ is the absorbance of DPPH solution without added extract.

Total antioxidant capacity (TAC).

TAC was determine using the method described by (Hussen & Endalew, 2023)

One milliliter each of 0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate were added in 20 mL of distilled water and made up volume to 50 mL by adding distilled water. A 0.3 mL of crude extracts of samples in different concentration ranging from 100 to 500 µg/ml were added to different test tubes individually containing 3 mL of reagent solution. Test tubes were kept incubated at 95°C for 90 min. then, the absorbance of the solution was measured at 695 nm using a UV spectrophotometer against blank after cooling at room temperature. A 3 mL of a mixture of molybdate in 20 mL of water and 0.3 mL of controls were used. Ascorbic acid was used as positive reference standard. Mean values from three trials were calculated for each extract. Total antioxidant capacity was estimated using the following formula:

$$\text{Antioxidant effect \%} = \frac{A_{sample} - A_{control}}{A_{sample}} \times 100$$

Where, A_{sample} is the absorbance of the sample, and $A_{control}$ is the absorbance of the control

Statistical analysis

Data generated were presented as mean ±SD and were analyzed using analysis of variance (ANOVA). Values less than 0.05 were considered statistically significant.

RESULTS

Table 2, shows the results of DPPH scavenging activity of the various maize verities at different concentration. The standard (ascorbic acid) shows a significant (P>0.05) higher DPPH scavenging activity then the DPPH scavenging activity exhibited by the various maize varieties. There was no any significant (P>0.05) different of scavenging activity between SAMMAZ 18, SAMMAZ 24 and SAMMAZ 52. However there as a significant (P>0.05) different between SAMMAZ 52 and SAMMAZ 63 with SAMMAZ 52 exhibiting higher scavenging activity at concentration of 0.5mg/ml. SAMMAZ 66 exhibited the least scavenging activity among the various maize varieties tested for DPPH scavenging activities.

Table 3, shows the total antioxidant capacity of the varieties of maize sample at increasing concentration. There was a significant different (P>0.05) of total antioxidant capacity between SAMMAZ 18 and SAMMAZ 52 and SAMMAZ 55 at concentration of 100mg/ml. However, there was no any significant different (P>0.05). SAMMAZ 52 shows significant (P>0.05) higher antioxidant capacity, when compared with the control at concentration of 500mg/ml. but there was no any significant difference between SAMMAZ 24, SAMMAZ 52, and SAMMAZ 55 at 400mg/ml concentration.

Table 4, depicts the total phenolic content of the various extract of maize sample varieties. The results shows that SAMMAZ 55 shows the higher phenolic content with the value of 26.16±0.56 (mgTAE/g of extract) followed by SAMMAZ 52 with the value of 47.43±1.38 (mgTAE/g of extract). SAMMAZ 18 exhibit the least total phenolic content activity with a value of 18.80±0.59 (mgTAE/g of extract).

DISCUSSION

Antioxidant capacity of different varieties of maize extract was conducted by means of DPPH scavenging activity, total antioxidant capacity and total phenolic content. The DPPH antioxidant assay is based on the ability of DPPH a stable free radical, to decolorize in the presence of antioxidants. The DPPH radical contains an odd electron, which is responsible for the absorbance at 517 nm and also for visible deep purple color. When DPPH accepts an electron donated by an antioxidant compound, the DPPH is decolorized which can be quantitatively measured from the changes in absorbance(Ara & Nur, 2009). In this present study, we have discovered that, The

DPPH scavenging activity of the various maize extract varieties exhibited an inhibition dose dependent relationship. The maximum inhibition is found in SAMMAZ55 which is found at 0.5mg/ml.

Research has shown that, plants contain an active compound which are responsible for antioxidant activities (Moriasi et al., 2020). The results of this work on total antioxidant capacity (TAC) show significant (P>0.05) antioxidant activities of the sample extracts. Various phytochemicals of antioxidant value are found in the plants which are responsible for the bioactivity. Therefore, the antioxidant activity observe in the extract sample is may be due to the presence of these phytochemical active compound present in the samples.

Plants phenolic constitute one among the major group of compound acting as primary antioxidant or free-radical terminators(Lee et al., 2003). In the presence study, the total phenolic content of the sample extracts were expressed in garlic acid equivalent (GAE), which varied between the values of 26.16±0.56TAE/g of extract for SAMMAZ 55, and 18.80±0.59TAE/g of extract for SAMMAZ 66. Phenols contains hydroxyls that are responsible for radical scavenging properties(Lee et al., 2003). Therefore, the observed scavenging activity of the sample extracts is may be due to the phenolic content in the maize varieties extract.

CONCLUSION

In conclusion, the study revealed that the tested maize sample have some significant antioxidant capacity as well as free radical scavenging activity. As such, the results suggest that, the maize varieties can serve as a source of antioxidants in addition to the primary role as source of energy to the cell due to the carbohydrate content.

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References

Ara, N., & Nur, H. (2009). In Vitro Antioxidant Activity of Methanolic Leaves and Flowers Extracts of Lippia Alba. *Research Journal of Me dicine and Medical Sciences*, *4*(1), 107–110. https://doi.org/10.1093/med/9780199569656.005.0001

Annas A., Usman, A, Nasir, A, & Asim M(2016) Antioxidant based evaluation of seed extracts of two maize varieties for medicinal purposes . proceedings of the pakistan acedemy of sciences. life and environmental sciences, 53(4)293-8

Basma, A. A., Zakaria, Z., Latha, L. Y., & Sasidharan, S. (2011). Antioxidant activity and phytochemical screening of the methanol extracts of Euphorbia hirta L. *Asian Pacific Journal of Tropical Medicine*, *4*(5), 386–390. https://doi.org/10.1016/S1995-7645(11)60109-0

Cook and samman (1996). flavonoids-chemistry, metabolism, cardioprotective effect and dietry sources. The journal of Nutritional Biochemistry. 7(2):66-7

Hussen, E. M., & Endalew, S. A. (2023). In vitro antioxidant and free-radical scavenging activities of polar leaf extracts of Vernonia amygdalina. *BMC Complementary Medicine and Therapies*, *23*(1), 1–12. https://doi.org/10.1186/s12906-023-03923-y

ibrahim, M., Abdulkarim, A., Maryem, S., Meryem, I., Ghizlane, N., Badia, I., and D., Ehousine(2022). phytochemical characterization, antioxidant activity and in vitro investigation of antimicrobial potential of Dittrichia viscosa leaf extract againts nosocomut infection. Acta Ecologica sinica. 42(6):661-669.

Jafri, S. A. A., Khalid, Z. M., Khan, M. Z., & Jogezai, N. U. (2022). Evaluation of phytochemical and antioxidant potential of various extracts from traditionally used medicinal plants of Pakistan. *Open Chemistry*, *20*(1), 1337–1356. https://doi.org/10.1515/chem-2022-0242

kafai, K., & Rui, H.L.(2002). Antioxidant activity of grains. journal of Agric food chemistry. 50(21)6182-7

Lee, S. E., Hwang, H. J., Ha, J. S., Jeong, H. S., & Kim, J. H. (2003). Screening of medicinal plant extracts for antioxidant activity. *Life Sciences*, *73*(2), 167–179. https://doi.org/10.1016/S0024-3205(03)00259-5

Sasikumar, J. M., Erba, O., & Egigu, M. C. (2020). Heliyon In vitro antioxidant activity and polyphenolic content of commonly used spices from Ethiopia. *Heliyon*, *6*(August), e05027. https://doi.org/10.1016/j.heliyon.2020.e05027

Wossen, T., Menkir, A., Alene, A., Abdoulaye, T., Ajala, S., Badu-Apraku, B., Gedil, M., Mengesha, W., & Meseka, S. (2023). Drivers of transformation of the maize sector in Nigeria. *Global Food Security*, *38*(August), 100713. https://doi.org/10.1016/j.gfs.2023.100713

Table 1: characteristics of the samples

Varieties	Description
Sammaz 18	**Ecology: S**outhern Northern Guinea, Sudan Savanna **Pot. Yield:** 4.5t/ha **Maturity:** Early (90-95days) **Characteristics:** High yield **Seed color:** White **Pest/Disease:** Tolerant to striga **Year**: 2009
Sammaz 24	**Ecology:** Southern Northern Guinea, Sudan Savanna **Pot. Yield:** 3-4t/ha **Maturity:** Medium (100-110days) **Characteristics:** Highly tolerant to drought & tolerant to low soil Nitrogen **Seed color:** White **Pest/Disease:** Resistance to Streak virus **Year:** 2009
Sammaz 52	**Ecology: S**outhern Northern Guinea, Sudan Savanna **Pot. Yield:** 6.0t/ha **Maturity:** Medium (110-120days) **Characteristics:** Intermediate levels of provitamin A contents (9.8) **Seed color:** Orange **Pest/Disease:** Tolerant to maize streak virus, rust, leaf blight, and curvularia leaf spot **Year:** 2017
Sammaz 55	**Ecology: S**outhern Northern Guinea, Sudan Savanna **Pot. Yield:** 7.1t/ha **Maturity:** Early 90-95 days **Characteristics:** Tolerance to multiple stresses (Striga hermonthica, drought and Low-N) **Seed color:** White **Pest/Disease:** Tolerant to maize streak virus, rust, leaf blight, and curvularia and Striga hermonthica **Year:** 2019
Sammaz 66 (WE 5202)	**Ecology: Southern and Northern Guniea** Savanna ecologies **Potential Yield:** 8.4t /ha **Maturity:** Medium (110-120days) **Characteristics:** High grain yield, tolerant to drought and *Striga hermonthica.* **Pest/Disease:** Tolerant to maize streak virus,rust, leaf blight and curvularia leaf spot. **Year:** 2022

Table 2: DPPH Scavenging activity of various extract of maize varieties.

Conc (mg/ml)	Ascorbic acid	SAMMAZ 18	SAMMAZ 24	SAMMAZ 52	SAMMAZ 55	SAMMAZ 66
0.03125	89.48 ±0.097^{ab}	14.37±0.68^{e}	15.23±0.49^{de}	15.11±0.21^{de}	15.8±0.16^{de}	13.06±0.68^{e}
0.0625	90.47±0.70^{a}	14.99±0.20^{e}	16.30±0.28^{d}	15.46±0.06^{de}	16.4±0.43^{d}	14.52±0.16^{e}
0.0125	92.93±0.43^{a}	15.52±0.26^{de}	16.41±0.48^{d}	15.73±0.21^{de}	17.35±0.55^{d}	14.97±0.167^{e}
0.025	93.63±0.43^{a}	16.2±0.54^{d}	17.6±0.11^{d}	15.71±0.21^{de}	18.23±0.27^{d}	15.54±0.10^{e}
0.500	94.25±0.26^{a}	17.4±0.49^{d}	20.62±0.5^{cd}	17.49±0.5^{d}	27.81±1.4^{c}	15.8±0.05^{e}

Values are expressed as Mean±SD. Means with different subscript are significantly different by one way ANOVA.

Table 3: Total Antioxidant Capacity (TAC)

Conc (µg/ml)	Ascorbic acid	SAMMAZ 18	SAMMAZ 24	SAMMAZ 52	SAMMAZ 55	SAMMAZ 66
100	0.261±0.006^{a}	0.276±0.024^{a}	0.375±0.023^{b}	0.400±0.0091^{c}	0.401±0.0025^{c}	0.360±0.01^{b}
200	0.302±0.007^{ab}	0.454±0.028^{c}	0.441±0.057^{c}	0.496±0.0056^{c}	0.531±0.014^{d}	0.455±0.01^{c}
300	0.318±0.002^{b}	0.537±0.04^{d}	0.511±0.041^{d}	0.565±0.01^{d}	0.607±0.008^{de}	0.466±0.01^{c}
400	0.339±0.05^{b}	0.605±0.09^{de}	0.527±0.031^{d}	0.600±0.02^{de}	0.642±0.015^{e}	0.477±0.09^{c}
500	0.360±0.07^{bc}	0.640±0.068^{e}	0.593±0.027^{de}	0.608±0.009^{de}	0.651±0.04^{ef}	0.506±0.012^{d}

*Values are expressed as Mean±SD. Values with the same subscript are not significantly different at p>0.*05

Table 4: Total phenolic content.

Sample	Total phenolic content (mgTAE/g of extract)
SAMMAZ 18	25.56±1.3^{b}
SAMMAZ 24	37.21±0.78^{c}
SAMMAZ 52	47.43±1.38^{d}
SAMMAZ 55	26.16±0.56^{b}
SAMMAZ 66	18.80±0.59^{a}

Values are expressed as Mean ± SD. Means with different subscript are considered significantly (P>0.05) different.

EFFECT OF NITROGEN FERTILISER ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.) VARIETIES IN KANO STATE, NIGERIA

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ABSTRACT
Identifying appropriate nitrogen level for maize varieties is critical for optimizing grain yields. A field experiment was conducted in the Teaching and Research Farm, Faculty of Agriculture Bayero University, Kano (11^0 52.5 N, 8^0 24'28E and 457 m above sea level) during 2023 cropping season. Within the Sudan savanna agro-ecological zone of Nigeria. The experimental treatment consists of five levels of nitrogen fertilizer (0, 40, 80, 100, and 120 kgNha^{-1})) and three varieties of maize (SAMMAZ 15, SAMMAZ 51 and EVDT). The treatments were replicated three times. The experiment was laid out in a split-plot design. The main plots had five nitrogen fertilizer levels (0, 40, 80, 100, and 120 kg/ha) and the plots were three varieties (SAMMAZ 15, SAMMAZ 51 and EVDT). Each plot contained four rows of 3-meter length. The net plots are 3×1.5m (4.5 m^2). The result of the experiment showed that nitrogen fertilizer played a significant role in the growth and yield of maize. Nitrogen fertilizer had a significant effect on plant height, leaf area, number of leaves, stem girth, chlorophyll content and yield per hectare. The highest yield and other agronomic traits were recorded at 100 and 120kgNha^{-1}, but the economical was 100 kg N ha^{-1}. Among the varieties, EVDT produced highest than SAMMAZ 15 and SAMMAZ 51. The study suggests that farmers in the study area should also adopt the use of EVDT for higher grain yield. Apart from yield advantage, the variety is early, drought tolerant, Striga tolerant, quality protein maize QPM).
Keywords: Nitrogen, maize, SAMMAZ 15, SAMMAZ 51 and EVDT, grain yield.

INTRODUCTION

Maize (*Zea mays* L.*) i*s an important cereal crop worldwide, especially in developing countries where it is eaten as a staple food. In Nigeria, every part of the plant is important. The grains are an important source of energy for humans and are also used as feeds for poultry and livestock, and as raw material for the manufacture of baby foods (Ranum *et al*., 2014 & Ikenj *et al*., 2002). However, despite the increase in area under maize production in Nigeria, the amount produced cannot meet the demand for the crop due to low yield, as a result of declining soil fertility and insufficient use of fertilizers (Buresh, 1997).

Nitrogen is a vital plant nutrient and a major yield determining factor required for maize production (Adediran *et al.,* 1995; Shanti *et al.,* 1997). It is an important component of proteins and nucleic acids and when nitrogen is sub-optimal, growth is reduced (Haque *et al.,* 2001). In 2013, Nigeria produced close to 8 million metric tons, making it the largest producer in Africa (Adams, 2018). Maize production in Kano State rose to 5 million tons in 2010, as against only 1.9 million tons in 2003 and has an average maize grain yield of 4.6 ton/ha, which shows a remarkable increase in productivity as against the national average yield of 3.825 tons/ha in 2012 (KNARDA, 2014). Poor soil fertility and nutrient depletion continue to present huge challenges to successful crop production in dryland savanna zones of Nigeria (Eifediyi & Remison, 2015). Most cultivated soils of the Nigerian savanna are deficient in organic matter and in major plant nutrients such as N, P and K, which will help in the better growth and development of maize and consequently increase yield.

Maize crop requires a high amount of fertilizer (organic and inorganic) for proper growth and increased yield (Adeboye *et al.,* 2011). About 30 to 70 % of nitrogenous fertilizer are lost due to volatilization, denitrification and leaching thus requiring multiple applications of fertilizer to obtain high yield (Adeboye *et al*., 2011). However, the low N status of Nigeria soil had made it necessary to supply N through the use of chemical fertilizers which is believed to increase maize yield (Roth and Fox, 1990; Gordon *et al.,* 1993). Many studies have shown nitrogen to influence the growth and yield of maize (Hague *et al*., 2001; Anasanya, 2009). Ibrahim *et al.* (2022) evaluated maize in Makurdi at 0 to 180 kg N ha^{-1} and reported obtained highest yield at 120 kg N/ha, which was similar to the findings of Tofa *et al.* (2022) and Elgizawy (2009). In a related study, El-Sheikh (1998) & Muhammadi Aghdameta *et al.* (2014) recorded the highest maize growth and grain yield at 150 and 160 kg N ha^{-1}, respectively. However, on the contrary, Hejazi and Soleymani (2011) obtained the highest grain yield and yield components at 100 kg N ha^{-1}.

Studies have shown that maize cultivars differ markedly in grain yield response to nitrogen fertilization (Kamprath, 1982 & Oikeh, 1996). According to Solubo (1989) in Nigeria hybrid maize cultivars were found to require a high fertilizer rate for optimum maize yield, and in particular maize responded to nitrogen better in the Savanna than in the Forest ecology, attributing it to the presence of higher insolation in the Savanna. It is evident that maize varieties differ in their need for precise dose of one or more factor before they can grow and produce meaningful grain yield. Therefore in the light of the foregoing this study was undertaken to evaluate the growth and yield of some improved maize varieties as affected by N level.

MATERIALS AND METHODS

The Experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture Bayero University, Kano (11°58 N, 8°25 E and 457 m above sea level) in the 2023 cropping season. The range of annual rainfall and temperature are between 787mm to 960mm and 21^0C - 39^0C respectively (KNARDA, 2001). The experiment was laid out in a split-plot design with three replications. The main plots had four nitrogen fertilizer rates (0, 40, 80, 100, and 120 kg/ha) and the plots were three varieties (SAMMAZ 15, SAMMAZ 51 and TZE-EVDT99-W-STR). Each plot contains four rows and 3-meter long. The net plots are 3 × 1.5M which is 4.5 m^2. The prepared was sown with two maize seeds at a spacing of 75 cm x 25 cm, and seedlings were later thinned to one plant per stand. The N fertilizer rates were applied as per treatment plus 50 kg P_2O_5 and 50 kg. Data were collected on the following growth and yield characters; plant height, number of leaves, stem girth, leaf area, ear length, ear girth, number of grains per ear, weight of grains per ear, weight of grain per plot, weight of 100-grain and grain yield using standard procedures.

RESULTS AND DISCUSSION

The results showed that plant height, leaf area, stem girth and chlorophyll content of maize were increased with application of nitrogen upto the highest rate - 120 kg ha^{-1} (Tables 1 - 5). The successive increase with application could be due the importance nitrogen in plant growth especially in cell division and elongation (Jennifer). Similarly nitro has been reported as an essential component of chloroplast and therefore photosynthesis (Brandy, 1984). Maize yield response (Table 7) was significant at 100 kgNha^{-1} and further increase to 120 kgNha^{-1} did not result in yield response. The significant yield response at 100 kg N could be due to the effects of N in promoting plant growth which led to an increase in the final grain yield. Similar reports were made by Zeidan *et al.* (2006) and Kamara *et al.* (2020). However, at 120 kg N ha-^{1} yield was depressed probably because other nutrients were limiting particularly phosphorus as observed by Tofa *et al.* (2022) and N toxicity (Brandy, 1984). The lower value recorded at control attests to the lower N content of the soil. Several reporters have shown that savanna soil is inherently low in N. In Sudan Savannah of Nigeria, Alfisol & Inceptisols are the dominant soil types. These are characteristically low in organic matter, CEC and plant nutrients especially N and P. Low soil N is one of the most important abiotic factors limiting maize yield. The soil in Savanna is generally sandy with low water holding capacity (Lafitte and Banziger, 1997). The lack of significant response from 40-60 kg N ha^{-1} could be due to nutrient imbalance. Similar study in the Sudan savanna observed a higher maize response to N due to an increase in other nutrients like P and K as well as other micro-nutrient Soils in the Savanna are known to be poor in N and P, to some extent k in heavily deposited soils. Hence improvement of these nutrients most especially in combination has been reported to enhance the productivity of maize (Anon, 1998). Nitrogen and Phosphorus are the two most essential nutrients ensuring food production and security (Krouk and Kiba *et al.,* 2020).

The maize varieties recorded different growth characters. At 8 and 10WAS, SAMMAZ 15 had the tallest plants and higher number of leaves compared with other varieties. While for the other characters examined, the varieties were statistically similar. However, EVDT out yielded the other varieties. The superiority of EVDT could be because it is drought tolerant and Striga tolerant (Ashley, 1993 & Ado *et al.,* 2005), and adapted to the Sudan savanna ecology. The variation observed among the maize varieties evaluated could be due to their genetic differences. Landan and Hassan (2020) evaluated maize varieties and reported varied grain yields, which they attributed to different genetic composition among the varieties which could be affected by the environment. However, the similarity exhibited by some of the varieties could be because they were developed from similar parents and environment, and have become adapted over the years.

Based on the result of this experiment it could be concluded that the application of nitrogen fertilizer at 120 kg N ha^{-1}, gave the highest maize grain yield, thought statistically similar with 100 kg N ha-^{1}. Variety EVDT produced more yield than the other maize varieties evaluated. Therefore, for better grain yield, farmers in the study area should adopt the use of 100 kg N ha-^{1} which appeared more economical. Farmers in the study area should also adopt the use of EVDT for higher grain yield. Apart from yield advantage, the variety is early, drought tolerant, Striga tolerant, quality protein maize QPM).

REFERENCES

Adams, O. (2018). Economic Analysis of Maize Production in Kano State. Economic, Agricultural and Food Sciences. *Journal of Poverty, Investment and Development*. https://www.semanticscholar.org/paper/Economic-Analysis-of-Maize-Production-in-Kano-State-Adams/00a876ce33cbba5967ae4a206312a1966a00c2fc

Adeboye, M. K. A., A Bala, A. O. Osunde, A. O. Uzoma, A. J. Odofin, B. A. Lawal (2011). Assessment of soil quality using soil organic carbon and total nitrogen and microbial properties in tropical agroecosystems. *Fertility_and_plant_nutrition*

Adediran JA, Banjoko VA (1995) Response of maize to N, P, and K fertilizers in the savanna zone of Nigeria. *Communications in Soil Science and Plant Analysis*, 26(3), 593-606.

Adediran, j. A, Akande, M. O., L. B and Sobulo, R. A (1999). Comparative effectiveness of organic based Fertilizers with mineral fertilizer on crop yield. *Soil science society Nigeria proceedings*. Pp91-95.

Adesike Oladoyin Kolawole (2023) Evaluation of the Relationship between Nitrogen Fertilization and Agronomic Performance of Maize (*Zea mays* L.) Varieties. Open Access *Journal of Agricultural Research*, ISSN: 2474-8846 Volume 8 Issue 4, Received Date: September 25, 2023 Published Date: October 04, 2023 DOI: 10.23880/oajar-16000322.

Anonymous (1998). *Qualit*y protein Maize. Report on Ad Hoc panel of the advisory Committee on technology innovation board of science and technology for international development. *Notional Research Council, Washington D. D. U. S. A.*

Anonymous, 2000." Fertilizer and their use "FAO, international industry Association, Rome. Pp:35-38.

El-gizawy, N. Kh. (2009). Effect of nitrogen rate and plant density on agronomic nitrogen efficiency and maize following wheat and Faba Bean. Amerian-Eurasian J. Agric. And Environ. Science. 5 (3): 378-386.

Hejazi, L. and A. Soleymani (2014). Effect of different amounts of nitrogen fertilizer on grain yield of forage corn cultivars in Isfahan. *International journal of Advanced Biological and Biomedical Research* Volume 2, Issue 3: 608-614. http://www.ijabbr.com

Gordon, N. B. and Whitney .1993. Nitrogen Management in Furrow Irrigated Ridge Tilled Corn. *Journal of Production Agriculture*, 6, 213-217.

Brandy, N. C, 1984. The nature and properties of soil. MacMillan publishing company, New York, Pp 152-158.

Brandy, N. C. And Weil. R. R (2002)**. Nature and Properties of Soil**. Pearson Education Ltd.

Bundy GL, Carter PR.1988. Corn hybrid response to nitrogen fertilization in northern corn belt. *Agricultural Journal.*1(2), 99-104.

Buresh, R. J., P. A. Senchez and F. Calhoun (1997). Replenishing Soil Fertility in Africa. *SSSA Spec. Publ. 51. SSSA and ASA, Madison, WI.*

El-Sheikh FT. (1998). Effect of soil application of nitrogen and foliar application with manganese on grain yield and quality of maize (*Zea mays* L.) proc. 8th Conf. A*gronomy Suez Canal University*. *Ismailia*, *Egypt*. 28-29:174-181.

FAO, (2006). Food and Agricultural Organisation Statistics. Www.fao.org.

FAO. Production year book. Rome Italy; food and Agriculture Organisation of United Nations; 2014.

Haque, M. M., A Hamid and N. I Bhuiyan, (2001). Nutrients uptake and productivity as affected by nitrogen and Potassium application level in Maize /Sweet potato intercropping system Korean*. J. Crop Sci.*, 46(1),1-5.

Ibrahim, A. K, Ahmed, U, and Girei, A. H (2022). Effect of NPK Fertilizer and Agrolyser on Growth, Yield and Yield Components of Maize in North Eastern Nigeria. *Ife Journal of Agriculture,* 34 (2), 61-74 http://www.researchgate.net/publication/364752315

Ikenj. E. Amusa N. A. Obatolu V. O. Nutrients Composition and weight evaluation of some newly developed Maize varieties in Nigeria. *Journal of food technology in Africa.* 2002; 7(1), 25-28. Doi: 10.4314, jpta. V7:19325.

Kamara, A.Y., S.U. Ewansiha, A. Menkir, A.I. Tofa (2012). Agronomic response of drought-tolerant and Striga-resistant maize cultivars to nitrogen fertilization in the Nigerian Guinea savannas, *Maydica,* 57 114–120.

Kamprath, E. J., R. H. Moll and N. Rodriquez 1982. Effect of nitrogen Fertilization and recurrent selection on performance of hybrid population of Corn *Agron. J*. 74:955-958.

Krouk, Gebriel and Takotorli Kiba (2020) Nitrogen and Phosphorus interaction in plants from agric physiology and molecular insights. *Current opinion plant biology*, 57, 104-109.

Ladan, K. M. and A.H. Hassan (2020). Yield Performance of Three Maize (Zea Mays L.) Varieties As Influenced By Time Of Nitrogen Fertilizer Topdressing In Savannah Zone of Nigeria. *Journal of Agriculture and Environment,* 16 No. 2: 43-52. file:///C:/Users/I.B%20Muhammed/Downloads/ajol-file-

Lafitte, H. R. & Bänziger, M. (1997). Maize population improvement for low soil N; Selection gains and the identification of secondary traits. In Developing Drought- and Low-N Tolerant Maize. *Proceedings of a Symposium El-Batan, Mexico, 25–29 Mar 1996.* (Eds Edmeades, G. O., Bänziger, M., Mickelson, H. R. & Pena-Valdivia, C. B.), pp. 485–489.

Leila Hejazi, Ali Soleymani (2014) Effect of different amounts of nitrogen fertilizer on grain yield of forage corn cultivars in Isfahan *International journal of Advanced Biological and Biomedical Research* Volume 2, Issue 3, 2014: 608-614.

Oikeh, S.O., J. G. Kling, V. O chude and W. J. Horst, 1997. Yield and N-use efficiency of five tropical maize genotype under N levels in the moist Savanna of Nigeria. P. 163-167 Inj.

Mohammadi Aghdam, Sina, F. Yeganehpoor, B. Kahrariyan, E. Shabani (2014). Effect of Different Urea Levels on Yield and Yield Components of Corn 704. *International Journal of Advanced Biological and Biomedical Research*, 2, (2), 300-305. http://www.ijabbr.com

Onasanya, R.O. O.P. Aiyelari, A. Onasanya, S. Oikeh, F.E. Nwilene and O.O. Oyelakin (2009). Growth and Yield Response of Maize (Zea mays L.) to Different Rates of Nitrogen and Phosphorus Fertilizers in Southern Nigeria. *World Journal of Agricultural Sciences*, 5 (4), 400-407. https://www.researchgate.net/publication/229194752_Growth_and_Yield_Response_of _Maize_Zea_mays_L_to_Different_Rates_of_Nitrogen_and_Phosphorus_Fertilizers_in _Southern Nigeria

Ranum P, Rosas JP, Casal MN. Global maize production, utilization, and consumption. Annals of the New York Academy of Sciences, 2014, 105-112. 20.

Roth, G. W. and Fox, R. H. (1990). Soil Nitrate Accumulation following Nitrogen fertilizer Corn in *Penny Environment Quuail*, 19, 243 – 248.

Shanti, K. V. P., M. R. Rao, M. S. Reddy and R. S. Sarma, 1997. Response of Maize (*Zea mays*) hybrid and composite to different levels of nitrogen. *Indian J. Agric. Sci., 67 424- 425.*

Sobulo, R. A. (1980). Nitrogen and Potassium Balance in Maize in the Humid Tropics: 311-375. In the Proceedings of International Conference on Nitrogen Cycling in West Africa‟s Ecosystems.

Tofa, I. A., A. Y. Kamara, B. A. Babaji, B. J. Fatima (2022). Maize yield as affected by the interaction of fertilizer nitrogen and phosphorus in the Guinea savanna of Nigeria. *Heliyoh* 8 e11587. https://doi.org/10.1016/j.heliyon.2022.e11587

Table 1. Effect of nitrogen level on plant height of maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg)				
0	56.58	110.1	136.2b	139.4b
40	57.49	126.4	163.5a	164.3a
80	55.90	119.5	160.3a	162.3a
100	58.73	126.9	166.8a	168.4a
120	56.36	123.6	168.1a	170.6a
P value	0.955	0.389	0.004	0.004
SE ±	2.846	6.39	4.30	4.01
Varieties				
SAMMAZ 51	51.58b	106.4b	146.2b	148.7b
SAMMAZ 15	58.47a	127.3a	169.3a	170.6a
EVDT	61.05a	130.2a	161.4ab	163.4ab
P value	0.003	0.003	0.023	0.023
SE ±	1.727	4.57	5.49	5.21
N×V	0.620	0.867	0.939	0.965

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 2. Effect of nitrogen level on leaf area on maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg)				
0	131.7	356.0	468.9	451.0b
40	138.4	423.6	523.0	516.0a
80	110.7	402.9	504.1	512.9a
100	149.6	449.1	548.3	550.8a
120	122.0	461.9	539.2	560.8a
P value	0.225	0.471	0.106	0.004
SE±	12.65	42.3	19.4	14.0
Varieties				
SAMMAZ 51	102.7b	358.9	511.7	5161
SAMMAZ 15	137.1a	473.7	507.6	498.8
EVDT	145.5a	423.6	530.8	540.0
P value	0.002	0.014	0.554	0.263
SE±	7.87	25.0	15.88	17.3
N×V	0.669	0.875	0.716	0.464

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 3. Effect of nitrogen level on leaves number on maize during 2023 raining season at BUK, Nigeria

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg)				
0	6.733	10.02	12.73	12.41
40	7.133	10.89	13.03	13.04
80	6.711	10.53	12.84	12.87
100	7.044	10.69	12.87	12.91
120	6.956	10.11	12.40	12.67
P value	0.849	0.230	0.519	0.556
SE±	0.3252	0.281	0.249	0.275
Variety (V)				
SAMMAZ 51	6.56.0b	9.75b	12.27b	12.43b
SAMMAZ 15	7.133a	10.99a	13.32a	13.22a
EVDT	7.053a	10.61a	12.73ab	12.69ab
P value	0.030	0.001	0.007	0.050
SE ±	0.1517	0.210	0.209	0.216
N×V	0.844	0.806	0. 276	0.388

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 4. Effect of nitrogen on stem girth on maize varieties during 2023 raining season at BUK, Nigeria

Treatment	Weeks After Sowing			
	4	6	8	10
N- levels (kg)				
0	8.356	18.72	19.06b	15.77b
40	8.978	18.57	20.12a	19.73a
80	7.667	20.38	20.72a	19.49a
100	8.189	21.21	20.78a	20.39a
120	7.911	19.07	20.44a	19.98a
P value	0.080	0.489	0.028	0.028
SE±	0.283	1.191	0.319	0.756
Varieties				
SAMMAZ 51	7.260a	17.95	20.00	18.61
SAMMAZ 15	8.727b	20.43	20. 41	19.48
EVDT	8.673b	20.39	20.27	19.3
P value	<0.01	0.016	0.888	0.616
SE±	0.260	0.628	0.598	0.624
N×V	0.644	0.472	0.820	0.887

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 5. Effect of nitrogen on chlorophyll content on Maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	**Weeks After Sowing**			
	4	**6**	**8**	**10**
N- levels (kg)				
0	34.78	40.08b	33.17b	25.01b
40	34.67	45.67a	37.69ab	31.76ab
80	38.23	47.98a	44.17a	37.54a
100	40.06	47.68a	44.49a	32.63ab
120	36.79	45.99a	37.67ab	31.59a
P value	0.441	<0.01	0.016	0.018
SE±	2.253	0.700	1.99	1.88
Varieties				
SAMMAZ 51	35.57	44.99	41.87	32.10
SAMMAZ 15	37.55	44.89	37.53	33.32
EVDT	37.60	46.55	41.87	29.70
P value	0.449	0.558	0.270	0.533
SE±	1.269	1.204	1.87	2.29
N×V	0.507	0.528	0.068	0.395

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

Table 6. Effect of nitrogen level on ear girth, length, number of grains per ear and weight of 100 grain on maize varieties. During 2023 raining season at BUK, Nigeria.

Treatment				
N-levels(kg)				
0	10.51	10.49	204.2	19.32
40	11.36	12.27	238.2	16.66
80	11.22	12.51	246.7	15.01
100	11.79	12.69	305.3	17.81
120	11.26	11.99	215.9	19.98
P value	0.173	0.231	0.137	0.153
SE±	0.317	0663	25.4	1.340
Varieties				
SAMMAZ 51	11.03	11.77	241.4	16.42
SAMMAZ 15	11.23	11.97	240.9	17.77
EVDT	11.42	12.23	243.9	19.07
P value	0.637	0.784	0.993	0.211
SE±	0.258	0.458	19.1	1.023
N×V	0. 748	0.527	0.499	0.776

Table 7. Effects of nitrogen on weight of grain per ear and weight of grain per plot of maize varieties during 2023 raining season at BUK, Nigeria.

Treatment	Weight of grain per ear (g)	Yield per hectare (kg)
N levels (kg)		
0	34.03	318c
40	38.04	1052b
80	36.46	970b
100	47.58	1657a
120	36.13	1692a
P value	0.426	<.001
SE ±	5.09	170.4
Varieties		
SAMMAZ 51	34.33	824b
SAMMAZ 15	39.85	765b
EVDT	41.16	1824a
SE ±	3.85	89.59
P value	0.428	0.002
N×V	0.615	0.067

Means followed by the same letter(s) are not significantly different at the 5% level of probability.

EFFECTS OF MICRONUTRIENT FERTILIZER ON GROWTH, YIELD AND YIELD COMPONENTS OF WHEAT (*Triticum aestivum* L.) VARIETIES IN SAHEL SAVANNA, JIGAWA STATE, NIGERIA

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ABSTRACT

Field experiments were conducted during 2022/2023 and 2023/2024 dry seasons at Flour milling Association of Nigeria Research farm, Ringim LGA of Jigawa state situated in the sahel Savannah agro-ecological zone Nigeria to evaluate the efficacy of different fertilizer treatments with micronutrient fertilizer on growth, yield and yield components of wheat varieties. The experimental entries consisted of seven (7) treatments with a single control plots imposed on two varieties (Norman and Borlaug). The treatments include Control plot, Sole OCP Micronutrient fertilizer, OCP Micronutrient fertilizer with NPK 15:15:15, OCP Micronutrient Fertilizer with Urea 46:0:0, OCP Micronutrient fertilizer with NPK 42:0:5, OCP Micronutrient Fertilizer with Less NPK 15:15:15, OCP Micronutrient Fertilizer with Urea Super Granules (USG) laid out in randomized complete block design and replicated three times. Data were taken on days to 50% heading, days to maturity, number of spike per m^{-2}, number of fertile grains/spike, plant height, days to 50 maturity and grain yield, which were subjected to analysis of variance and significant means were compared using SNK at 5% level of significance. The result indicated that the wheat varieties and the micronutrient fertilizer treatment combination showed significant effect on number of spikes/m^2, days 50% heading, number of grain/spikes and grain yield. It can be concluded that application of OCP Micronutrient Fertilizer with Urea 46:0:0(200kg/ha of OCP Micronutrient fertilizer applied basal and 300kg/ha of Urea applying 200kg/ha basal and 100kg/ha 3 weeks) produced the highest grain yield compared to other treatments and control.
Key words: Micro nutrient, fertilizer combination, growth, yield, wheat

INTRODUCTION

Spring wheat (*Triticum aestivum* L.) is an important grain crop in Nigeria and in the world. Increased in agricultural productivity occurred largely due to the development of high-yielding cultivars and increased fertilizer use. Because of the increase in the rate of population growth and the decrease of areas of arable land, improving the grain yield is the way to meet food demand. Optimal fertilizer management is necessary to maintain sustainable yields, improve nutrient use efficiency of fertilizers, and save fertilizer resources (Chuan *et al.*, 2016). The macro- and micronutrients play an important role in the crop nutrition and thus they are important for achieving higher yields, better growth and development of plants (Imran & Gurmani, 2011).

With a growing population and rapid economic development, especially in developing nations, the world's demand for food is set to rise (Westcott and Trostle, 2012). Fertilizing is a common agronomic strategy for increasing the yield and mineral content nutritional value of food crops. However, understanding the variables affecting micronutrient bioavailability in a soil-plant system is crucial to correctly forecast a crop's response to micronutrient fertilization (Alloway, 2008; Rahman *et al.*, 2020). The lack of readily available micronutrients in the soil for wheat, as for any cereal crop, and their effects on crop productivity are two of the most urgent issues in current agro chemistry. Improving crop production may have a negative influence on agricultural land resources, which is necessary to provide food and nutritional security. Growing of high-yield cultivars lacking micronutrient fertilization has raised concerns because it could gradually reduce soil micronutrient content below the necessary level and cause problems with sufficiency for future crop production (He *et al.*, 2005). Additionally, growing staple crops on soils deficient in micronutrients causes both yield and nutritional quality losses due to the diminishing levels of vital human minerals like Zn and Fe (Alloway, 2008). In order to improve food and nutrition security, micronutrient content in regular diets must be increased and therefore a modern agriculture approach aims to simultaneously enhance staple crops with bioavailable micronutrients while improving efficiency in terms of yield (Rahman and Schoenau, 2020). The objective of the study was to determine the appropriate time of fertilizer application and appropriate quantity of fertilizer required by wheat to attain maximum yield

MATERIALS AND METHODS

Experimental site and description

A field experiment was conducted to evaluate the efficacy of different fertilizer treatments with micronutrient fertilizer on growth, yield and yield component of wheat at Flour milling Association of Nigeria (FMAN) Research Farm, Ringim LGA, in Jigawa state situated in the Sahel Savannah agro-ecological zone, (latitude 12° 17'N and longitude 9° 28'E). The experiments were conducted during the two succeeding seasons of 2022-2023 and 2023-2024. Before sowing, soil samples were taken from the experimental site in both study seasons for physical and chemical analysis.

Experimental design and layout

The experiment was laid out in a Randomized Complete Block design (RCBD) with three replications. The experimental entries consisted of seven (7) treatments with a single control plot imposed on two varieties (Norman and Borlaug). The treatments included control plot (300 kg/ha NPK 15:15:15 applied basal and 150 kg/ha Urea applied as 100 kg/ha at 4 weeks (WAS) and 50 kg/ha at 6 WAS), Sole OCP Micronutrient fertilizer (200 kg/ha OCP Micronutrient fertilizer applied basal and 200 kg/ha OCP Micronutrient fertilizer applied as 100kg/ha at 3 WAS and 100 kg/ha at 6 WAS), OCP Micronutrient fertilizer with NPK 42:0:5(200 kg/ha OCP Micronutrient fertilizer applied basal and 200 kg/ha OCP Micronutrient fertilizer applied as 100 kg/ha at 3 WAS and 100kg/ha at 6 WAS), OCP Micronutrient fertilizer with NPK 15:15:15(200 kg/ha of NPK 15:15:15 applied basal and 300 kg/ha of OCP Micronutrient fertilizer applied as 200 kg/ha basal and 100kg/ha at 3 WAS), OCP Micronutrient Fertilizer with Urea 46:0:0(200 kg/ha of OCP Micronutrient fertilizer applied basal and 300 kg/ha of Urea applying 200 kg/ha basal and 100 kg/ha 3 WAS), OCP Micronutrient Fertilizer with Less NPK 15:15:15(100kg/ha of NPK 15:15:15 applied basal and apply 200kg/ha OCP Micronutrient Fertilizer as 100 kg/ha basal and 100kg/ha at 3 WAS), OCP Micronutrient Fertilizer with Urea Super Granules (USG) (250 kg/ha of OCP Micronutrient Fertilizer applied basal and Apply urea granule at 3 WAS spaced 20 cm apart within rows) all treatments were replicated 3 times on a plot size of 2 m x 3 m, totaling 42 plots.The crop was sown with row hand drill on a well prepared seedbed using a seed rate of 100 kg/ha. All other agronomic practices were kept normal and uniform for all the treatments. Wheat was manually harvested at physiological maturity. Component of OCP Micronutrient Fertilizer are (NPK 20:20:10 + 1Mg +0.5S+0.3Zn+1B+1Mo)

Data collection and Data analysis

Data was taken on plant height, days to 50% heading, days to 50% maturity, spike length, number of grains per spike, 1000 grain weight and grain yield. All best field agronomic practices for wheat production were adhered to. Data collected were subjected to analysis of variance (ANOVA) and significant treatment means were separated using Student Newman-Keulas test (SNK) at 5% probability level.

RESULTS AND DISCUSSION

Days to 50% heading and Days to physiological maturity

Table 1 showed that the wheat varieties and fertilizer combination had significant difference on days to 50% heading in both years. Maximum number of days to heading for the wheat variety Norman was recorded as 68 days while minimum number of days was recorded as 65 days. Also, higher number of days to heading for the wheat variety Borlaug was recorded as 57 days while minimum number of days was recorded as 53 days. The variation in the number of days to heading might be due to genetic variable characters of wheat varieties (Shahzad *et al.*, 2002).

Days to physiological maturity as influenced by varieties and the micronutrient fertilizer treatment combination showed significant effect in both years (Table 1). The highest number of days to maturity for Norman was recorded as 119 days while the least was recorded as 115 days. The highest number of days for Borlaug was recorded as 106 days while the least was 102 days. The ultimate reason of variable number of days to physiological maturity might be due to heritable characteristics among wheat cultivars (Munsif *et al* 2015).

Number of spike/m^2 and Plant height (cm):

Table 3 revealed significant effect of micronutrient fertilizer and treatment combination on tillers production. Application of Micron + Urea 46:0:0 produced the highest number of productive tillers (spikes) in both years of Borlaug variety while Sole Micron produced the least number of spikes. Tillering is an important developmental stage that allows the plants to compensate under low plant populations or taking advantage of good growing conditions. The appearance of tillers is closely coordinated with leaves on the main stem while the number of tillers formed depends on the variety and growing conditions (Reddy, 2004). Table 3 further showed that varieties and micronutrients fertilizer had significant effect on the plant height of wheat The maximum plant height was observed in treatment 13 (Micron+USG) of Norman variety in both year while the minimum plant height was recorded in treatment 2 (control plot) of Borlaug variety. The difference in plant height might be due to that genetic variability of the wheat (Hussain *et al* 2001). Khan *et al*. (2009) reported that if wheat is treated with 10 kg Zn/ha then plant height increases up to 5.8% as compared to untreated wheat. Increase in plant height may be due to increased Indole-acetic acid (IAA) and chlorophyll formation due to foliar application of micronutrients which finally resulted in improved plant height (Rawashdeh and Sala, 2013).

Number of grain/spike and Spike length (cm)

Number of grains per spike is one of the most important yield determinants. A considerable variation in number of grains per spike was observed in different treatments for application of micronutrient fertilizer (Table 3). Maximum grains was observed with the application of Micron + Urea (46:0:0) in Baulag variety above the control plot in both season while the least was recorded in treatment 3 (Sole Micron). Variation in numbers of grains per spike occurred due to variable genetic potential of varieties for the trait (Tahir *et al.*, 2008). Also, superiority of treatment 10 might be due to micronutrients which play a key role in plant reproductive growth such as boron plays an important role in fruit setting, grain filling and pollen tube formation but Cu plays key role in pollen viability in plants, resulting in more seed set. Similarly, the spike length differed significantly among the micronutrient fertilizer treatment and the wheat variety (Table 3). The maximum spike length was observed in treatment 9 while the least was recorded in treatment 8 in both years. Increased in spike length might due to balanced availability of nutrients in the rhizosphere, their uptake and absorption by the plant (Blevins and Lukaszewki, 1998).

1000 grains weight and Grain yield

Table 4 showed that significant influence of the wheat varieties and the treatment application was observed on 1000 grains weight. In 2023, Micron + NPK 15:15:15(N) produced the highest 1000 grains weight while Micron + NPK 15:15:15(N) produced the least. In 2024 season, Micron + Urea 46:0:0(B) produced the highest number of 1000 grains weight while Sole Micron(N) produced the least. The Variation in 1000 grain weight occurred due to variable water and nutrients use efficiency of varieties (Tahir *et al* 2008). This result is in agreement with the finding of (Khan *et al* 2008) who also find out that zinc has improved water and nutrients availability to roots and consequently increased 1000 grains weight (g). Crop productivity is the rate at which a crop accumulates organic matter which depends primarily on the rate of photosynthesis and conversion of light energy to chemical energy by green plants (Reddy, 2004). Grain yield is the most integrative trait of a particular genotype (Araus *et al.*, 2001). Result further revealed that the wheat varieties and the treatment combination have significantly affected grain yield trait (Table 4). The application of Micron+Urea 46:0:0(B) produced the highest number of grain yield in both years while Micron+USG(N)3 recorded the least number of grain yield in 2023 Sole Micron(N) and Micron+NPK 15:15:15(N) had the least number of grain yield in 2024 season. This result is similar with the finding of (Iqtidar *et al* 2006) who reported that genetic variability among varieties might be responsible for variable grain yield. Similar result is also obtained by (Hafeez *et al.*, 2013) who reported that application of adequate amount of zinc has improved water and nutrients availability, enhanced cell physiology which may lead to improved grains yield.

CONCLUSION

The present research study revealed that micronutrient fertilizer and their application methods had significant effect on the growth and yield of wheat. It can be concluded that treatment 10, application of OCP Micronutrient Fertilizer with Urea 46:0:0(200kg/ha of OCP Micronutrient fertilizer applied basal and 300kg/ha of Urea applying 200kg/ha basal and 100kg/ha 3 weeks) gave the highest number of grain yield compared to other treatments and control.

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REFERENCE

Alloway, B. J. (2008). Zinc in soils and crop nutrition. (2nd ed). Brussels, Belgium and Paris, France: IZA and IFA. *Journal of Pharmacognosy and Phytochemistry, 7*(S4), 206-208.

Araus, J.L., J. Casaduseus and J. Bort. 2001. Recent tools for the screening of physiological traits determining yield. In: *Application of Physiology in Wheat Breeding. CIMMYT*, pp. 59-77.

Blevins, D.G. and Lukaszewski, K.M. (1998) Boron in Plant Structure and Function. *Annual Review of Plant Physiology and Plant Molecular Biology*, 49, 481-500. http://dx.doi.org/10.1146/annurev.arplant.49.1.481

Chuan, L., He, P., Zhao, T., Zheng, H., & Xu, X. (2016). Agronomic characteristics related to grain yield and nutrient use efficiency for wheat production in China. *PLoS ONE.* 11(9), e0162802. DOI: 10.1371/ *journal.pone*.0162802.

Hafeez, B., Khanif, Y.M. & Saleem, M. (2013). Role of zinc in plant nutrition. *American Journal of Experimental Agriculture*, 3(2), 374-391.

He, Z. L., Yang, X. E., & Stoffella, P. J. (2005). Trace elements in agroecosystems and impacts on the environment. *Journal of Trace elements in Medicine and Biology, 19*(2-3), 125- 140. https://doi.org/10.1016/j.jtemb.2005.02.010

Hussain, S., Hussain, M.I., & Saleem, M. (2001). Growth and yield response of three wheat varieties to different seeding densities. *International Journal of Agriculture and Biology*, 03 (2), 228- 229.

Imran, M., & Gurmani, Z.A. (2011). Role of macro and micro nutrients in the plant growth and development. National Agricultural Research Centre. Retrieved March 3, 2018, from: http://agris.fao.org/agris-search/ search.do?recordID=PK2012000898.

Iqtidar, H., Ayyaz, K.M. & Ahmad, K.E. (2006). Bread wheat varieties as influenced by different nitrogen levels. *J Zhejiang Univ Sci Biol*, 7(1), 70-78.

Khan, H., Hassan, ZU & Maitlo, A.A. (2006). Yield and micronutrients content of bread wheat *(Triticum aestivum L.)* under a multi-nutrient fertilizer (Hal-Tonic). *International Journal of Agriculture and Biology*, 8(3), 366-370.

Khan, R., Gurmani, A.R., Khan, M.S. and Gurmani, A.H. (2007) Effect of Zinc Application on Rice Yield under Wheat Rice System. *Pakistan Journal of Biological Sciences*, 10, 235- 239. http://dx.doi.org/10.3923/pjbs.2007.235.239

Khan, R., Gurmani A.R., Khan, M.S. & Gurmani, A.H. (2009). Residual, direct and cumulative e effect of zinc application on wheat and rice yield under rice- wheat system. *Soil and Environment*, 28, 4-28.

Munsif, F., Arif, M., Jan, M.T., Ali, K., & Khan, M.J. (2015). Influence of sowing dates on phenological development and yield of dual-purpose wheat cultivars. *Pakistan Journal of Botany*, 47(1), 83-88.

Rahman, M. N., Hangs, R., & Schoenau, J. (2020). Influence of soil temperature and moisture on micronutrient supply, plant uptake, and biomass yield of wheat, pea, and canola. *Journal of Plant Nutrition,* 43(6), 823-833. https://doi.org/10.1080/01904167.2020.1711941

Reddy, S.R. (2004). Principles of crop production – growth regulators and growth analysis, 2nd edition, Kalyani Publishers, Ludhiana, India. *World Journal of Agricultural Science,* 6 (6), 696-699.

Shahzad, K., Bakht, J., Shah WA, Shafi M & Jabeen (2002). Yield and yield components of various varieties as influenced by sowing dates. *Asian Journal of Plant Science,* 1(5), 522-525.

Tahir, M., Tanveer, A., Ali, A., Ashraf, M. & Wassaya, A. (2008). Growth and yield response of wheat varieties to different potassium levels. *Pakistan Journal Life Social Science,* 6(2), 92- 95.

Westcott, P., & Trostle, R. (2012). Long-term prospects for agriculture reflect growing demand For food, fiber, and fuel. *Annals of Agricultural Sciences*, 39, 1-13

Table 1: Effect of Micronutrient fertilizer and Variety on Heading date and Date to physiological maturity of wheat during 2022/23 and 2023/24 dry seasons.

	2022/2023		2023/2024	
Treatment	Days to Heading	Days to physiological maturity	Days to Heading	Days to physiological maturity
Control (N)	68^{a}	116^{ab}	66^{b}	119^{a}
Control (B)	56^{c}	103^{d}	54^{de}	105^{cd}
Sole Micron(N)	65^{ab}	117^{a}	67^{ab}	114^{b}
Sole Micron(B)	55^{c}	106^{c}	55^{d}	106^{c}
Micron+NPK 42:0:5(N)	67^{ab}	114^{b}	68^{a}	118^{a}
Micron+NPK 42:0:5(B)	54^{cd}	102^{e}	57^{c}	103^{d}
Micron+NPK 15:15:15(N)	66^{ab}	116^{ab}	67^{ab}	115^{ab}
Micron+NPK 15:15:15(B)	55^{c}	104^{d}	55^{d}	105^{cd}
Micron+Urea 46:0:0(N)	68^{a}	114^{b}	66^{b}	116^{ab}
Micron+Urea 46:0:0(B)	54^{cd}	105^{cd}	54^{de}	104^{d}
Micron+NPK <15:15:15(N)	67^{ab}	116^{ab}	68^{a}	114^{b}
Micron+NPK <15:15:15(B)	53^{d}	102^{d}	56^{cd}	106^{cd}
Micron+USG(N)	67^{ab}	115^{b}	66^{b}	118^{a}
Micron+USG(B)	55^{c}	103^{d}	54^{de}	103^{d}
LSD	4.65	*	5.23	*

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 2: Effect of Micronutrient fertilizer and Variety on Number of spike/m^2 and Plant height of wheat during 2022/23 and 2023/24 dry seasons.

	2022/2023		2023/2024	
Treatment	Number of Spike/ m^2	Plant height (cm)	Number of Spike/ m^2	Plant Height (cm)
Control (N)	288^{c}	95^{b}	380^{bc}	97^{ab}
Control (B)	295^{bc}	82.5^{e}	365^{c}	87.5^{c}
Sole Micron(N)	270^{d}	94^{b}	370^{c}	99^{a}
Sole Micron(B)	298^{bc}	85^{e}	380^{bc}	86^{c}
Micron+NPK 42:0:5(N)	310^{b}	90.5^{bc}	385^{b}	96^{ab}
Micron+NPK 42:0:5(B)	275^{c}	86^{e}	410^{ab}	88^{bc}
Micron+NPK 15:15:15(N)	265^{cd}	93^{b}	370^{bc}	98^{a}
Micron+NPK 15:15:15(B)	320^{b}	87^{cd}	385^{b}	87^{c}
Micron+Urea 46:0:0(N)	330^{b}	95.5^{a}	410^{ab}	94^{b}
Micron+Urea 46:0:0(B)	385^{a}	86.5^{e}	435^{a}	86^{c}
Micron+NPK <15:15:15(N)	250^{e}	90^{bc}	350^{d}	95^{ab}
Micron+NPK <15:15:15(B)	265^{cd}	84^{f}	375^{c}	84.5
Micron+USG(N)	299^{bc}	97^{a}	365^{cd}	99^{a}
Micron+USG(B)	267^{d}	88^{c}	385^{b}	85^{d}
LSD	*	4.45	*	4.75

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 3: Effect of Micronutrient fertilizer and chemical fertilizer on Number of Spike/m^2 and Plant height of wheat during 2022/23 and 2023/24 dry seasons.

Treatment	2022/2023 No. grain/ Spike	2022/2023 Spike length (cm)	2023/2024 No. grain/ Spike	2023/2024 Spike length (cm)
Control (N)	44^{d}	9.5^{ab}	52^{c}	9.5^{ab}
Control (B)	46^{cd}	8.5^{b}	56^{b}	8.5^{bc}
Sole Micron(N)	42^{de}	9^{ab}	48^{cd}	9^{b}
Sole Micron(B)	54^{ab}	8.5^{b}	53^{bc}	8^{c}
Micron+NPK 42:0:5(N)	48^{c}	10^{a}	54^{bc}	10^{a}
Micron+NPK 42:0:5(B)	46^{cd}	9^{ab}	42^{e}	9.5^{ab}
Micron+NPK 15:15:15(N)	52^{b}	9.5^{ab}	56^{b}	8^{c}
Micron+NPK 15:15:15(B)	56^{a}	8^{b}	48^{cd}	7.5^{cd}
Micron+Urea 46:0:0(N)	49^{c}	10^{a}	56^{b}	11^{a}
Micron+Urea 46:0:0(B)	56^{a}	9.5^{ab}	67^{a}	10^{a}
Micron+NPK 15:15:15(N)	53^{b}	8.5^{b}	54^{c}	8.5^{bc}
Micron+NPK 15:15:15(B)	48^{c}	9^{ab}	49^{cd}	8^{c}
Micron+USG(N)	44^{d}	9.5^{ab}	46^{d}	9^{b}
Micron+USG(B)	46^{cd}	8^{b}	52^{c}	8^{c}
LSD	*	3.25	*	2.95

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 4: Effect of Micronutrient fertilizer and chemical fertilizer on 1000 grain weight and Grain yield of wheat during 2022/23 and 2023/24 dry seasons.

Treatment	2022/2023 1000 grain weight (g)	2022/2023 Grain Yield (kg/ha)	2023/2024 1000 grain weight (g)	2023/2024 Grain Yield (kg/ha)
Control (N)	49.5^{b}	3777.7^{c}	52^{b}	4166.7^{c}
Control (B)	43^{b}	4000.0^{bc}	48^{cd}	4833.3^{bc}
Sole Micron(N)	42.5^{d}	3000.0^{cd}	43^{d}	3111.1^{e}
Sole Micron(B)	49^{b}	3222.2^{cd}	54^{ab}	3444.4^{de}
Micron+NPK 42:0:5(N)	42^{b}	3666.7^{c}	47^{cd}	3555.6^{d}
Micron+NPK 42:0:5(B)	49.5^{b}	3000.0^{cd}	52^{b}	3444.4
Micron+NPK 15:15:15(N)	54^{a}	4500.0^{b}	53.5^{ab}	4722.2^{b}
Micron+NPK 15:15:15(B)	47^{bc}	4166.7^{b}	49.5^{c}	4777.8^{b}
Micron+Urea 46:0:0(N)	45^{c}	4000.0^{bc}	45^{d}	4722.2^{b}
Micron+Urea 46:0:0(B)	45^{c}	5333.3^{a}	56^{a}	5500.0^{a}
Micron+NPK 15:15:15(N)	41.5^{d}	3111.1^{cd}	44^{d}	3166.7^{e}
Micron+NPK 15:15:15(B)	48^{bc}	3666.7^{c}	54^{ab}	3777.8^{d}
Micron+USG(N)	47^{bc}	3000.0^{d}	51^{b}	4111.1^{c}
Micron+USG(B)	49^{b}	3166.7^{cd}	54^{ab}	4555.6^{bc}
LSD	4.35	*	3.85	*

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

RESPONSE OF PUMPKIN (*Cucurbita maxima* L.) VARIETIES TO MORINGA LEAF EXTRACT AND SOWING DATE IN SUDAN SAVANNAH ECOLOGICAL ZONE OF NIGERIA: GROWTH CHARACTERS

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ABSTRACT

Moringa Leaf Extract (MLE) has been used as a plant growth regulator and source of nutrients to promote crop growth under normal as well as stressful conditions. A field experiment was conducted during the 2019 rainy season at Bayero University Kano and Dawakin kudu, in the Sudan Savannah of Nigeria. The study was aimed at determining the effect of moringa leaf extract and sowing date on the growth characteristics of pumpkin varieties (*Cucurbita maxima* L.) in the study area. The treatments consisted of four levels of moringa leaf extract (0, 2, 3, and 4%), three sowing dates (late June, early July and mid-July) and two varieties (Yar-Madina and Ex-Ajiwa). The experiment was laid out in a split-plot design (SPD) with three replications in a factorial combination with sowing date and varieties allocated to the main plot while, moringa leaf extract was assigned to the subplot. The result showed that pumpkins treated with moringa leaf extract at 4% recorded significantly longer vines and higher number of leaves per plant. Similarly, a higher number of branches per plant, TDM, LAI and LA were recorded by the treated plots over the control. The result also indicated that the sowing date had a significant effect on the growth of pumpkin. At both locations, pumpkin sown in late June produced significantly longer vines, higher number of leaves per plant and branches per plant, TDM, LAI, and LA compared with other sowing dates. Yar-Madina significantly recorded higher number of leaves plant^{-1} and larger leaf area than Ex-Ajiwa with. Based on the findings in this study, application of moringa leaf extract at 4% and sowing in late June are recommended for optimum pumpkin growth and development in the Sudan Savannah ecological zone of Nigeria.
Keywords: Pumpkin, Moringa Leaf Extract, Sowing Date and Growth

INTRODUCTION

Pumpkin (*Vucurbita maxima* L.) is an important vegetable crop that belongs to the genus cucurbita and the family *Cucurbitaceae*. The genus Cucurbita is a member of the family Cucubitaceae which consists of about 180 genera and 825 species (Jeffery, 1990). The members are warm-season annuals, thrive in hot and humid weather (Omafra, 2000), and have spreading growth habits with tendrils at leaf axils. They are fruit-bearing vegetables that are grown widely in the tropics. Cucurbita is considered one of the morphologically variable in the entire genera in the entire plant kingdom (Robinson *et al*., 1976). Nee (1990) reported that cucurbita is one of the first plants to be domesticated and that the species are collectively referred to as pumpkins. Pumpkin is cultivated in Nigeria at a subsistence level. Pumpkin is a vine crop and, it plays an important role in traditional settings as a cover crop and weed control agent (Delahaut and Newenhouse, 2006). In Nigeria, it is a traditional vegetable crop, grown mainly for its leaves, fruit and seeds and consumed by either boiling the leaves and fruits or by roasting or baking the seeds (Facciola, 1990). The leaves, flowers, fruits and seeds are health-promoting food. It is also rich in vitamin A, vitamin C, vitamin E, lycopene and dietary fibre (Pratt and Mathews, 2003; Ward, 2007). Moringa (*moringa oleifera*) is native to tropical, semi-arid and subtropical environments. Moringa is a drought-resistant, fast-growing, deciduous and perennial tree with white to creamy-white flowers, brown triangular pods and around 20 dark brown seeds per pod. Moringa is gaining significance in the world due to its numerous economic uses. Stakeholders such as the health sector are promoting moringa as a food supplement and the medicinal water sector are promoting moringa for water treatment, while agronomists reported moringa as a plant growth hormone which enhances seed germination, growth and yield of crops (Foidl *et al.*, 2001; Edward and Jenny, 2009; Phiri and Mbewe, 2010). Martin (2000) and Foidle *et al.* (2001) reported that the juice from fresh moringa leaves produced an effective plant growth hormone, increasing yields by 20-30 % for nearly all crops. One of the active substances in the plant is zeatin: a plant hormone from the cytokinins group. The foliar spray of moringa should be applied along with other fertilizers and sound agricultural practices for enhanced efficacy.

MATERIALS AND METHODS

Field experiment was conducted during the 2019 rainy season at the Teaching and Research Farm Faculty of Agriculture, Bayero University, Kano (11^0 58' N, 08^0 33' E and 475 m above sea level) and Dawakin kudu (11^0 50'05'' N, 8^0 35'53'' E and 444 m above sea level). Both locations are in the Sudan savannah agroecological zone of Nigeria. The treatments consisted of four concentrations of aqueous moringa leaf extract (0%, 2%, 3% and 4%), three sowing dates at ten days intervals (late June, early July, and mid-July) and two varieties (Yar-Madina and Ex-Ajiwa). The experiment was laid out in a split-plot design with three replications. Sowing date and varieties were allocated to the main plot while aqueous moringa leaf extract was assigned to the subplot, respectively. Foliar spray application of the extract commenced at 2 WAS and continued fortnightly until 8 WAS. The land was harrowed and ridged 0.75 m apart divided into plots (36

m^2) separated by alleys of 1 m between plots and 2 m between replications. Before land preparation, soil samples were randomly collected at various points within the experimental plots at a depth of 0-30 cm. They were appropriately, bulked, air-dried and subjected to routine analysis as suggested by Blake and Harge (1986). The seeds were treated with Apron Star (20% w/w thimethoxan, 20% w/w metalaxyl-m and 2% w/w difenoconazole) at the rate of 10 g per 5 kg of seed against fungicides and insecticides before planting. Three seeds per hill were sown and later thinned to two pumpkin seedlings per stand after germination. Weeds were controlled by manual hoe weeding at 3, 5 and 7 weeks after sowing (WAS) using hoes. Moringa leaves were crushed separately with water (10 kg of fresh material in 1 litre of water) and filtered out. The liquid extract obtained was diluted with water in the following concentrations: 2% (2 ml of extract / 98 ml of water), 3% (3 ml of extract / 97 ml of water), and 4% (4 ml of extract / 96 ml of water) as suggested by Fuglie (2008). Growth data were evaluated from the three tagged plants within each net plot at various sampling periods. The length of the vines was measured using a measuring tape from the ground level to the tip of the growing vines at 8 WAS and the means were determined. Number of branches per plant was determined at 8 WAS by counting the number of branches emanating from the primary vine of the tagged plant and the mean value calculated and recorded. The number of leaves produced per tagged plant per plot was counted at 8 WAS and the mean was recorded. The TDM per plant was determined at 8 WAS at both locations. Two plants per plot from the two outer rows of pumpkins at each sampling period were cut from the ground, oven dried at 70^0C to a constant weight and the mean was recorded. The total leaf area per plant was determined at 8 WAS using leaf area meter (YMJ/A model 1) from the 3 tagged plants per plot and mean recorded.

LAI is the ratio of leaf surface area per unit of land surface. This was determined following the formula of Duncan and Hasketh (1968).

$$LAI = \frac{LA}{GA}$$ Where LA = leaf area and GA = Ground area

Data collected were subjected to analysis of variance (ANOVA) using Genstat 17th edition. Significant treatment means were ranked using the Student Newmans Keuls Test (SNK).

RESULTS AND DISCUSSION

The results of this study showed that almost all the growth characters examined responded positively to the application of moringa leaf extract levels (Tables 1 and 2). At the two locations application of moringa at 4 % resulted in longer vines, a higher number of branches and leaves while the lowest values were obtained with zero dosage (Table 1). The significant effect of moringa leaf extract on pumpkin vine length might be due to the role of plant growth regulators (PGR) in promoting cell division, elongation and crop growth. In an earlier study, Foidle *et al*. (2001) reported a significant effect on plant height on crops with foliar application of moringa leaf extract. The significant effect of moringa leaf extract on several leaves per plant might be connected with the ability of some crops to manifest a response to growth hormones faster than others. This result supported the earlier report of Remison and Mgbeze (2004) that number of leaves per plant of cowpea was significantly higher with PGR. Also according to Prabhu *et al.* (2009), number of leaves per plant of Kalmegh (*Andrographis paniculata*) increased with an aqueous extract of moringa at 2% concentration. This might be the reason for the significant effect of moringa leaf extract on leaf area per plant and leaf area index (LAI). Moringa leaf extract is rich in zeatin, carotenoids, phenols, ascorbates, potassium, and calcium which might have growth-promoting capabilities, which increase the leaf area by decreasing chlorophyll degeneration (Foidle *et al*., 2001). This finding has also been supported by Muhamman (2011) that leaf area of tomatoes was increased with moringa leaf extract.

At both locations, pumpkin sown in late June recorded longer vines, higher number of branches and leaves, higher dry matter per plant, higher LA and LAI (Tables 1 and 2). The effect of sowing date was significant on growth and growth characters of pumpkin in this study. The vegetative growth of pumpkin was significantly influenced by sowing date. Longer pumpkins bearing many leaves with higher dry matter were observed in pumpkin sown early in late June than those sown at later dates. Furthermore, pumpkin sown in late June recorded a significantly higher yield per hectare. Probably because the plants had enough vegetative and adequate photosynthetic activities due to early sowing compared to those sown later in the season. In accordance with the results obtained from this experiment, Bannayan *et al.* (2017) have reported an increased crop growth with optimum sowing date and a reduction in crop growth when sowing is delayed after the optimum time. This study indicated that the response of varieties to most of the growth characters evaluated were not significant. However, there were few significant differences at some sampling periods with Yar-Madina having a significant edge over Ex-Ajiwa concerning the number of leaves per plant and leaf area per plant. This might be due to the adaptability of the Indigenous variety to the environment (Lawal *et al*., 2009; Lassa and Wali, 2015) or cross-pollination because it has been reported that if pumpkin varieties were planted at a trekking distance of less than 250 m, cross-pollination would take place (Benard *et al*. 2018). This made it difficult to get true-to-type pumpkin fruits.

CONCLUSION

The result of this study showed that the growth and growth characteristics of pumpkin varieties were significantly influenced by the application of moringa leaf extract and sowing date in the study areas. Based on the result of this study application of moringa leaf extract at 4% resulted in higher growth parameters examined. Similarly, pumpkin sown in late June recorded significantly higher growth characters compared to other sowing dates. The result also revealed that Yar-Madina had a significant advantage over Ex-Ajiwa in some of the growth characters evaluated. Therefore the authors suggested the application of moringa leaf extract at 4% and sowing Yar-Madina in late June for optimum pumpkin growth and development in the Sudan Savannah ecological zone of Nigeria.

REFERENCES

Bannayan, M., Mortazagoldani. and Mohammad, R. N. (2017). Growth Analysis of Pumpkin (*Cucurbta pepo* L.) Under Various Management Practices and Temperature Regimes. *Agricultural Research and Technology: Open Access Journal*, **11**(1):555801.

Benard, H. Z., Edward, J. G. and Charles, T. S. (2008). Yield of Marketable Pumpkins and Squash Vary Considerably According to Weather Season, Type and Cultivar, Extension

News Letter, Michigan State University, Retrieved from www.msu.edu.

Blake, G. R. and Hartge, K. K. (1986). Methods of Soil Analysis Part 1 Agronomy Monographs No 9, 2nd Edition. American Society of Agronomy and Soil Science, Madison 161. Pp 20.

Delahaut, K. A. and Newenhouse, A. C. (2006). Growing Pumpkin and Other Vine Crops in Wisconsin: A Guide for Fresh Market Growers, University of Wisconsin Extension Publication, PP. 22.

Dunkan, N. G. and Hasketh, J. D. (1968). Net Photosynthesis Rates, Relative Growth Rates and Leaf number, 22 Rates of Maize at Eight Temperatures. *Crop Science*, **8**: 35-46.

Edward, B. and Jenny, J. (2009). ECHO, N. Ft. Myers, FL 33917, USA.

Facciola, S. (1990). Cornucopia-A Source Book for Edible Plants, Kamping Publications, California, U.S.A. PP 677.

Foidle, N., Makkar, H. P. S. and Becker, K. (2001). The Potential of *Moringa oleifera* for Agricultural and Industrial Uses. In Fuglie, L. J. (Editor) *The Miracle Tree*: The Multiple Attributes of Moringa. CTA and CWS, Dakar, Senegal. 168 pp.

Fuglie, L. (2008). New Uses Moringa Studies in Nicaragua. ECHO Technical News. *http://www.echotech.org*. Retrieved.

Jeffery, D. (1990). Appendix: An Outline classification of Cucurbitaceae. In: Bates DM, Robinson RW, Jeffery C. Biology and Utilization of the Cucurbitaceae. Ithaca and London: Cornell University, pp. 449- 463, 485.

Lassa, I. A. and Wali, A. S. (2015). Response of Pumpkin (*Cucurbita maxima* L.) Varieties to Defoliation Severity and Manure Rate. *Dutse Journal of Agriculture and Food Security*, **2**: 83-91.

Lassa, I. A., Usman, M., Usman, A. and Bugaje, S. M. (2015). Correlation and Regression Analysis of Squash Pumpkin (*Cucurbita maxima* L.) in Response to Defoliation Severity and Manure Rate. *Gashua Journal of Irrigation and Desertification Studies*. **1**(1&2): 69-74.

Lawal, A. B. (2000). Response of Cucumber (*Cucumis sativa* L.) to Inter-cropping with Maize (*Zea mays* L.) and Varying Rate of FYM and Inorganic Fertilizer. (Unpublished PhD thesis). Ahmadu Bello University, Zaria, pp 267.

Lawal, A. B. (2009). Correlation and Path Coefficient Studies in Squash Pumpkin (*Cucurbita maxima* L.). *Advances in Horticultural Sciences.* **23**(3): 197-200.

Lawal, A. B., Aissami, B. M. and Lawan, H. M. (2009). Influence of Mineral Fertilizer on Productivity and Growth of Four Varieties of Squash Pumpkin (*Cucurbita maxima* L.) *Advances in Horticultural Science,* **23**(3): 201-204.

Martin, L.P. (2000). The Moringa Tree. ECHOTechnical Note. http:// www.echonet.org Retrieved.

Muhamman, M. A. (2011). Effect of Aqueous Extract of Moringa (*Moringa oleifera* LAM.) and Nitrogen Rates on the Performance of Some Crops. (Unpublished PhD thesis). Bayero University, Kano, Nigeria. Pp 20-140.

Nee, M. (1990). The Domestication of Cucurbita (Cucurbitaceae), *Econ. Bot.***44**(3): 56-68.

Omafara, S. (2000). Pumpkin and Squash Production. Ministry of Agriculture, Food and Rural Affairs Ontario. Available at http://www.ontla.on.ca/library/repository.

Phiri, C. and Mbewe, D. N. (2010). Influence of Moringa Leaf Extract on Germination and Seedling Survival of Three Common Legumes. *Int Journal Agric Biology*. **12**: 315-317.

Prabhu, M. A., Ramesh, K. A. and Rajamani, K. (2009). Influence of Biostimulants on Growth, Yield and Economics of Kalmegh (*Andrographis paniculata*). *Madras Agricultural Journal*. **3**(3): 150-155.

Pratt, S.G, Mathew, K. (2003) Super Foods RX: Fourteen Foods That Will Change Your Life, Harper Collins, New York, 352 pp.

Remison, S. U. and Mgbeze, (2004). Response of Cowpea Plant to Foliar Application of Growth Regulators and Coconut Water. *The Nigerian Journal of Agriculture and Forestr*.**1**(1): 1-2.

Robinson, R. W., Munger, H. M. and Whitaker, D. W. (1976). Genes of Cucurbita, *Hort. Sci.* **8**(11):554-568.

Wards, E. (2007). 7 Nutrients Your Diets May Be Missing Available online: http://www.medicinenet.com/script/main/art.asp?articlekey=76710.

Table 1: Effect of Moringa Leaf Extract and Sowing Date on Vine Length (cm), Number of Branches and Number of Leaves Plant^{-1} of Pumpkin during 2019 Rainy Season at BUK and D/kudu

Treatment	Vine length		Number of branches		Number of leaves	
	BUK	D/kudu	BUK	D/kudu	BUK	D/kudu
Moringa Extract (%)						
0	235.6d	217.3d	1.72c	1.52d	28.73c	29.77c
2	297.7c	244.9c	1.83b	2.28a	34.25b	36.75b
3	320.2b	288.1b	2.06a	2.44a	33.87b	32.55c
4	340.6a	321.2a	2.22a	2.61a	38.91a	47.08a
SE ±	2.640	3.770	0.237	0.197	0.639	1.371
Probability level	0.004	0.008	0.023	0.034	0.001	0.001
Sowing Date						
Late June	277.8a	272.6a	1.92	2.4 a	38.09a	35.97
Early July	255.3b	250.4b	2.11	2.43a	31.47b	39.37
Mid-July	245.1c	241. 2c	2.11	2.11b	32.26b	34.27
SE ±	2.510	4.730	0.101	0.109	0.784	1.293
Probability level	0.004	0.017	0.313	0.027	0.001	0.052
Variety (V)						
Yar-Madina	270.0	261.1	2.02	2.01	35.40a	30.50
Ex-Ajiwa	263.9	267.4	2.07	2.04	32.48b	29.97
SE ±	2.050	3.850	0.056	0.144	0.640	1.056
Probability level	0.485	0.385	0.419	0.423	0.009	0.530
Interaction						
S x V	0.069	0.142	0.154	0.223	<.001	0.001
S x M	0.081	0.093	0.235	0.064	0.003	0.078
V x M	0.134	0.183	0.377	0.165	0.464	0.001
S x V x M	0.299	0.175	0.108	0.181	0.212	0.082

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using the Student–Newman Keuls Test.

Table 2: Effect of Moringa Leaf Extract and Sowing Date on Total Dry Matter (g), Leaf Area (cm^2), Leaf Area Index of Pumpkin during 2019 Rainy Season at BUK and Dawakin Kudu

Treatment	Total dry matter (g)		Leaf area (cm^2)		Leaf area index	
	BUK	D/kudu	BUK	D/kudu	BUK	D/kudu
Moringa Extract (%)						
0	93.69d	93.20c	6075c	6499c	1.55c	1.43c
2	104.7c	93.20c	8342b	9859b	1.75b	1.45c
3	120.2b	123.2b	8858b	8462b	1.93a	1.62b
4	136.9a	131.1a	11356a	15889a	2.01a	1.73a
SE ±	1.574	2.270	238.3	536.0	0.095	0.045
Probability level	0.001	0.010	0.001	0.001	0.001	0.001
Sowing Date						
Late June	122.9a	110.1	10280a	10350ab	2.00a	1.76a
Early July	102.1b	112.8	7283c	11222a	1.87b	1.45b
Mid-July	116.5a	107.6	9410b	8960b	1.76c	1.43b
SE ±	2.768	1.850	304.1	534.4	0.049	0.058
Probability level	0.002	0.184	0.001	0.039	0.004	0.008
Variety (V)						
Yar-Madina	120.9 a	113.3	9308a	12786a	1.89	154
Ex-Ajiwa	106.9 b	109.0	8007b	7569b	1.87	157
SE ±	2.260	1.510	248.3	436.3	0.090	0.074
Probability level	0.004	0.314	0.004	0.001	0.0175	0.191
Interaction						
S x V	<.001	0.223	<.001	<.001	0.066	0.149
S x M	0.002	0.145	0.062	0.012	0098	0.559
V x M	0.057	0.064	0.376	<.001	0.642	0.495
S x V x M	0.086	0.181	0.386	0.056	0.461	0.567

Means in the same column followed by the same letter (s) are not significantly different at 5% level of probability using Student–Newman Keuls Test.

EFFECTS OF ORTHOSILICIC ACID FERTILIZER ON STEM DIAMETER, STEM LIGNIN COMPOSITION AND FRUIT YIELD OF TOMATO

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ABSTRACT

Tomato plants often exhibit a prostrate growth habit at maturity due to weak stems and inconsistencies in the growth rates of upper (USD) and basal stem diameters (BSD). This study evaluates the effects of orthosilicic acid (OSA) fertilizer on tomato growth, focusing on its impact on stem lignin composition and strength. Four tomato cultivars—Kerewa, Roma-Savanna, Tropimech, and UC-82—were tested with OSA applications at 0, 500 and 1000 ml ha^{-1}, with 50 kg ha-^{1} of 15-N:15-P:15-K as basal fertilizer. The experiment followed a completely randomized block design. Application of 1000 ml ha^{-1} of OSA significantly enhanced vegetative growth, including plant height, USD, BSD, the rate of growth of USD and BSD, and leaf area. However, it reduced lignin content in the stems, leading to an increased prostrate angle (58.13°). In contrast, applying 500 ml ha^{-1} of OSA increased lignin content in the stems (except in Tropimech) and improved the rate of growth of the upper stem in Kerewa, though it decreased basal stem growth rate in Tropimech. Kerewa achieved the highest fruit yield per plant and the lowest prostrate angle (7.50°), attributed to a consistent increase in the growth rates of USD and BSD with OSA application. The results suggest that moderate OSA application (500 ml ha^{-1}) can enhance lignin content and promote a more erect growth habit in tomatoes, thereby improving both growth and fruit yield.

Keywords: basal stem, stem lignin, silicon, upper stem,, fruit yield.

INTRODUCTION

Prostrate growth in tomato plants is a significant issue affecting yield and fruit quality, often leading to increased production costs (Ozminkowski et al., 1990; Olagunju et al., 2019). Tomato stems typically exhibit a robust basal diameter and a narrower upper stem diameter during the vegetative stage. As the plant matures, the basal stem becomes thinner compared to the upper stem, resulting in prostrate growth, particularly under field conditions (Olagunju et al., 2024). This condition is exacerbated by the heavy fruit load at maturity, which the tomato stem architecture struggles to support. Consequently, the use of stakes to support the plants at maturity adds to production costs (Frasca et al., 2014) and increases the risk of fruit rot due to prolonged soil contact, making pest and disease management more challenging.

Orthosilicic acid (OSA) fertilizer is a foliar-applied silicon source that strengthens plant stems mechanically (Tayade et al., 2022). While plants in the Poaceae family are major silicon accumulators, tomato plants from the Solanaceae family accumulate silicon at lower levels. Nonetheless, silicon fertilization can still benefit tomatoes (Lei et al., 2024). Silicon has been reported to mitigate both biotic and abiotic stress impacts and enhance photosynthetic efficiency, leading to improved crop yields (Barão, 2023). Achieving an optimal balance between increased yield and enhanced stem strength through silicon application, particularly in the basal stem, is essential for maximizing productivity.

Stem strength in plants is influenced by structural components such as lignin, cellulose, and hemicelluloses, with lignin being crucial for rigidity and structural integrity in cell walls. Differences in lignin content between upper and basal stem regions in tomatoes may reflect variations in growth dynamics that affect overall plant growth habits. This study investigates how silicon treatment impacts upper and basal stem diameters and lignin content in tomato stems, and explores its effects on fruit yield, shedding light on the underlying morphological and physiological mechanisms.

MATERIALS AND METHODS

Experimental Site: The study was conducted in an open field pot arrangement near the Faculty of Agricultural Production and Renewable Resources, Olabisi Onabanjo University, Ayetoro Campus. The site experiences temperatures between 22°C and 34°C and relative humidity of 74% to 85%. The loamy-sand soil from the upper crest of the college farm has good drainage and high iron content. Watering was done with rainwater and supplemental irrigation from a borehole, applied only on rainless days.

Experimental Design: Four tomato cultivars were used: Roma-VF, Tropimech, UC-82 (improved determinate), and Kerewa (local indeterminate). The experiment included three fertilizer treatments with orthosilicic acid (OSA): 0 ml ha^{-1} OSA, 500 ml ha^{-1}OSA, and 1000 ml ha^{-1} OSA while 50 kg/ha of 15N:15P:15K. was applied as basal fertilizer to all experimental plants. The design was replicated three times, resulting in 36 treatment combinations (4 cultivars × 3 treatments × 3 replications).

Experimental Setup: Each 7-liter pot was filled with 5 kg of loamy-sand soil. Seeds were germinated and nursed for 21 days before transplanting one seedling per pot. OSA treatments were spaced 2 meters apart, with replicate blocks aligned perpendicular to wind flow. Fertilizer was applied two weeks after transplanting. OSA was sprayed three times starting two weeks post-transplanting, with solutions prepared at 2 ml/l for 500 ml/ha and 4 ml/l for 1000 ml/ha, applied during cooler hours.

Stem Lignin Analysis: At full fruit formation, basal and upper stem segments (5 cm each) were collected, cleaned, and ground into powder form. Lignin was extracted using ethanol and toluene (Salim et al., 2021) and quantified using the acetyl bromide method (Moreira-Vilar, 2014).

Data Collection: At fruit maturity, data on vegetative (stem diameters, plant height, leaf area, posture score), lodging (lodging angles), and fruit yield (number, weight per plant, average fruit weight) were collected. Stem segments were dried, ground, and analyzed. Ratios and diameter variations were calculated following Xie et al. (2019) and Olagunju et al. (2024). The plant habit angle was computed as: $\text{Plant habit angle} = (X - X_i) \times \{\frac{\text{Maximum angle } (90^0)}{X_n - X_i}\}$

where 'X' represents actual visual plant habit score while X_i and X_n are respectively minimum (1) and maximum (5) visual plant habit scores.

Data Analysis: Data were analyzed using ANOVA with Fisher's Protected LSD for mean separation. Correlation analysis was performed, with data standardized by computing the fractions of each data point relative to overall parameter means.

RESULTS AND DISCUSSION

The effects of orthosilicic acid (OSA) fertilizer rates on vegetative growth, lignin composition, and fruit yield attributes of tomato are summarized in Table 1. Application of 1000 ml ha^{-1} OSA significantly increased vegetative growth parameters, including plant height, basal and upper stem diameters, average stem diameter, rate of change of upper stem, and leaf area, resulting in more sprawling growth habits and prostrate angle of 58.13° across cultivars. However, this high OSA rate decreased lignin content in both upper and basal stems. In contrast, moderate application at 500 ml ha^{-1} significantly increased lignin composition in both stem parts. This suggests a trade-off between growth rate and lignin accumulation, where higher OSA dose boost growth but diminish lignin content, affecting stem strength and structural integrity.

Among the cultivars, Kerewa showed significant differences in basal stem diameter, average stem diameter, rate of change of basal stem diameter, and lignin composition of the upper stem, as well as in fruit attributes such as the number of fruits per plant and total fruit weight. Kerewa consistently recorded the highest values for these variables. Significant interactions between OSA fertilizer rates and cultivars were observed for the rate of change in upper stem diameter and lignin content of both stem parts.

Figure 1 illustrates how OSA fertilizer rates and cultivars interact to affect stem diameter growth and lignin composition. With increased OSA to 500 ml ha-¹, lignin content in both basal and upper stems increased, except for Tropimech, which showed a decrease. Without OSA, Kerewa and Roma-savanna had higher lignin content in the basal stem compared to the upper stem. The observed differences in lignin composition between basal and upper stems can be attributed to their respective maturity and structural roles. The basal stem, being more mature, requires higher lignin content for enhanced support of the plant's upper parts (Abiven et al., 2011) . Conversely, apical stems, characterized by ongoing cell division, exhibit varying lignin patterns. Notably, with an increased OSA application rate of 500 ml ha-¹, lignin deposition in the upper stem matched the levels found in the basal stem especially in Kerewa and Roma-Savanna but then declined sharply with a further increase to 1000 ml ha-¹ OSA across all cultivars. This increased lignin accumulation in the upper stem at 500 ml ha-1 may be due to the direct effects of foliar-applied OSA on the tomato foliage. These findings are consistent with previous studies showing that lignin content varies among different plant organs and developmental stages, and is influenced by fertilization practices (Wang et al., 2023).

Growth rate responses differed from lignin composition trends. Only Kerewa experienced consistent growth increases in both stem parts with higher OSA rates. The upper stem growth rate rapidly increased with 500 ml ha-¹ OSA, matching the basal stem diameter. The consistent increase in growth rates of both basal and upper stems, especially in the Kerewa cultivar, contributed to a more balanced stem architecture. Kerewa maintained a reduced prostrate angle (more erect growth) compared to other cultivars, demonstrating a consistent rise in growth with increasing OSA application. This suggests that breeding for cultivars with uniform stem diameter along the stem length could reduce prostrate growth, improving fruit quality and reducing production costs associated with staking. No significant growth changes were observed with 1000 ml ha-¹ OSA for Kerewa and Roma-savanna while UC-82 did not show significant changes in stem growth across OSA rates.

Table 2 presents correlation analysis results between vegetative growth variables, yield attributes, and lignin composition. Significant correlations were found among stem diameters, plant height, and average stem diameter, with the highest correlation between basal stem diameter and average stem diameter (0.90**). Plant height, upper stem diameter, rate of change of upper stem diameter, leaf area, and lignin content of both stem parts correlated with prostrate angle. Lignin composition showed negative correlations with the prostrate angle (-0.46 for upper stem and -0.50 for basal stem). An inverse correlation between stem lignin content and prostrate angle further indicates the role of lignin in strengthening the stem and supporting erect growth. The positive correlation between vegetative growth variables and posture angle suggests that increased growth contributes to a prostrate growth habit possibly through increased self-load on plant. Therefore, managing the balance between growth rate and lignin composition is crucial for breeding improved tomato cultivars with desirable growth habits and structural stability.

CONCLUSION

Orthosilicic acid fertilizer was effective in increasing the vegetative growth of tomato cultivars when applied at higher dozes but cumulates in increased prostrate angle leading to prostrate growth. Meanwhile, moderate application of 500 ml ha-1 of OSA fertilizer increased the lignin composition of both basal and upper stem of the tomato. Managing the trade-off between growth rate and lignin composition is crucial for breeding improved tomato cultivars with desirable growth habits and structural stability.

REFERENCES

Abiven, S., Heim, A., & Schmidt, M. W. I. (2011). Lignin content and chemical characteristics in maize and wheat vary between plant organs and growth stages: consequences for assessing lignin dynamics in soil. Plant and Soil, 343, 369–378. https://doi.org/10.1007/s11104-011-0725-y.

Barão, L. (2023). The use of Si-based fertilization to improve agricultural performance. Journal of Soil Science and Plant Nutrition, 23(1), 1096-1108. https://doi.org/10.1007/s42729-022-01106-1.

Frasca, A. C., Ozores-Hampton, M., Scott, J., & McAvoy, E. (2014). Effect of plant population and breeding lines on fresh-market, compact growth habit tomatoes growth, flowering pattern, yield, and postharvest quality. HortScience, 49, 1529–1536.

Lei, F., Pan, X., Lin, H., Zhang, Z., Zhang, W., Tan, H., Yang, M., & Liu, H. (2024). Silicon improves the plant growth and fruit quality of cherry tomato (Solanum lycopersicum var. cerasiforme) under nitrogen imbalance by modulating nitrogen assimilation and photosynthesis. Journal of Soil Science and Plant Nutrition. Advance online publication. https://doi.org/10.1007/s42729-024-01902-x.

Moreira-Vilar, F. C., Siqueira-Soares, R. d. C., Finger-Teixeira, A., de Oliveira, D. M., Ferro, A. P., da Rocha, G. J., Ferrarese, M. de L. L., dos Santos, W. D., & Ferrarese-Filho, O. (2014). The acetyl bromide method is faster, simpler and presents best recovery of lignin in different herbaceous tissues than Klason and thioglycolic acid methods. PLOS ONE, 9(10), e110000. https://doi.org/10.1371/journal.pone.0110000.

Olagunju, S.O., Sosanya, O.S., Oguntade, O.A., Adewusi, K.M., Odusanya, O.A., Nassir, A.L., Joda, A.O., Adegoke, A.T., & Banjo, O.B. (2019). Prostrate or upright growth habit in tomato cultivars. Advances in Horticultural Science, 33(4), 465-474.

Olagunju, S. O., Sosanya, O. S., Oguntade, O. A., Adewusi, K. M., Soremi, P. A. S., Joda, A. O., & Nassir, A. L. (2024). Effect of NPK fertilizer on upper and basal stem diameters and implication on growth habit of tomato. Journal of the Saudi Society of Agricultural Sciences, 23, 55-66.

Ozminkowski Jr., R. H., Gardner, R. G., Henderson, W. R., & Moll, R. H. (1990). Prostrate growth habit enhances fresh-market tomato fruit yield and quality. HortScience, 25(8), 914–915. https://doi.org/10.21273/HORTSCI.25.8.914.

Salim, R. M., Asik, J., & Sarjadi, M. S. (2021). Chemical functional groups of extractives, cellulose and lignin extracted from native Leucaena leucocephala bark. Wood Science and Technology, 55(2), 295-313. https://doi.org/10.1007/s00226-020-01258-2.

Tayade, R., Ghimire, A., Khan, W., Lay, L., Attipoe, J. Q., & Kim, Y. (2022). Silicon as a smart fertilizer for sustainability and crop improvement. Biomolecules, 12(8), Article 1027. https://doi.org/10.3390/biom12081027.

Wang, G.-L., Wu, J.-Q., Chen, Y.-Y., Xu, Y.-J., Zhou, C.-L., Hu, Z.-Z., Ren, X.-Q., & Xiong, A.-S. (2023). More or Less: Recent Advances in Lignin Accumulation and Regulation in Horticultural Crops. Agronomy, 13(11), 2819. https://doi.org/10.3390/agronomy13112819.

Table 1: Effects of orthosilicic acid fertilizer rates on vegetative growth, lignin composition of upper and basal stems and fruit yield of tomato cultivars.

Sources/ levels of variation	PH (cm)	BSD (mm)	USD (mm)	ASD (mm)	SD:PH	SDV cm^{-1})	rt-BSD (mm day^{-1})	rt-USD (mm day^{-1})	LA (cm^{2})	LUS (%)	LBS (%)	NFP	AWF (g)	TFWP (g)	AFV (cm^{3})	PP	P angle
OSA rates (OSA)																	
0ml ha^{-1}	40.64^{b}	5.63^{b}	4.45^{b}	5.04^{b}	0.13^{a}	0.52^{a}	0.08^{a}	0.08^{b}	15.69^{b}	12.61^{b}	14.48^{b}	3.42^{a}	9.24^{a}	27.25^{a}	11.09^{a}	1.42^{b}	9.38^{b}
500ml ha^{-1}	37.78^{b}	5.85^{b}	4.71^{b}	5.28^{b}	0.17^{a}	0.50^{a}	0.09^{a}	0.08^{b}	12.70^{b}	16.09^{a}	16.35^{a}	4.08^{a}	11.39^{a}	38.97^{a}	10.62^{a}	1.25^{b}	5.63^{b}
1000 ml ha^{-1}	51.38^{a}	6.70^{a}	5.66^{a}	6.18^{a}	0.12^{a}	0.28^{a}	0.11^{a}	0.10^{a}	21.15^{a}	12.56^{b}	12.91^{c}	3.50^{a}	14.57^{a}	45.64^{a}	17.19^{a}	3.58^{a}	58.13^{a}
LSD	*8.35*	*0.62*	*0.55*	*0.47*	*0.05*	*0.42*	*0.02*	*0.01*	*5.01*	*0.61*	*1.10*	*1.97*	*6.91*	*17.05*	*5.99*	*0.76*	*17.02*
Significance	**	**	**	**	ns	ns	ns	**	**	**	**	ns	ns	ns	ns	**	**
Cultivars (C)																	
Kerewa	49.04^{a}	6.71^{a}	5.32^{a}	6.02^{a}	0.12^{a}	0.44^{a}	0.12^{a}	0.10^{a}	14.47^{a}	14.28^{a}	15.24^{a}	7.00^{a}	8.50^{a}	54.50^{a}	10.19^{a}	1.33^{a}	7.50^{a}
Roma-savanna	43.66^{a}	5.94^{b}	4.77^{a}	5.36^{b}	0.14^{a}	0.53^{a}	0.09^{b}	0.08^{a}	16.26^{a}	13.65^{ab}	14.64^{a}	1.67^{b}	13.68^{a}	24.20^{b}	14.93^{a}	2.33^{a}	30.00^{a}
Tropimech	37.81^{a}	5.76^{b}	4.69^{a}	5.23^{b}	0.17^{a}	0.42^{a}	0.09^{b}	0.08^{a}	18.34^{a}	13.23^{b}	14.03^{a}	2.67^{b}	13.90^{a}	34.70^{b}	15.93^{a}	2.22^{a}	27.50^{a}
UC-82	42.54^{a}	5.80^{b}	4.97^{a}	5.39^{b}	0.13^{a}	0.35^{a}	0.08^{b}	0.09^{a}	16.98^{a}	13.86^{ab}	14.40^{a}	3.33^{b}	10.86^{a}	35.74^{ab}	10.81^{a}	2.44^{a}	32.50^{a}
LSD	*9.64*	*0.71*	*0.64*	*0.54*	*0.05*	*0.49*	*0.02*	*0.02*	*5.78*	*0.71*	*1.27*	*2.27*	*7.98*	*19.69*	*6.92*	*0.87*	*19.65*
Significance	ns	**	ns	*	ns	ns	*	ns	ns	*	ns	**	ns	*	ns	ns	ns
OSA x C	ns	ns	ns	ns	ns	ns	ns	*	ns	**	*	ns	ns	ns	ns	ns	ns

**,* = significant at 1% and 5% level of probability; ns= non-significant; LSD = Least significant difference. OSA = Orthosilicic acid fertilizer; NPK = 15-Nitrogen: 15-Phosphorus: 15 Potassium; PH = Plant height; BSD= Basal stem diameter; USD= Upper stem diameter; ASD=Average stem diameter; SD:PH= Stem diameter to plant height ratio; SDV= Stem diameter variation; rt-BSD= rate of change of basal stem diameter; rt-USD= rate of change of upper stem diameter; LA= Leaf area; LUS= Lignin content of upper stem; LBS= Lignin content of basal stem; NFP= Number of fruits plant^{-1}; AWF= Average weight of fruit; TFWP= total fruit weight plant^{-1}; AFV= average fruit volume; PP= Plant posture; P-angle= angle of posture

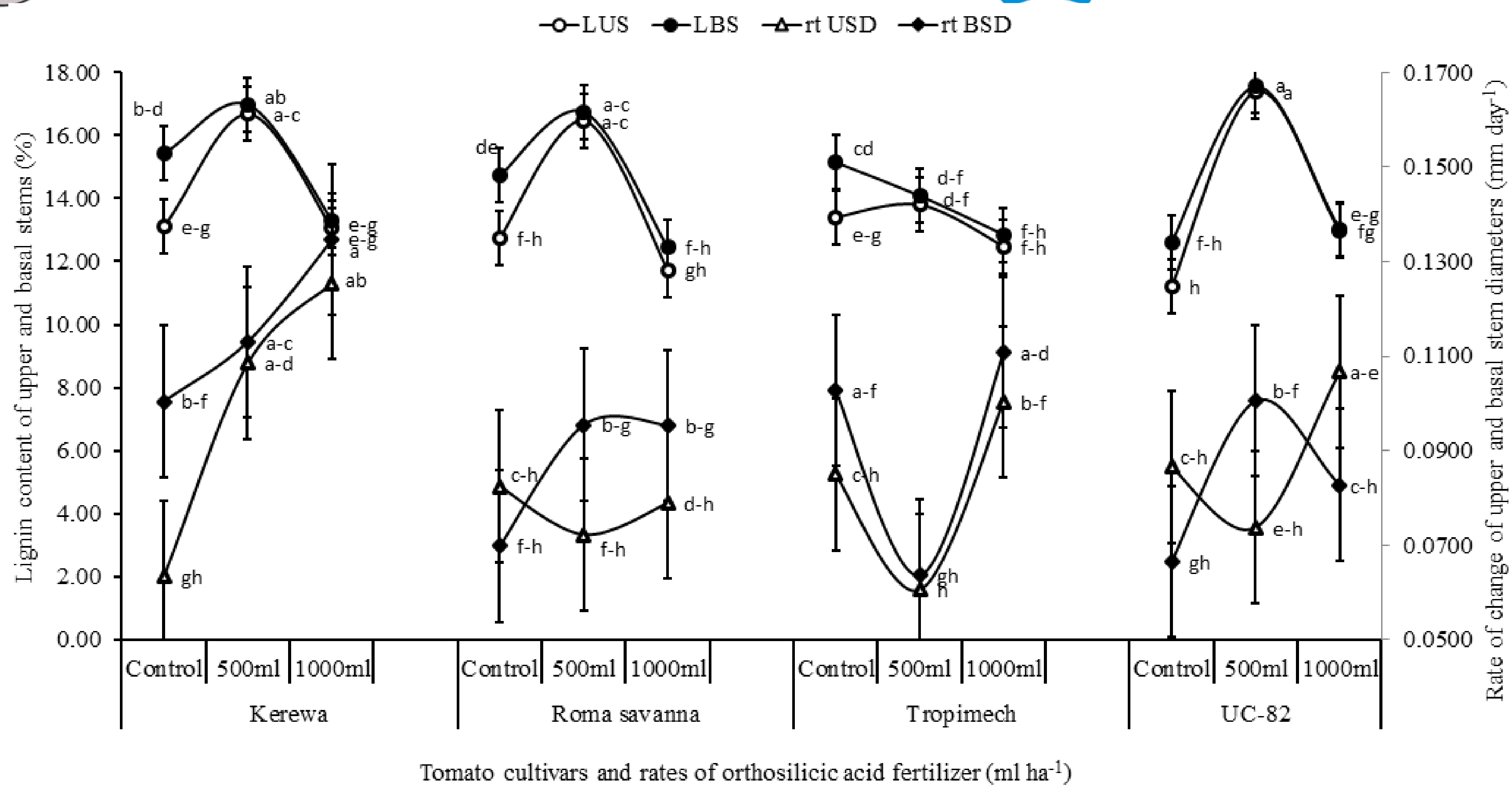

Figure 1: Interaction of cultivar and OSA fertilizer rates on stem lignin composition and rate of growth of upper and basal stem of tomato cultivars.

Please note that different error bars were used for each of lignin composition comparisons and rate of change comparisons of stem diameters. Overlapping error bars with same letter(s) within each row of graphs, representing each of stem lignin composition and rate of growth in stem diameters graph, are not significantly different from one another.

Table 2: Pearson moment correlation between vegetative and yield attributes and lignin composition of upper and basal stems of tomato cultivars under orthosilicic acid fertilizer rates

	PH	BSD	USD	AvSD	SD_PH	SDV_N	rt_BSD	rt_USD	LA	LUS	LBS	NF	AWF	TFW	AFV	P-angle
PH																
BSD	**0.60**															
USD	**0.45**	**0.58**														
AvSD	**0.60**	**0.90**	**0.87**													
SD_PH	**-0.86**	***-0.40***	-0.21	***-0.35***												
SDV_N	-0.22	0.11	**-0.56**	-0.22	0.21											
rt_BSD	***0.40***	**0.78**	***0.33***	**0.64**	-0.25	0.23										
rt_USD	**0.45**	**0.43**	**0.79**	**0.67**	-0.31	***-0.40***	***0.36***									
LA	**0.45**	0.27	0.22	0.28	***-0.40***	-0.13	0.04	0.24								
LUS	-0.01	0.07	-0.08	0.00	0.02	0.11	0.21	-0.08	-0.30							
LBS	-0.03	-0.01	-0.19	-0.11	-0.02	0.22	0.02	-0.16	-0.24	**0.82**						
NF	0.27	***0.36***	0.21	0.33	-0.19	-0.05	0.27	0.22	-0.23	0.16	0.13					
AWF	0.24	0.28	-0.02	0.16	-0.05	0.12	0.27	-0.13	0.23	-0.07	-0.22	-0.25				
TFW	**0.46**	**0.56**	0.28	**0.48**	-0.24	-0.05	***0.41***	0.16	0.03	0.11	-0.04	**0.69**	***0.42***			
AFV	0.33	***0.35***	0.04	0.23	-0.15	0.05	0.27	-0.08	0.32	-0.26	***-0.38***	-0.14	**0.93**	**0.48**		
P-angle	***0.34***	0.11	***0.42***	0.29	-0.17	-0.31	-0.05	***0.33***	**0.43**	**-0.46**	**-0.50**	-0.26	0.29	0.01	***0.36***	

Values in bold form are significant correlations at 1% level of probability while those in bold italics are significant at 5% level of probability. Correlation threshold values for the two levels of probability i.e 1% and 5% are respectively 0.43 and 0.33. Please see the full meanings of acronyms used in this table in Table 1.

AMARANTH (A*maranthus spp.*) VARIETAL GROWTH PERFORMANCE AND RELATIONSHIP AMONG MORPHOLOGICAL CHARACTERISTICS IN KASHERE, GOMBE STATE, NIGERIA

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ABSTRACT

Amaranth is known for its adaptability to a wide range of climates and soil conditions. This adaptability has facilitated its cultivation in diverse geographical regions, ranging from tropical to temperate zones. Each variety exhibits distinct morphological traits contributing to the overall genetic variability of the amaranth crop. This study aimed to assess variability for growth performance of amaranth and to analyze their relationship for better adaptability. The potted experiment consisted of three different varieties of amaranth laid out in a Completely Randomized Design in three replications under glass house condition. The findings revealed that A. hypchundriacus exhibited the most vigorous growth in plant height, leaf length, and leaf width, making it the most robust variety. A. cruentus demonstrated moderate growth characteristics, while A. retroflexus showed the smallest size but quicker maturation. All varieties had a similar texture change from smooth to rough and a color shift from green to dark green as they matured. A. hypchundriacus also outperformed in seed yield and biomass, while A. retroflexus excelled in leaf yield, and A. cruentus provided a balanced performance. The study concludes that A. hypchundriacus is best suited for grain and biomass production due to its superior growth and yield traits. A. retroflexus is recommended for leafy vegetable production due to its quick maturity and high leaf yield, and A. cruentus offers a versatile option for varied production needs. The findings highlight significant genetic variability that can inform breeding programs aimed at improving Amaranth's adaptability, yield, and nutritional value Recommendations include selecting A. hypchundriacus for high-yield production, A. retroflexus for regions with shorter growing seasons, and A. cruentus for a balanced approach. Further research is suggested to explore the varieties under different conditions and to assess their nutritional content. Additionally, agricultural extension services should focus on guiding farmers on optimal practices for Amaranth cultivation based on these findings. This research contributes to enhancing agricultural practices in the region, optimizing crop management, and advancing breeding strategies
Keywords*:* Amaranth *spp*; Growth Performance; Kashere; Correlation; Characters

INTRODUCTION

Amaranth (*Amaranthus* spp.) has a rich history deeply rooted in diverse cultures around the world. The genus Amaranthus is believed to have originated in the Americas, with archaeological evidence indicating its use by ancient civilizations such as the Aztecs and Incas (Smith, 2008). These cultures not only utilized amaranth as a staple food but also held it in high regard for its cultural and ceremonial significance. Beyond its cultural and nutritional roles, amaranth is recognized for its potential in sustainable agriculture. Its ability to thrive in diverse environments contributes to biodiversity conservation and the cultivation of crops that are resilient to changing climatic conditions (Cheng 2018). Amaranth (*Amaranthus spp*.) stands out as a nutritionally dense crop, offering a unique profile of essential nutrients that contributes to its reputation as a valuable and health-promoting food source. Amaranth is renowned for its exceptionally high protein content, and its protein profile is notable for being well-balanced and containing all essential amino acids. (Malik *et, al,*. 2023*)*.

The protein content in amaranth seeds can range from 12% to 17%, making it comparable to the protein content found in animal products (Martinez-Ballesta *et al.,* 2016). This high-quality protein profile contributes to its importance, especially in regions where protein deficiency is a prevalent dietary concern. Amaranth is a rich source of various vitamins, including vitamin A, vitamin C, vitamin E, and several B vitamins. The presence of vitamin A is particularly significant for its role in maintaining vision, immune function, and skin health. Additionally, the abundance of B vitamins, such as folate, riboflavin, and niacin, contributes to energy metabolism and overall well-being (Martinez-Ballesta *et al.,* 2016). Amaranth is a mineral powerhouse, providing essential minerals that are crucial for various physiological functions. It is particularly rich in calcium, iron, magnesium, phosphorus, potassium, and zinc. (Malvi 2011).

The calcium content in amaranth is noteworthy, making it a valuable option for individuals seeking alternative sources of this essential mineral, especially those who are lactose intolerant or have limited access to dairy products (Bressani, 2004). Several unique nutritional qualities set amaranth apart from other crops: Amaranth is distinguished by its high lysine content, an essential amino acid that is often deficient in cereal grains. This makes amaranth a complementary protein source when combined with other grains, contributing to a more balanced amino acid profile in the diet (Mburu *et, al,*. 2011).

Amaranth is naturally gluten-free, making it a valuable grain alternative for individuals with gluten sensitivity or celiac disease. Its gluten-free nature has led to increased interest in incorporating amaranth into gluten-free diets and the development of gluten-free products. Amaranth contains various phytochemicals and antioxidants, including polyphenols and flavonoids (Achigan-Dako *et, al,*. 2014). These compounds contribute to its potential health-promoting properties and may offer protection against oxidative stress and inflammation (Gomez-Caravaca *et al.,* 2017). Amaranth has gained prominence in modern agriculture owing to its adaptability to diverse climates and soils, as well as its potential as a sustainable and resilient crop. Its unique characteristics contribute to its increasing recognition as an essential component of sustainable agriculture practices.

Amaranth leaves are renowned for their high content of essential nutrients, including proteins, vitamins, and minerals (Iftikhar and Khan, 2019). The leaves are particularly rich in proteins, offering a well-balanced amino acid profile. Additionally, they are a good source of vitamins such as vitamin A, vitamin C, and several B vitamins, contributing to overall nutritional adequacy (Martinez-Ballesta *et. al.,* 2016). Amaranth leaves are a notable source of essential minerals, with significant concentrations of calcium, iron, magnesium, phosphorus, potassium, and zinc (Sarker *et al,*. 2020).

The availability of these minerals contributes to the nutritional diversity offered by amaranth, addressing dietary deficiencies in regions where access to such minerals may be limited (Bressani, 2004). Given its nutritional richness, amaranth leaves have been recognized as a potential tool for addressing malnutrition, particularly in areas where access to a diverse range of foods is limited. The leaves' nutritional density positions amaranth as a crop with the capacity to improve dietary quality and contribute to food security.

This research holds substantial significance in enhancing agricultural practices related to amaranth cultivation. Insights into morphological character relationship for the development of improved cultivation practices tailored to specific amaranth varieties. The aim of this study is to determine the morphological growth performance of amaranth varieties and relationship among the morphological characters in Kashere.

METHODOLOGY

Study Area

The experiment was conducted in the Teaching and Research Farm, Faculty of Agriculture, Federal University of Kashere, Akko L.G.A., Gombe state, Nigeria. It is located at an elevation of 431 meters above sea level. It lies between latitude $9^{o.}$ 55 N and longitude 11^{0} E, on the Northern fringes of the Northern Guinea Savanna belt of Nigeria.

Treatment and Experimental Design

Experimental procedures

The research adopted Completely Randomized Design (CRD) in Three (3) replications to minimize variability and account for potential confounding factors. The three (3) amaranth varieties were randomly assigned to two pots in each replication (Total of Six Pots per replication), allowing for a robust comparison of characters. These give a total of 18 pots in three replications. Broadcasting method was applied during planting and later thinned to 4 stands per pot for each variety.

Selection of Amaranth varieties and Cultural Practices

The three species of amaranth used in this study are: *A. hypchundriacus A. cruentus* and *A. retroflexus.* The seeds were sourced from local markets in Kashere, Gombe State. Before planting, the Amaranth seeds were cleaned and free from any contaminants. The seeds were sowed directly into the pots at a depth of about 1-2 cm. The seeds were spaced evenly to avoid overcrowding, which was to enhance growth and prevent competition for resources. The soil was consistently moist but not waterlogged. The pots were watered regularly, allowing the top inch of soil to dry out slightly between watering.

A pot with adequate drainage holes was chosen to prevent waterlogging, which can lead to root rot. The size of the pots was 20-30 cm in diameter, which was filled with a high-quality potting mix that includes animal dung and the soil was well-draining and rich in organic matter.

The plants were regularly inspected for signs of pests such as aphids or spider mites, and diseases like mildew or fungal infections. Appropriate pest control methods were used to maintain good sanitation practices so as to minimize the risk of problems.

Data collection and data analysis

Morphological Characters were recorded based on observations on the field. These include:

2 Plant height (cm): Measured for the top soil to the tip of the plant
3 Leaf size: Measure the length and width of representative leaves.
4 Leaf color: Note the color of both the upper and lower leaf surfaces.
5 Leaf texture: Observe the texture of leaves, whether they are smooth, rough, or have specific surface features.

All data collected were subjected to Analysis of Variance (ANOVA) using SAS software. Significant means were separated using Least Significance Difference (LSD) tool at 5% level of significance. Pearson Correlation Coefficient was carried out to determine the relationship among the morphological characters.

RESULTS AND DISCUSSION

Varietal Performance of Selected Amaranth Varieties

Plant Height (cm)

The plant height is recorded at four different growth stages and the values represent the mean plant height for each variety at each stage (Table 1). *A. hypchundriacus* appeared to be the tallest variety consistently across all growth stages, indicating it has the most vigorous growth among the three varieties. *A. cruentus* generally shows moderate growth, while *A. retroflexus* consistently has the lowest plant height (Table 1). Despite *A. hypchundriacus* having the highest heights, the differences between the varieties are not statistically significant (P<0.05) at week 2, 3, and 4 with *A. cruentus*. This means that the observed differences in height could be due to random variation rather than a true difference between the varieties. These findings suggest that while *A. hypchundriacus* shows a trend of being the tallest variety, further investigation or more data might be needed to confirm these differences are significant in practical terms. This study conforms with the findings of Kandpal *et al.* (2015); Iftikhar and Khan (2019).

Leaf Length (cm)

Table 2 show the length of leaf of the amaranth varieties at 4 stages of growth during the period of the experiment. *A. hypchundriacus* consistently exhibits the greatest leaf length across all four weeks, showing significantly (P<0.05) longer lengths compared to *A. retroflexus* at all stages. *A. cruentus* show moderate leaf length, while *A. retroflexus* has the shortest length across all weeks. At Week 1, *A. hypchundriacus* is significantly longer than *A. retroflexus*, but the difference between *A. hypchundriacus* and *A. cruentus* is not significant (P<0.05). At Weeks 2, 3, and 4, *A. hypchundriacus* is significantly longer than *A. retroflexus*, but the difference between *A. hypchundriacus* and *A. cruentus* does not reach statistical significance, nor does the difference between *A. cruentus* and *A. retroflexus*. *A. hypchundriacus* appears to be the most vigorous variety in terms of leaf length growth, especially when compared to *A. retroflexus*, which consistently shows the least growth. Similar findigs were observed by Kandpal *et al.* (2015); Iftikhar and Khan (2019).

The results suggest that *A. hypchundriacus* may be more suited to conditions in Kashere, Gombe State, or that it possesses inherent genetic characters promoting better growth under the conditions studied. However, more significant differences between *A. hypchundriacus* and *A. cruentus* would need further examination to draw stronger conclusions regarding their relative performance.

Leaf width (cm)

Table 3 reported the effect of different varieties of amaranth grown at Kashere at four different growth stages. *A. hypchundriacus* consistently shows the greatest leaf width across all four weeks, indicating it has a more vigorous lateral growth compared to the other varieties. *A. cruentus* generally shows moderate width, while *A. retroflexus* has the narrowest width throughout the study. Both *A. cruentus* and *A. hypchundriacus* are significantly wider than *A.*

retroflexus in week 1 (P<0.05). While at week 2, *A. hypchundriacus* is significantly wider than both *A. cruentus* and *A. retroflexus*. *A. hypchundriacus* is significantly wider than *A. retroflexus* both at week 3 and week 4, but the difference between *A. hypchundriacus* and *A. cruentus* is not statistically significant (P<0.05).

A. hypchundriacus is the most robust variety in terms of plant width, particularly when compared to *A. retroflexus*. The data suggest that *A. hypchundriacus* has better lateral growth, which could be advantageous for ground coverage and resource competition. *A. cruentus* also performs relatively well but does not exhibit the same significant advantages over *A. hypchundriacus* (P<0.05) Similar findings were indicated by Joshi *et al*. (2018) and Kandpal *et al.* (2015). Further studies might explore the implications of this lateral growth on yield and other agronomic traits.

Qualitative Growth Characters

Leaf texture

All varieties exhibit a smooth texture, indicating a similar stage of development during the early weeks of growth (Table 4). At Late Growth in week 4, the shift to a rough texture in week 4 is consistent across all varieties, signalling a maturation phase or a response to external factors as the plants develop. The consistent texture change from smooth to rough across all varieties suggests a typical growth pattern for Amaranth in this environment. The rough texture in the later stage could be an indicator of the plant's maturation, potentially impacting factors like leaf toughness or water retention. Understanding this texture transition could be valuable for determining the optimal harvest time or for breeding purposes if texture is an important trait for particular uses of Amaranth. This is in line with the observations made by Cabanillas *et at*., (2017).

Leaf colour

At weeks 1 and week 2, all varieties display green leaves, indicating a typical early-stage colour for Amaranth plants (Table 5). This colour suggests that the plants are in an initial growth phase with active photosynthesis. While at the late growth in week 3 and week 4, the shift to dark green leaves in the third week indicates a maturation phase. Dark green leaves are typically associated with higher chlorophyll content, which could be linked to increased photosynthetic efficiency and nutrient accumulation.

The consistent colour changes from green to dark green across all varieties indicates a common developmental pattern for Amaranth in this environment. This colour progression might be used as a visual indicator of the plant's growth stage and readiness for certain agricultural practices, such as harvesting. The uniformity across varieties suggests that color might not be a distinguishing trait among these particular Amaranth varieties under the given conditions. This was also observed by Cabanillas *et at*. (2017); Joshi *et al*. (2018).

Correlation Coefficient

Table 6 showed the correlation coefficient among the studied growth characters of the Amaranth. It shows that there is a strong, significant ($P<0.05$) and positive relationship among the studied characters during the period of the experiment (Table 6). This indicated that as the plant height is increasing, the leaf length and leaf width are also increasing simultaneously. Plant height increases positively as the leaf length and leaf width increases consistently. Similarly, leaf length increases as the leaf width also increase indicating a strong influence of plant height, leaf length and leaf width on the growth performance of amaranth. This is in conformity with the findings of Gerrano *et al*. (2015).

CONCLUSION

The study has revealed significant varietal performance among the selected Amaranth varieties, influencing their morphological characters and yield potential. *A. hypchundriacus* emerged as the most robust variety, particularly suited for biomass production due to its taller height and larger leaf size. *A. cruentus* demonstrated balanced growth characteristics, making it versatile for various uses. *A. retroflexus*, with its shorter stature is ideal for leafy vegetable production and regions with shorter growing seasons. Strong and positive relationship exist among the studied growth performance of the amaranth varieties.

RECOMMENDATION

This study recommended that further studies be conducted to explore the performance of these varieties under different environmental conditions and management practices. Additionally, research into the nutritional content of the different varieties could provide valuable insights for optimizing Amaranth cultivation for specific health benefits.

REFERENCES

Achigan-Dako, E. G., Sogbohossou, O. E., & Maundu, P. (2014). Current knowledge on Amaranthus spp.: research avenues for improved nutritional value and yield in leafy amaranths in sub-Saharan Africa. *Euphytica*, *197*, 303-317

Bressani, R. (2004). Amaranth: A Traditional Crop with Nutritional Potential.* In M. Hermann and J. Heller (Eds.), Promoting the conservation and use of underutilized and neglected crops. 17. Proceedings of the Second International Symposium on Amaranth, 1–5 August 1990 (p. 32-47). Rome: IPGRI.

Cabanillas, C., Tablada, M., Ferreyra, L., Pérez, A., & Sucani, G. (2017). Sustainable management strategies focused on native bio-inputs in Amaranthus cruentus L. in agro-ecological farms in transition. *Journal of Cleaner Production*, *142*, 343-350.

Cheng, A. (2018). Shaping a sustainable food future by rediscovering long-forgotten ancient grains. *Plant Science*, *269*, 136-142

Gerrano, A. S., Jansen van Rensburg, W. S., & Adebola, P. O. (2015). Genetic diversity of Amaranthus species in South Africa. *South African Journal of Plant and Soil*, *32*(1), 39-46.

Gomez-Caravaca, A. M., et al. (2017). *Amaranth (Amaranthus cruentus) from crop to health: Analytical methods and recent advances in phytochemistry.* Phytochemistry Reviews, 16(6), 959–988. doi:10.1007/s11101-017-9509-7.

Iftikhar, M., & Khan, M. (2019). Amaranth. *Bioactive factors and processing technology for cereal foods*, 217-232

Kandpal, B. K., et al. (2015). *Genetic diversity and population structure of vegetable amaranth (Amaranthus tricolor L.) in India as revealed by microsatellite markers.* Physiological and Molecular Biology of Plants, 21(3), 349–357

Malik, M., Sindhu, R., Dhull, S. B., Bou-Mitri, C., Singh, Y., Panwar, S., & Khatkar, B. S. (2023). Nutritional composition, functionality, and processing technologies for Amaranth. *Journal of Food Processing and Preservation*, *2023*, 1-24.

Malvi, U. R. (2011). Interaction of micronutrients with major nutrients with special reference to potassium. *Karnataka Journal of Agricultural Sciences*, *24*(1).

Martinez-Ballesta, M. C., et al. (2016). *Amaranthus cruentus and Amaranthus hypochondriacus: Nutritional Quality and Physicochemical and Functional Properties.* Food Research International, 89(Pt 1), 1118–1126

Mburu, M. W., Gikonyo, N. K., Kenji, G. M., & Mwasaru, A. M. (2011). Properties of a complementary food based on amaranth grain (Amaranthus cruentus) grown in Kenya. *Journal of Agriculture and Food Technology*, *1*(9), 153-178

Sarker, U., Hossain, M. M., & Oba, S. (2020). Nutritional and antioxidant components and antioxidant capacity in green morph Amaranthus leafy vegetable. *Scientific Reports*, *10*(1), 1336.

Smith, A. M. (2008). *Amaranth: History, taxonomy, and distribution.* In J. Janick (Ed.), Horticultural Reviews, 34, 1-20

Table 1: Effect of Different Varieties of Amaranths on the Plant Height at four stages of Plant Growth

Variety	Week1	Week2	Week3	Week4
Amaranthus cruentus	3.433	7.767	18.883	23.067
Amaranthus retroflexus	2.333	5.367	8.217	10.600
Amaranthus hypchundriacus	6.333	14.983	28.783	34.483
LS (P<0.05)	**	**	**	**
LSD	3.2774	7.634	15.039	17.092

LS = Level of Significance at 5%, LSD = Least Significance Difference. ** = significant at 1%,

* = Significant at 5%

Table 2: Effect of Different Varieties of Amaranths on the Leaf Length at four stages of Plant Growth

Variety	Week1	Week2	Week3	Week4
Amaranthus cruentus	1.617	4.333	8.000	10.217
Amaranthus retroflexus	1.4333	3.033	3.983	4.883
Amaranthus hypchundriacus	2.6333	6.817	12.500	13.533
LS (P<0.05)	**	**	**	**
LSD	1.1514	3.1072	6.5219	7.0346

LS = Level of Significance at 5%, LSD = Least Significance Difference. ** = significant at 1%, * = Significant at 5%

Table 3: Effect of Different Varieties of Amaranths on the Leaf Width at four stages of Plant Growth

Variety	Week1	Week2	Week3	Week4
Amaranthus cruentus	1.500	1.7667	2.883	3.4000
Amaranthus retroflexus	0.8167	1.4500	1.883	2.4000
Amaranthus hypchundriacus	1.26667	2.6500	4.517	4.4167
LS (P<0.05)	**	**	**	**
LSD	0.3322	0.8342	2.5591	2.0075

LS = Level of Significance at 5%, LSD = Least Significance Difference. ** = significant at 1%, * = Significant at 5%

Table 4: Textural Performance of the Amaranth Leaf at Various Stages of Growth

Variety	Week1	Week2	Week3	Week4
Amaranthus cruentus	Smooth	Smooth	Smooth	Rough
Amaranthus retroflexus	Smooth	Smooth	Smooth	Rough
Amaranthus hypchundriacus	Smooth	Smooth	Smooth	Rough

Table 5: Leaf Colour Performance of the Amaranth at all stages of Growth during the period of the Study

Variety	Week1	Week2	Week3	Week4
Amaranthus cruentus	Green	Green	Dark Green	Dark Green
Amaranthus retroflexus	Green	Green	Dark Green	Dark Green
Amaranthus hypchundriacus	Green	Green	Dark Green	Dark Green

Table 6: Correlation Coefficient among the Studied Characters of the Amaranth Varieties

	Plant Height	Leaf Length	Leaf Width
Plant Height	1.00		
Leaf Length	0.888**	1.00	
Leaf Width	0.718**	0.704**	1.00

** = Significant at 1% level of Significance, * = Significant at 15% level of Significance

RESPONSE OF MAIZE (*Zea mays* L.) VARIETIES TO TRACE ELEMENTS IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2021 rainy season at the Teaching and Research Farm Aliko Dangote University of Science and Technology Wudil and Research Farm of the Faculty of Agriculture Bayero University Kano, located in the Sudan Savanna of Nigeria to improve maize productivity by improving nutritional demands via adding some micro nutrients. The treatments consisted of four levels of Boron and Zinc each at 5 kg ha^{-1} and 2. 5 Kg ha^{-1} as soil application, 1.12 kg ha^{-1} and 0.56kg ha^{-1} as Boron foliar application while 0.5 kg ha^{-1} and 0.25 kg ha^{-1} as Zinc foliar applications respectively with a control. Two varieties of maize Sammaz 27 and Oba super1 was used, the experiment was laid out using Randomized Complete Block Design (RCBD). The treatments were applied at 2 and 4WAS and data was collected on plant height, chlorophyll content, fresh and dry weight as well as grain yield and subjected to analysis of variance using Genstat 17th edition. The result showed that maize treated with Zinc at 5kg ha^{-1} and Boron at 0.56kg ha^{-1} as soil and folia application recorded significantly tallest plant at 83.50cm and 82.33cm of plant height at 6WAS at BUK and 106cm and 78.5cm at Gaya respectively. Similar trend was observed with respect to chlorophyll content At BUK, chlorophyll content was highest with application of Zinc at 5 kg/ha at 62.98/6WAS while fresh plant weight recorded the highest value with foliar application of Boron at 0.56 kg /ha at 606.0g in BUK as against the control with 433.7g. Sammaz 27 shows appreciable response to the treatment levels of Boron 0.56kg/ha and Zinc 5kg/ ha as soil and folia application respectively, followed by Oba super1 hybrid with a moderate response to the same treatment levels and application method. Based on the findings of the study it has recommend the application of Zinc at 5kg/ha as soil application and 0.56kg/ha of Boron as folia application for maize improvement.

INTRODUCTION

Maize is one of the most important staple food crops in Nigeria, among the cereals, it has the largest area devoted to its cultivation. Maize is a major cereal and one of the most important food, feed and industrial crops in Nigeria. Maize provides energy, vitamins and has some amount of protein. The livestock industry consumes more than half of the total maize production annually NAERLS, (2014). Grain yield of maize in Nigeria over the last several decades has been hovering at 2/tons per hectare (t/ ha) which is far less than the yield of about 7t/ ha observed in well-managed field experiments (Fakorede and Akinyemiyu 2023). One of the plausible reasons for the huge Maize yield gap in Nigeria, as in other countries of Sub-Saharan Africa is poor soil fertility, inherently low soil nutrient reserves as well as continuous cropping with inadequate nutrient replenishment. Maize is a heavy feeder requiring an intelligent fertilizer programs, it requires much of nitrogen, phosphorus, potassium, calcium and magnesium, in a related development by (Brandy *et al.,* 2002) has indicated that neglecting vital soil management and soil improvement practices contributed to soil nutrient depletion. Up to the present time emphasis has been on the application of nitrogen (N), phosphorous (P) and potassium (K) as fertilizer, while (Agbede *et al.,* 2004) emphasized that the optimum Maize production can be achieved by having soil consisting of accessible macro and micro nutrients. Blanket fertilizer application and continuous use of only major elements (NPK) without taking in to cognizance the vital role of other essential nutrients like Boron and Zinc contribute to low maize yield. Soil nutrient balance studies have shown depletion of soil nutrient as one of the most important constraints to sustainable agriculture in Savanna areas of Nigeria (Rego *et al.,* 2014). However, researchers in various locations in the Nigerian savanna have observed that the application of micronutrients coupled with the current intensive use of land could lead to high maize crop productivity.

MATERIALS AND METHOD

The experiment consisted of nine treatment levels as Boron and Zinc at 2.5kg/ha and 5kg/ha a direct soil application and another treatment levels of Boron at 1.12kg/ha and 0.56kg/ha as folia application and 0.5kg/ha and 0.25kg/ha as Zinc folia application on two varieties of maize with a control and replicated three times in a Randomized Complete Block Design (RCBD). The gross plot consisted of four ridges of 0.75m apart and 3m long given a total area of $9m^2$ /one plot. The two inner rows serve as net plot at $4.5m^2$ for yield assessment while the outer was used for sampling purpose and as discard. 0.5m was provided between plots and 1m between replication as lee ways respectively, each replication consisted of eighteen plots of $9m^2$ and replicated three times with total area estimate of $432m^2$.

RESULTS

Plant height (cm)

Effect of Trace elements on maize varieties to plant height at BUK and Gaya during 2021 rainy season is presented in Table 1. The result showed that at 4 and 6WAS in BUK and Gaya the height of the two varieties were statistically similar. However, at Gaya Sammaz 27 significantly produced taller plant than Oba super1. Application of Boron and Zinc, however at 6 WAS in BUK at 0.56 kg ha^{-1} and Zinc at 5 kg ha^{-1} recorded significantly taller plants which were statistically similar to Boron at 2.5 kg ha^{-1}, but different from other rates of Boron and Zinc. Application of Zinc at 5kg/ha significantly recorded taller plants than Zinc at 0.25 and 2.5 as well as Boron at 2.5kg/ha at 4WAS. Similar trends were observed in the same location at 6WAS except that the result was similar with control but different from all other rates of Boron and Zinc. Interaction between Varieties and trace elements was significant at 6WAS in both locations as indicated in table 2. The height of maize varieties does not change with increase or decrease rate of the trace element except at Zinc 5kg/ha, were Sammaz 27 produced taller plants than Oba super1 in BUK. However, considering the varieties individually Sammaz27 was observed to significantly produced tallest plants with application of Boron at 0.56kg/ha and Zinc at 5kg/ha than other rates of trace elements in Gaya. The plant height does change significantly with Oba super1 by increase or decrease in Trace elements used. Table 1.

Chlorophyll content

Response of maize varieties to trace element on chlorophyll content at BUK and Gaya during 2021 rainy season is presented in Table 3. The result showed that at 6 WAS in both locations the chlorophyll content of the two varieties were not significant, significant difference in chlorophyll content was observed among maize varieties in both locations at 9 WAS. SAMMAZ 27 produced the highest level of chlorophyll content while the lowest content was observed from Oba Super 1. Application of Trace elements has no effect on chlorophyll content at 6WAS in both locations, however at 9 WAS there was a significant effect of Trace elements on chlorophyll content. The highest chlorophyll content was observed on plants treated with Boron at 0.56 kg ha-1 and Zinc at 5 kg ha-1 while the lowest value of chlorophyll was recorded on plants treated with Zinc at 0.25 kg ha-1 in both locations.

Fresh plant weight, dry plant weight and grain yield (t/ha)

Response of maize varieties to trace element on plant fresh weigh, dry weight and grain yield of maize at BUK and Gaya during 2021 rainy season is presented on Table 4. The result showed that application of Boron at 0.56kg produced the heaviest fresh weight which is significant in both locations and the interaction between varieties and trace element on fresh Plant weight were not significant in both Buk and Gaya. On Plant dry weight Application of zinc at 5kg/ha is significantly different from all other rates of trace elements in both locations. The interaction between varieties and trace element rates on plant dry matter was not-significant in both locations. On Grain Yield Weight application of zinc at 5kg/ha is significantly different all other trace element, however on varieties SAMMAZ 27 produced the highest yield (1.36) which is significant.

DISCUSSION

The results of this study showed a significant effect of zinc on growth, yield and yield components of maize. The significant effect of zinc on plant height and chlorophyll content of maize could be attributed to the significant role in growth and metabolism of plant. Zn is an element present in the enzyme system as co-factor and activator of many enzymes, Blackie *et al*. (1993). Significant influence of zinc on leaf area and fresh plant weight might be attributed to plant height and more number of leaves in this treatment because Zinc enhances photosynthesis. This indicates that the micro nutrients help to activate the synthesis of tryptophan and precursor of IAA which is responsible for stimulation of plant growth and accumulation of biomass. A significant effect of zinc on dry cob weight, fresh cob weight, Stover weight, 100grain weight and grain yield this could be probably because sufficient plant nutrients like zinc were applied to the maize treatment. The significant influence of boron on plant height and chlorophyll content of maize could be due to the fact that boron is known to enhance photosynthetic and metabolic activity which leads to an increase in various plant pathways responsible for cell division and elongation, similar findings were also reported by Singh *et al*., (2017). Similarly Boron influenced leaf area and fresh plant weight which could be attributed due to plant height and more number of leaves was found in this treatment because of photosynthesis enhanced in the presence of boron. Differences in terms of growth and yield characters observed among maize varieties can be attributed to their diverse genetic constitution as a result of selection by plant breeders who selected the varieties according to diverse traits. The non-significant effect of varieties to the characters evaluated during the studies implies that the effects of all the treatment combinations were the same.

CONCLUSION

The results of the study shown the growth and yield characters of maize varieties were significantly influenced by the application of boron and zinc. Based on the result of the study application of Zinc at 5 kg/ha a direct soil mode of application and Boron at 0.56 kg/ha a folia mode of application resulted in higher growth, yield and yield component. Similarly, SAMMAZ-27 had significant advantage over OBA super-1 in most of the characters evaluated including interaction between variety and trace element.

REFERENCES

Adamu. A. K., (2010). Effects of Planting Pattern and Nitrogen Levels on Growth and Yield of Sorghum and Pepper Intercrop (Unpublished MSc Project). Bayero University Kano Nigeria, *pp* 1-67.

Agbede. O. O, and Otonko, E.A., (2004) Effect of Agrolyzer Micro-nutrient and NPK Nutrition on the Yield of Maize. *Nigerian Journal of Soil Science*. (2) 64-67.

Ahma. A. R., Chang H.Y., and Rahman M.M., (2021) Effect of Zinc on the growth and yield of maize (zea mays.) cultivated in a tropical arid soil using different application techniques *Earth and Environmental Science* (4)756

Alloway. B. J., (2008). Zinc in Soils and Crop Nutrition. Paris France: IFA; and Belgum; *Ann Agric Sci* (3): 1035-1050.

Belgium: IZA. and Fertilizers Application on Maize at South Tahareer province. *Ann AgricSci* (3): 1035-1050.

Bingham, F.T (1982) Boron. In, methods of soil analysis pat 2 *soc. Agron. Madison*, 431-448.

Bishinu H, Jiban S and banduhu R. (2010) Effects of micro nurients on growth and productivity of maize in acidic soil,(NARP) napal agricultural programme international Resarch jornal of applied and basic science vol1-15 available on line at hattp 11 www.Ecisi. Com.

Black, R.E., (200). Zinc deficiency, Infectious Diseases and Mortality in the Developing World of Nutrition, *jonal ofnutrition*, 133:1485-1489.

Brandy, N.C and Weil R.R.,(2002).**Micronutrient and other Trace Elements, the Nature and Property of Soil** (13TH Ed) Pearson education publishers Singhapur *pp*. 638-668.

Brandy, N.C and Weil, R.R (2002).**the Nature and Properties of Soil** (13th Ed) Prentice Hall, *Inc New jersey*, USA pp199-223

Das k, Dang R, Shivananda TN, and Sur P. 2005 Interaction between phosphorus and Zinc on the Biomass yield and yield attributes of the medicinal plants stevia (satevia rebaudiana). Science world jornal, 5:390-395.

Das, D.K (2000). ***Micronutrients and their Behavior in Soils and Plants***. *Kalyani Publishers, New Delhi,* pp55- 61

Ezui, K.S., Franke, A.C., and Mando, A., (2016). Fertilizer requirements for balanced nutrition of cassava across eight locations in West Africa *Field Crop Res*. 18569–78.

Fakorede, M. A. B., Akinyemiyu, O.A., (2003). Climatic change: effects on maize production in a tropical rainforest location. In: Badu-Apraku, B., Fakorede, M.A.B., Ouedraogo, M., Carsky, R.J., Menkir, A. (Eds.), Maize Revolution in West and Central Africa, *pp*. 272–282 Proceedings of regional maize workshop. Cotonou

Gomez K. A. and Gomez A.A., (1984). Statistical procedure for Agricultural research *intl. PP 12- 31*

ICRESAT. (2009). Innovations for Changing World, Annual Report 2008.Patancheru, Andhra Pradesh, India: *International Crops Research Institute for semi-Arid Tropics PP, 3:16-17, India.*

Lombin, G, and Mustafa, S, (1980) Fertilizer requirement of Cotton in the savanna areas of Nigeria. Ind.j.Agric.sci. 50: 851-857

Myer, R. J. K and Johansen, C. (2002). Nutrient Balances; A guide to improving the soil fertility

Nelson D.W and Sommers, L.E (1982). Total Carbon, Organic Carbon and Magnesium under Zinc New Jersey, USA PP199-223 and 33-379.

Ogunlela,V.B, Kumar V, and Ologunde O.O, (1986) Agronomic investigations of the effects of applied nitrogen, phosphorus, potash and boron on the yield of upland cotton(Gossypium hirsutum L.) in the northern states of Nigeria. Samaru conference paper ll. Inst. For Agric. Res., Ahmadu Bello University Zaria.

Reamaekers, (2001).Introduction to Tropical Crops.Plain Sand Drived Soils of Southeastern Nigeria*Productivity of Maize in Acidic Soil, PP,9-12.*

Rego T. S, Seeling B, and NageswerаRao,(2014) V. *Research journal of applied and basic science vol 1-15 available online at hattp 11 www.*Ecisi.research station and in small holder (peasant) area of Zimbabwe soil science and plant analysis.

Samuel L. Tisdale, Wemer L. Nelson, James D. Beaton and John L. Helvin, (1993*) soil fertilitys and Derived Soils of southern Nigeria.PP 46-86*

Sasakawa Global (2000). Nigeria Project (2010) *Simplified Guide for Crop Production. PP 9-11.*

Singh M.V., (2009). Micronutrient Nutritional Problems in Soils of india and improvement for human and animal health. *journal of fertilizers* ***5****(4): 11-26.*

UNICEF (2012). Report – Pneumonia and Diarrhea: Tackling the Deadliest Diseases for the World's Poorest Children. *UNICEF 77 PP Widely and Sons.* Production, Marketing, Processing & Utilization in Nigeria Extension Bulletin No. 217 National Agricultural Extension Research Liaison Services NAERLS, Zaria, July 2014

Table 1: Effect of Trace elements on Maize Varieties to Plant Height (cm) at BUK and Gaya during 2021 Rainy Season.

	BUK		Gaya	
	Weeks After Sowing			
Treatments	4	6	4	6
Varieties				
SAMMAZ 27	50.48	70.5	54.50a	81.70a
Oba Super 1	46.19	65.5	46.10b	68.00b
SE	3.03	2.71	2.19	3.58
Probability level	0.166	0.074	<001	0.010
Trace elements				
Control	44.80	64.17bc	51.67abc	77.50ab
Boron at 5 kg ha^{-1}	52.00	72.50ab	47.67bc	68.33b
Boron at 2.5 kg ha^{-1}	42.80	62.50bc	49.33abc	70.17b
Boron at 1.125 kg ha^{-1}	45.50	54.17c	50.33abc	80.67b
Boron at 0.56 kg ha^{-1}	58.20	82.33a	60.33ab	78.50b
Zinc at 5 kg ha^{-1}	48.00	83.50a	62.50a	106.0a
Zinc at 2.5 kg ha^{-1}	51.30	62.00bc	42.67c	67.17b
Zinc at 0.5 kg ha^{-1}	42.50	64.50bc	49.33abc	65.50b
Zinc at 0.25 kg ha^{-1}	49.80	66.50bc	39.00c	59.83b
SE±	6.44	5.74	4.64	7.60
Probability level	0.305	<001	<001	0.009
Interaction				
F x V	NS	**	NS	*

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

Table 2: Interaction between Varieties and Trace element on Plant Height (cm) 6 WAS in BUK and Gaya 2021Rainy season

Fertilizers (F)	**Varieties (V)**	
	SAMMAZ 27	Oba Super 1
	BUK 2021	
Control	62.00c	66.33c
Boron at 5 kg ha^{-1}	75.33c	69.67bc
Boron at 2.5 kg ha^{-1}	64.00c	61.00c
Boron at 1.125 kg ha^{-1}	52.00c	56.33c
Boron at 0.56 kg ha^{-1}	92.33ab	72.33bc
Zinc at 5 kg ha^{-1}	107.3a	59.67c
Zinc at 2.5 kg ha^{-1}	59.33c	64.67c
Zinc at 0.5 kg ha^{-1}	63.33c	65.67c
Zinc at 0.25 kg ha^{-1}	59.00c	74.00bc
SE±	5.74	
	Gaya 2021	
Control	75.00	80.00b
Boron at 5 kg ha^{-1}	63.33b	73.33b
Boron at 2.5 kg ha^{-1}	77.33b	63.00b
Boron at 1.125 kg ha^{-1}	80.00b	81.33b
Boron at 0.56 kg ha^{-1}	83.00b	74.00b
Zinc at 5 kg ha^{-1}	138.33a	73.67b
Zinc at 2.5 kg ha^{-1}	82.33b	52.00b
Zinc at 0.5 kg ha^{-1}	60.00b	71.00b
Zinc at 0.25 kg ha^{-1}	76.33b	43.33b
SE±	10.74	

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method.

Table 3: Response of Maize Varieties to Trace element on Chlorophyll Content during 2021 Rainy Season at BUK and Gaya

	BUK		Gaya	
	Weeks After Sowing			
Treatments	6	9	6	9
Varieties				
SAMMAZ 27	40.50	52.79a	33.02	40.50a
Oba Super 1	43.18	49.42b	34.43	29.60b
SE±	1.380	1.054	0.946	1.520
Probability level	0.178	<001	0.299	<001
Trace elements				
Control	40.88	48.67b	33.19	30.40b
Boron at 5 kg ha^{-1}	44.39	47.83b	36.10	27.95b
Boron at 2.5 kg ha^{-1}	39.40	46.60b	32.57	30.50b
Boron at 1.12kg ha^{-1}	38.24	47.41b	32.28	48.34b
Boron at 0.56 kg ha^{-1}	45.16	61.07a	33.23	55.6
Zinc at 5 kg ha^{-1}	46.19	62.98a	33.30	54.53a
Zinc at 2.5 kg ha^{-1}	42.64	50.66b	32.87	30.22b
Zinc at 0.5 kg ha^{-1}	38.45	47.41b	33.97	30.93b
Zinc at 0.25 kg ha^{-1}	45.16	46.42b	35.98	27.27b
SE±	2.927	2.235	2.006	3.230
Probability level	0.450	0.030	0.857	<001
Interaction				
F x V	NS	**	NS	**

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

Table 4: Response of Maize Varieties to Trace elements on Plant Dry Weight and Grain Yield during 2021 Rainy Season at BUK and Gaya

Treatments	Fresh Plant Weight (g) BUK	Fresh Plant Weight (g) Gaya	Plant Dry Weight (g) BUK	Plant Dry Weight (g) Gaya	Grain Yield (t ha^{-1}) BUK	Grain Yield (t ha^{-1}) Gaya
Varieties						
SAMMAZ 27	424	341	176.6	252.7	1.330	1.362a
Oba Super 1	467	337	179.1	217.6	1.226	1.186b
SE±	20.6	18.5	6.020	13.43	0.041	0.039
Probability level	0.150	0.894	0.775	0.074	0.086	0.003
Trace elements						
Control	433.7b	324.3	184.1c	135.4c	1.068d	1.002c
Boron at 5 kg ha^{-1}	429.5ab	359.7	145.1c	182.5c	0.734e	1.219bc
Boron at 2.5 kg ha^{-1}	392.8b	386.7	135.9c	186.1c	1.071d	1.147c
Boron at 1.125 kg ha^{-1}	396.2b	289.0	159.0c	164.6c	1.272bcd	1.307bc
Boron at 0.56 kg ha^{-1}	606.0a	367.0	265.1b	315.8b	1.542b	1.355bc
Zinc at 5 kg ha^{-1}	529.7ab	353.5	312.3a	553.0a	1.854a	1.868a
Zinc at 2.5 kg ha^{-1}	435.3b	332.7	118.8c	213.3c	1.487bc	1.502b
Zinc at 0.5 kg ha^{-1}	414.8b	342.7	155.4c	197.9c	1.301bcd	1.051c
Zinc at 0.25 kg ha^{-1}	369.8b	295.7	144.8c	167.9c	1.176cd	1.011c
SE±	43.7	39.3	12.78	28.48	0.124	0.117
Probability level	0.013	0.710	<001	<001	<.001	<.001
Interaction						
F x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment column are not significantly different at 5% level of probability using Student-Newman Keuls Test. APM = Application Method

STRATEGIES TO IMPROVE POTATO (*Solanum tuberosum* L.) PRODUCTION IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted in the 2018/2019 dry seasons at two locations in Kano State to evaluate the effect of planting periods, planting density and propagation methods on growth and tuber yield of potato. The experimental treatments consisted of five planting periods, two methods of propagation and three plant densities. These were combined and laid out in an incomplete-block design; in fractional factorial using custom D-optimality criterion. The result of the study showed that planting period had a significant effect on days to emergence, leaf area index, number of tubers per stand, average tuber weight, tuber size, and tuber yield per hectare. The study results showed that, statistically higher tuber yield was recorded in potato planted in late October and early November beyond which there was a significant reduction with every delay in each planting period. Propagation method was observed to have no significant effect on most of the parameters measured in this study. However, planting density significantly affected most of the growth, yield and yield components of potato. Potato planted at a density of 66,666 significantly increased tuber yields per hectare. Significant interaction between location and planting period, likewise planting period and planting density were also recorded. The result of this study has shown that with the increase in plant density, an increase noticed in yield of potato likewise potato tubers when planted early at the onset of dry season produces higher yield. It could be concluded that potato production in the study area is feasible and better when planted early at a density of 66,666. Thus, farmers are advised to use cut seed to minimize the cost of seed since planting whole seed gives same yield as cut seed.

INTRODUCTION

The cultivation of potato (*Solanum tuberosum* L.) has gained significant attention globally due to its high nutritional value and adaptability to various agro-ecological zones. As a staple food, potato plays a crucial role in ensuring food security and providing income for farmers (Immanuel *et al.*, 2024). In Nigeria, the Sudan Savanna region presents unique opportunities and challenges for potato production due to its distinct climatic conditions, characterized by a semi-arid environment, with variable rainfall patterns and temperatures (Schultze, 2024). The Sudan Savanna of Nigeria, characterized by its hot and dry climate, offers a unique environment for potato cultivation. However, the region's potential for high potato yield is often undermined by improper planting periods, propagation methods, and plant densities. These factors significantly influence the growth, development, and yield of potato crops, making it essential to identify optimal agronomic practices tailored to the local environment (Lamessa & Zewdu, 2016).

Despite the potential for potato production in the Sudan Savanna, farmers in the region face challenges related to low yields and inconsistent production (Ugonna *et al.*, 2013). These challenges are often linked to the lack of region-specific guidelines on the appropriate planting period, propagation method, and plant density. Without such information, farmers may continue to use suboptimal practices, leading to poor crop performance and economic losses. This study aims to investigate the effects of planting period, propagation method, and plant density on the growth and yield of potato in the Sudan Savanna of Nigeria.

MATERIALS AND METHODS

Field experiment was conducted in the 2018/2019 dry seasons at the Teaching and Research Farms of the Faculty of Agriculture, Bayero University, Kano (BUK) and Aliko Dangote University of Science and Technology, (ADUST) Wudil to evaluate the effect of planting periods, planting density and propagation methods on growth and tuber yield of potato. The experimental treatments consisted of five planting periods (late October, early November, mid-November, late November and early December), two methods of propagation (using whole seed and cut seed) and three plant densities (66,666, 43,333, and 33,333) per hectare. These were combined and laid out in an incomplete-block design; in fractional factorial using custom D-optimality criterion.

Plot size was 3m x 4m long consisting of four ridges. The planting materials were sourced from National Root Crop Research Institute (NRCRI) sub station, Jos. NPK 15:15:15 was applied at the rate of 240kg/ha (Ugonna *et al.* 2013). Earthening up was done uniformly by hilling the soil arround the plant at 4 weeks after planting (Tesfaye *et al.* 2012). Plants were irrigated at an interval of four days as recommended by Dibal (2005).

Data Collection and Analysis

Data on Days to emergence, Leaf area index, Number of tubers per stand, Tuber size, average tuber weight and Tuber yield were collected and were subjected to analysis of variance (ANOVA) using JMP Pro 14 statistical package (SAS, 2018). Significant means were ranked using Tukey's HSD.

RESULTS AND DISCUSSION

Table 1 presents the results of the soil analysis for the experimental sites. This indicated that the soils at Wudil contained 59.81% sand, 21.32% silt and 18.84% clay. Therefore, soil texture was classified as sandy clay. The soils at BUK contained 64.20% of sand, 19.43% of silt and 16.37 of clay; hence, the soil texture was classified as clayey sand. It was observed that soil at Wudil was slightly acidic (6.41) and neutral (7.35) at BUK. The result also indicated that total nitrogen was high in both BUK and Wudil. The available phosphorus was medium (11.14) at Wudil and low (2.39) at BUK. Other significant differences in micronutrients of the soils of the two sites were seen, especially CU, Mn, and Fe which were relatively higher at Wudil.

The number of days to emergence showed significant variation across the different planting periods (Table 2). Early emergence was observed at Bayero University, Kano (BUK) site., This could generally be associated with higher yields, suggesting that a quicker start in the growing season allows for a longer period of vegetative growth and tuber development before the onset of less favorable conditions, such as heat stress. A similar result was obtained by Oliveira (2015). Komen (2016) also reported that Variation existed between Locations, location with optimal microclimates and early planting dates saw quicker emergence and higher yields.

The results of this study showed significant variation in the leaf area index (LAI) across different locations, planting periods, and plant densities. LAI is a vital indicator of the crop's ability to intercept light, which directly influences photosynthesis and, ultimately, the yield. The study found that the planting period had a significant effect on LAI with late October planting having the higher (16.84) LAI. Early planting periods, which are typically characterized by optimal moisture and temperature conditions, led to higher LAI values. This could be attributed to the fact that early planting allows for better establishment of the crop before the onset of potentially adverse conditions later in the season Saldaña-Villota, (2024). Plant density was also found to significantly influence LAI, tubers planted at a density of 66,666 has higher (14.69) LAI. Higher plant densities generally resulted in increased LAI due to the greater number of plants per unit area contributing to the overall leaf coverage (Derebe and Kola 2024)

The results of this study indicate that the number of tubers per stand was significantly influenced by the planting period, while other factors such as location and plant density did not show a significant effect. This finding showed the critical role of the timing of planting in determining the reproductive success and yield potential of potato plants Khan et *al.* (2024). The significant effect of the planting period (6.99) on the number of tubers per stand could be attributed to the alignment of planting with optimal environmental conditions, particularly temperature. Early planting, ensures that potato plants receive sufficient temperatures during the critical stages of tuber bulking (Dhakad, 2024). Significant interaction existed between location and planting period, this shows that the impact of planting period on tuber yield can vary significantly depending on local environmental conditions.

The study also revealed significant variation in tuber size with respect to location, planting period, plant density, and the interaction between location and planting period. These factors collectively influence the growth conditions and physiological development of potato tubers, impacting their size and overall quality. BUK produces larger sized tubers (16.80cm). Locations with rich, well-drained soils and optimal temperature ranges generally produce larger tubers. Regions with higher soil fertility often support robust tuber growth, resulting in larger sizes David, (2024). The planting period also plays a significant role in determining tuber size this can lead to the development of larger tubers as plants have more time to grow and mature before the end of the growing season. Plant density significantly effect on tuber size, planting at a low density of 33,333 resulted in larger tubers (15.99cm). Higher plant densities often lead to competition for resources such as water, nutrients, and light, which can restrict individual tuber growth and result in smaller sizes. In contrast, lower plant densities reduce competition, allowing plants to access more resources and potentially produce larger tubers. The study found a significant interaction between planting period and plant density concerning tuber size. This interaction reveals that the impact of planting density on tuber size is influenced by the timing of planting, and vice versa (Khan*et al.*, 2024). The study also found that average tuber weight was significantly influenced by location, planting period, and plant density. Location plays a crucial role in determining average tuber weight. Environmental conditions such as soil type, fertility, and microclimate significantly impact tuber growth. The planting period also significantly affects average tuber weight, Early planting (late October) which typically align with more favorable conditions presented a higher average root weight (122.16), which allowed for a longer growing period under favorable conditions. This extended period supports greater tuber growth and development, leading to heavier tubers at harvest (Zou *et al.*, 2024). Plant density has a direct impact on average tuber weight. Higher plant densities often lead to increased competition for resources such as water, nutrients, and light. This competition can restrict individual tuber growth and result in smaller, lighter tubers. The study revealed that tuber yield was significantly affected by location, planting period, plant density, and the interaction between location and planting period. Planting period plays an important role in determining tuber yield. Early planting generally leads to higher (21.25 t/ha) yields because it allows plants to grow and mature under favorable conditions throughout the growing season, similar result was obtained by Khan, *et al* (2024). Plant density also has a direct impact on tuber yield. Higher plant densities can lead to increased competition for resources, such as water, nutrients, and light, which can reduce individual tuber size and overall yield per plant. However, higher densities can increase the number of plants per unit area, potentially improving total yield, similar findings were reported by Zuo *et al.* (2024).

CONCLUSION

Optimizing planting period and plant density according to local environmental conditions is crucial for maximizing potato yield and tuber size. While propagation method does not significantly affect production, focusing on the timing of planting and managing plant density can lead to improved outcomes in potato cultivation. These findings provide valuable guidance for farmers and agricultural advisors in the Sudan Savanna, aiming to enhance productivity and achieve better results in potato farming.

REFERENCES

David, M. T. (2024). Assessing climate variability to the vulnerability of crop yield in Benue state Nigeria.

Derebe, A. D., & Kola, A. W. (2024). Effect of planting density on growth, light interception and tuber yields of potato varieties (Solanum tuberosum l.) at Guji highland of outheastern Ethiopia. *Ethiopian*

Dibal J. M. (2005) varietal response of Irish potatoes to irrigation scheduling in the Northern guinea-savannah zone of Nigeria. Thesis submitted to the postgraduate school, Ahmadu Bello University, Zaria**.**

Dhakad, A. (2024). Chapter-19 Potato (*Solanum tuberosum*). *Vegetable Crop Cultivation*, 267.

Immanuel, S., Jaganathan, D., Prakash, P., & Sivakumar, P. S. (2024). Cassava for Food Security, Poverty Reduction and Climate Resilience: A Review. *Indian Journal of Ecology*, *51*(1), 21-31.

Khan, M. S., Hoogenboom, G., Gillani, S. M., Shah, A. S., & Khan, I. (2024). Effects of Planting Date and Genotypes on Potato Growth and Yield Determination in a Sub-Tropical Continental Growing

Lamessa K, Zewdu A (2016). Effect of spacing and fertilizer dose on growth and yield of potato (*Solanum tuberosum* L.) Gudane variety at West Hararghe, Eastern Ethiopia. *International Journal of Horticulture and Ornamental Plants* 2(1): 011-018.

Oliveira, J. S. (2015). Growth and development of potato (Solanum tuberosum L.) crops after different cool season storage. Lincoln University Digital Thesis, New Zealand.

Saldaña-Villota, T. M., & Cotes-Torres, J. M. (2024). Fluctuations in Radiation Use Efficiency throughout the Growth Cycle in Diploid Potato Crop. *American Journal of Potato search*, *101*(2), 99-113.

Schultze, M., Kankam, S., Sanfo, S., & Fürst, C. (2024). Agricultural Yield Responses to Climate Variabilities in West Africa: A Food Supply and Demand

Analysis. *Land*, *13*(3), 364.Potato in the North Rift Region of Kenya (Doctoral dissertation, University of Eldoret).

Tesfaye W (2013) Determinants of technical efciency in maize production: the case of smallholder farmers in Dhidhessa District, Illubabor Zone, Ethiopia. A M.Sc. Thesis presented to School of Graduate Studies of Haramya University

Ugonna C.U, Jolaoso M.O, Onwualu A.P (2013). A Technical Appraisal of Potato value Chain in Nigeria *International Research Journal of Agricultural Science and Soil Science* 3(8): 291-301.

Zou, C., van der Putten, P. E., Mossink, L., Lommen, W. J., van Ittersum, M. K., & Struik, P. C. (2024). Using sprouting behaviour to quantify physiological ageing of seed tubers of potato (Solanum tuberosum L.). *Environmental and Experimental Botany*, *219*, 105648

Table 5: Physical and chemical properties of soils of the experimental sites at 0-30cm depths during 2017/2018 and 2018/2019 dry seasons.

Soil properties	Wudil	BUK
Physical		
Sand %	59.81	64.20
Silt %	21.35	19.43
Clay%	18.84	16.37
Classification	Sandy clay	Clayey sand
Chemical		
pH (1:1)	6.41	7.35
O C (%)	0.61	0.55
N (%)	0.09	0.07
P (mg/kg)	11.14	2.39
Mn (mg/kg)	11.74	3.72
Zinc (mg/kg)	1.86	7.48
Fe (mg/kg)	180.41	128.29
Exchangeable base (cmol(+)kg^{-1})		
Ca	1.39	1.14
Mg	0.34	0.51
K	0.08	0.07
Na	0.015	0.013
ECEC (effective cation exchange capacity)	1.82	1.73

Analyzed at Central laboratory Centre for Dryland Agriculture Bayero University K

Table 2: Effects of Location, Planting Period, Propagation Method and Planting Density on some growth any yield components of Potato In 2018/2019 Dry Seasons at Wudil and BUK

	Days to emergence	Leaf Area Index	Number of tubers	Tuber size (cm)	Average tuber weight (kg)	Tuber yield t/Ha
Location (L)						
Wudil	15.70b	10.18b	5.61	13.11b	51.21b	7.60b
Buk	14.96a	16.63a	5.50	16.80a	113.89a	20.86a
Probability level	0.0001	0.001	0.336	0.001	0.001	0.001
SE±	0.0017	0.440	0.082	0.109	1.144	0.288
Planting period (P)						
Late October	14.62a	16.84a	6.99a	18.17a	122.16a	21.25a
Early November	15.753c	14.88b	6.68a	16.53b	111.59b	18.35b
Mid November	15.37bc	13.14bc	5.03b	14.34c	79.26c	13.48c
Late November	15.71c	12.17c	4.88b	13.52d	56.28d	10.82d
Early December`	15.21a	9.99d	4.20c	12.23e	43.46e	7.25e
Probability level	0.0001	0.001	0.001	0.001	0.001	0.001
SE±	0.176	0.695	0.129	0.172	1.808	0.455
Propagation method(M)						
Whole seed	15.43	13.36	5.58	15.09	83.62	14.56
Cut seed	15.23	13.45	5.53	14.82	81.48	13.90
Probability level	0.2100	0.895	0.624	0.086	0.189	0.108
SE	0.117	0.440	0.082	0.109	1.144	0.288
Planting Density (D)						
66,666 (20cm)	15.09	14.69a	5.62	14.23c	75.80c	16.17
43,333 (30cm)	15.53	12.82b	5.53	14.66b	81.21b	13.93b
33,333 (40cm)	15.38	12.70b	5.51	15.99a	90.64a	12.59c
Probability level	0.0898	0.017	0.702	0.001	0.001	0.001
SE±	0.137	0.538	0.100	0.133	1.401	0.353
Interaction						
L X P	0.675	0.081	0.036	0.016	0.744	0.009
L X M	0.675	0.987	0.445	0.895	0.981	0.994
L X D	0.756	0.413	0.452	0.824	0.525	0.873
P X M	0.744	0.994	0.710	0.520	0.796	0.281
P X D	0.859	0.761	0.955	0.400	0.067	0.456
M X D	0.500	0.125	0.965	0.513	0.805	0.901

Levels not connected by same letter are significantly different.

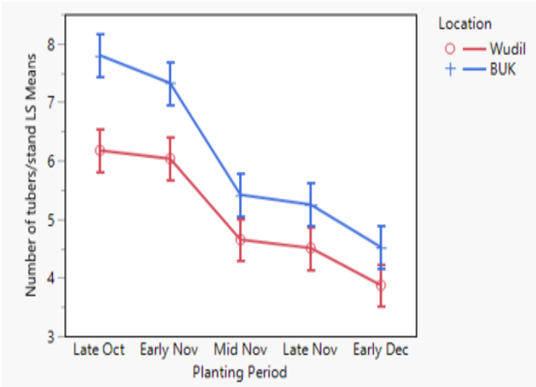

Figure 1: Interaction between Location and Planting Period on Number of Tubers per Stand of Potato in 2018/2019 Dry Seasons at Wudil and BUK.

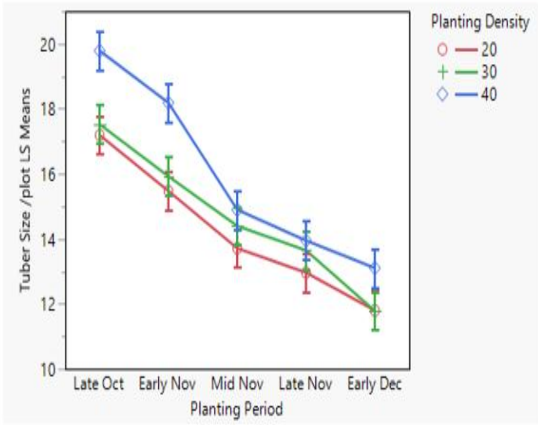

Figure 2: Interaction between Location and Planting Period on Tuber Size Per plot of Potato in 2018/2019 Dry Seasons at Wudil and BUK.

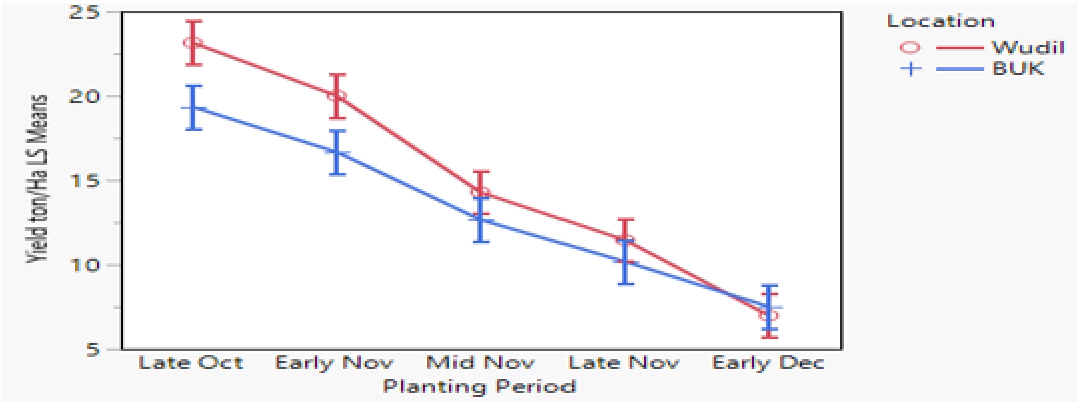

Figure 3: Interaction between Location and Planting Period on Tubers yield per hectare of Potato in 2018/2019 Dry Seasons at Wudil and BUK.

YEAR EFFECT AND CROPPING SYSTEM ON YIELD AND YIELD COMPONENTS OF WHITE YAM (*Dioscorea rotundata*)

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Abstract
African yam bean (AYB) and yam are indigenous crops that are imbued with intercrop compatibility, yield and nutrition components necessary for food security and financial reward for farmers. A research experiment was carried out on intercropping African yam bean (Sphenostylis stenocarpa) and white yam (Dioscorea rotundata) grown at the Federal College of Education (Special), Oyo. The factorial experiment involving five accessions of AYB and three white yam landraces, were laid out in Randomized Complete Block Design (RCBD) with three replications over a two cropping seasons (2020 and 2021). The yield effects of the different yam landraces were assessed for genetic diversity and Genotype by Environment (G X E) interaction effects on nine traits performances for: Mean Treatment of performances, Cropping Year performances and Cropping Accessions performances for nine traits were tested. Mean separation of the levels of the different factors was done with Turkey honestly significant differences at P≤0.05 in SAS. ANOVA revealed significant (P≤0.05) differences among the yield and yield components of AYB accessions and yam landraces. At sole level yam had the highest mean performances for the traits (five of six) and highest in 2021 Cropping year (four of six) over the 2020; while the test for Cropping pattern revealed that, Gambari yam landrace had the best trait performances (four of six) over the other two. Moreover, farming system under intercrop condition, BAYB2 (Benue landrace intercrop with TSs217A Genotype) recorded the best combiner with the highest tuber yield (2.83 tons/ha) over sole system where Benue recorded 2.08 tons/ha. However, Benue intercrop with AYB5 (TSs357A) recorded the least yield report (1.38 tons/ha).

Keywords: Accessions, cropping pattern, cropping seasons, intercrop, landraces and yield performance.

INTRODUCTION

Yam is a tropical crop and it is grown primarily for domestic consumption and commercial for man animal use in Africa. The production and consumption of the crop is hinged to its densely rich nutrients and cultural significance (Igbawua *et al*., 2022). Yam is ranked as the "king of crops" in some cultural settings of Nigeri. Generally, there are several species of yam in the genus Dioscorea; but only six are traditional and proven to be economically important staple species (Igbawua *et al*., 2022), they include: *Dioscorea rotundata* (White yam), *Dioscorea bulbifera* (Aerial yam), *Dioscorea dumetorum,* (Trifoliate yam), *Dioscorea alata* (Water yam), *Dioscorea esculenta* (Chinese yam), *Dioscorea cayennensis* (Yellow yam). Nigeria is the leading producer of yams (Dioscorea spp.) in the world, accounting for 66% (about 50.1 million tons) of annual global production (FAO, 2015, Apu *et al.*, 2020) on 2.90 million hectares (Verter and Beˇcv´aˇrov´a 2015) and 6.24 million hectares (Apu *et al.*, 2020) respectively.

In addition to its value as a staple crop, in Nigeria, yams are a major source of income for most individuals and have tremendous cultural importance because they are employed in numerous religious and cultural rituals. Yam is an important source of dietary calories and contributed on average more than 200 Kilocalories per person per day to over 300 million people between 2006 and 2010. Beyond its economic and nutritional values, the ownership and cultivation of yam has several cultural and social meanings to specific ethnic groups (Ecoma and Ecoma, 2013). Yams exhibit diverse agro-ecological adaptation, diverse maturity periods, and in-ground storage capability, thus permitting flexible harvesting times, which aids sustained food availability (Obidiegwu *et al*., 2023).

Against the natural phenomenon of plant nutrients depletion and poor harvest on repeated soil, African yam bean (AYB) has been found to improve tuber yield in yam through its potent soil nutrient enrichment after previous cropping (Okogbe, 2023). Cultivation of yam had often been associated with intercropping with different forages and legumes for additional benefits (Ahmed and Jeb, 2014; Zemba et al., 2018; Ajala *et al*., 2020; Peter and Umweni, 2021). AYB has been discovered to cater for the gap for need to improve food security and environmental sustainability (Agbowuro, 2021 and Adewale and Nnamani, 2022). Its addition in cropping has increased its advocacy for the adoption of polymorphous cropping patters, especially with crops it can share good companionship with. Furthermore, intercropping yam with other crops has added to the agronomic proficiency, not only in terms of yield and soil enhancement, but also, to the social and economic statuses of the farmers. Study by Okogbe, (2023) revealed that yam production at intercrop level did not deter the yield and yield components of yam, compared to that at sole cropping system. From the tradition of yam production in Nigeria and Ghana, AYB has a significant record of compatibility with white yam (Ibeawuchi *et al.*, 2007). It is essential to adopt a cropping pattern that enhances food security and environmental friendliness. (Jabro *et a*l, 2009). In all the major yam producing regions of Nigeria, yam is dominantly cultivated in rural areas, and still characterized by traditional and subsistent agriculture. Study by Enesi, *et al.,* (2018) shows that tillage practices profoundly affect soil physical properties. The prospects of intercropping of yam with AYB to commercial and mechanized farming remain poor. Nevertheless, the yam/AYB intercrop provides an example of the presence of the competition gap, within the period each crop makes maximum demands on the growth factors (soil-moisture, soil nutrients, light etc.) and land use equivalent ratio

(LER) resulting in higher total yields than the sole crops (Maitra, *et al*., 2021; Okogbe, 2023). Intercropping has shown to have several advantages such as better utilization of environmental factors, compensatory and greater yield of food, increasing the return per unit area and insurance against crop failure (Silwana and Lucas 2002).

There are multi-faceted benefits attached to Yam/AYB intercrop system; which include: Soil fertility and sustainability (Jabro *et al*., 2009; Ojuederie *et al*. 2019) intercropping makes the most use of the available soil and soil nutrients optimum use of soil, soil protection and improvement of fertility different crops feed from different zones of the soil; this helps to maximize soil usage (Gitari, 2020); greater yield and greater income: this generates more income for the farmer without really taking up any major expenditure, as the infrastructure available or the land remains the same (Agbowuro *et al*., 2020). Besides the benefit of generation of more income for the farmer without really taking up any major expenditure, there is, the aversion of the risk of sole crop failure. (Nnamani, *et al*., 2021); social stability among many others.

Investigation on the promising benefits in yam-AYB intercrop has been minimally reported. The present research was conducted over two years on the same piece of land, and it involved different land races of yam and different cultivars of AYB. The objective of the study therefore entails understanding of variation in tuber productivity of different yam landraces under sole and intercropped conditions with different cultivars of AYB.

MATERIALS AND METHODS

A repeated field experiment was conducted in 2020 and 2021 to identify the effect of year and the role of environment (cropping systems) on the tuber yield of yam landraces at the Teaching and Research farm, College of Education (Special), Oyo, Nigeria.

The experiment involved: three white yam landraces and five genotypes of African yam bean. Three white yam (*Dioscorea rotundata*) landraces were sourced from local markets in southwestern Nigeria (Benue landrace was collected from Ilora farm settlement in Afijio, Oyo state; Gambari landrace was obtained from Odo-Oro yam market, Ikole, Ekiti State and Uwala was obtained from Makeke yam stead, Akoko-Edo, Edo State). AYB seeds were sourced from the Genetic Resources Centre (GRC), International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and the Breeding programme at the Federal University Oye-Ekiti, Nigeria. Fifteen treatment combinations between the two crops were generated, moreover, the three yam landraces were also grown in sole. The resultant 18 treatments were laid out in a randomized complete block design of three replications in the years 2020 and 2021. Yam setts were established in March/April of each year and AYB were sown beside developing yam in July of each year. Basic cultural practices were adhered to during the experiment.

Data were collected on weight of tuber/plant, number of tubers/plant, tuber circumference/plant, tuber yield/plot, number of yam vine(s)/plant and tuber yield/ha. Data for the two years were pooled and subjected to analysis of variance (ANOVA) and mean separation using Tukey honestly significant differences at $P\leq0.05$ in SAS (version 9.4).

RESULTS AND DISCUSSION

From Table 1, the 18 treatment combinations differ significantly (p≤0.01) for the six measured traits. This reveals that the 18 treatment combinations differed. Effect of the years was significant too for all traits except number of vines and tubers/plant. Since these two variables did not vary due to the influence of year effect as environment, they may probably be under genetic influence. Moreover, treatment by year effect significantly (p≤0.01) affected all the variables except number of tubers/plant (Table 1). The coefficient of variation for four of the traits were lower than 20% except that of that of the number of vines and tubers/plant (Table 1).

In Table 2, the mean tuber yield was higher at sole cropping pattern (24097.7 kg) than the intercrop system with AYB accessions (19803.9 kg). However, the highest tuber was recorded under the intercropping system (BAYB2) of the *Benue* white yam landrace with TSs537A, an AYB accession. By magnitude, the treatment had the highest tuber yield (28323 Kg) from the study although it was not significantly different from the best sole grown white yam, the *Gambari* whose tuber yield/ha was 27335Kg. Similarly, the highest number of tubers/plot was recorded in *Gambari* (4.42) and BAYB2 (4.02). Conversely, the least yield was recorded with *Benue* landrace (20180c-g) and GAYB2 recorded the least intercrop performance (13841g). (Table 2). This seems to reflect variability in responses of different genotypes, such that the best performance of *Benue* was enhanced by intercropping while the *Gambari* landrace had the best performance for tuber yield when under a sole condition. Therefor e from the above, sole cropping favoured *Gambari* while intercrop with AYB favoured *Benue*, cultivar. Meanwhile, different white yam landraces may be selective of their best crop combiners, but in this study the intercrop combination of *Benue* with AYB produced highest tuber yield, by inference, AYB may be one of the best companion crops with *Benue* cultivar of white yam. Precisely, TSs357A exhibits good companionship with *Benue* landrace, meanwhile the same genotype impeded the performance of *Gambari* for tuber yield/ha (Table 2).

Although this study did not include in-depth interaction of the two crops at the rhizosphere, however, that African yam bean supported soil environment around the yam with nitrate (through nitrogen fixation process notable of all legumes), is a primary axiom. This further confirms that Nitrogen is an important macronutrient for yam production. Our findings corroborated that of: Sulivan, (2003); Ibeawuchi *et al*., (2007) and Ghosh *et al*., (2007) who reported that intercropping practice must have been been popular because of its advantages over sole cropping which include yield stability and security, and higher profitability due to higher combined returns per unit area of land. The tuber circumference is however not a function of tuber weight, yield per plot and yield /Ha. *Gambari* recorded 34.62 cm whereas, *Uwala* (with a lesser yield/Ha and tuber weight, pooled a better result on the tuber girth (36.39 cm). Under the intercrop combination, UAYB1 recorded the best tuber girth (38.39 cm) while GAYB1 had the least result (30.56 cm). Table 2 further revealed that the number of vines per plant and number of tubers per plant were not consistent indicators of tuber yield/Ha, tuber yield per plot and tuber weight per plant (Table 2).

Generally, from Table 3, sole cropping of the yam landraces only significantly supported tuber circumference, while tuber yield/ha, number of vines/plant, tuber yield/plot, tuber weight/plant and number of tubers/plant were significantly supported by the different intercropping system by the different AYB genotypes. For the three yam landraces, AYB5 (TSs217A) significantly combined and supported the highest performances of tuber yield/ha, tuber yield/plot, and tuber weight/plot but the best AYB combiner for the three white yam landraces for number of vines/plant was AYB 1(DSs4) (Table 3). This result revealed that intercropping yam with AYB is significantly profitable for tuber yield/ha, tuber yield/plot, and tuber weight/plot. However, subsequent research would be needed to reveal classical reasons for the identified support in this study. Against so many assumptions of negative interference of intercrop on yield and yield components of yam, AYB offers agronomic boost on yam yield and consequently improves the standard of living of farmer. The result findings are in consonant with the report by (Diby *et al*.,2009 and Ampofo, *et al*., (2010) who related tuber yield to lack of robust varieties adapted to agro-ecological environments of savannah under climatic constraints.

Table 4 described the range of yield performance of yam traits as influenced by year of cultivation. The performances for number of yam vine per plant and number of tubers per plant, had higher performances in 2020; whereas performances relating to main crop yield such as circumference of yam vine, tuber weight and tuber yield per/ha (30.57) were higher in the following agronomic year, 2021. The experiment indicated that TSs217A is an excellent combiner with the different yam landraces; while on the other hand, TSs357A is not recommendable for intercrop combination, especially with Benue yam landrace. The recorded better yield performance in the subsequent year (2023) over the previous year of experimentation depicts the influence of AYB accessions in improving soil nutrients and fertility. Ghosh *et al*., (2007); Diby *et al.,* (2009); Norman *et al.,* (2015); Gitari *et al.,* (2020) and Maitra *et al.,* (2021) reported a similar inference that: tuber yield is positively influenced by legumes intercrop and secures food production.

Figure 1 presents differing performances of the 18 treatments in the two years of the experiment for tuber yield. In the three sole conditions, the year effect was significant for *Benue* and *Gambari* with 2021 as the better supporting year. The tuber yield of *Uwala* was consistent for two years, moreover, the landrace equally had the lead yield of about 25 tonnes in 2020 compared to the other treatments. Uwala can be described as a stable white yam cultivar. This result generally identified 2021 as a better year. In all, intercrop combination of Benue white yam landrace and AYB 2 had the best tuber yield (Figure 1). Except in GAYB3, GAYB5 and UAYB4, higher yield for all the treatment occurred in 2021. This showcased the role of the environment in support and realization of the magnitude of agronomic parameters. Diby *et al*., (2009) reported the significance of species in securing high yield in yam production.

REFERENCES

Adewale, B. D. and Nnamani, C. V. (2022) Introduction to food, feed, and health wealth in African yam bean, a locked-in African indigenous tuberous legume. *Frontiers in Sustainable Food Systems*; https://doi.org/10.3389/fsufs.2022.726458 ·

Agbowuro G. O., Salami A. E., Aluko M., Olajide O. O (2020). Phenotypic variability among African yam bean landrace accessions from different Agro-ecologies of Nigeria. *Nigeria Agriculture Journal*; 52:70-76

Agbowuro, G. O. (2021) Introduction to African yam Bean (*Sphenostylis stenocarpa* [Hochst. Ex A Rich.] Harms). *Innovare Academic Sciences Pvt Ltd.* 9:6

Ahmed M.Y and Jeb, D.N. "land suitability for sorghum using multicriteria evaluation (MCE) and analytical hierarchy process (AHP) in Bunkure Kano state, Nigeria", IOSR *Journal of Agriculture and Veterinary Science* 7 (2014) 25.

Ajala, O.N., Kpadonou, G. E. Adjadeh, T.A. Akponikp`e, P. B & Olaniyan, J. O. (2020) "Soil suitability evaluation for production of improved cassava (Manihot esculenta) varieties in Kwara state, Nigeria: A GIS-Based and Multi-Criteria analysis", *West African Journal of Applied Ecology* 28(158)

Diby, N.L., Hgaza, V.K., Bi, T.T., Assa, A., Carsky, R., Girardin, O. and Frosard, E (2009) Productivity of yam (Dioscorea spp)as affected by soil fertility. Journal of animal and plant science. 5: 494-506

Ecoma C. S and Ecoma L. E. (2013) Edele festival of the Itigidi people of Cross River State and its impact. *International Journal of Asian Social Sciences*. 3:1781-1792.

Enesi, R.O., Hauser, S., Lopez-Montez., A & Osonubi., O. (2018) Yam tuber and maize grain yield response to cropping system intensification in south-west Nigeria, *Archives of Agronomy and Soil Science,* 64:7, 953-966, DOI: 10.1080/03650340.2017.1404580

Food and Agricultural Organization (FAO) (2015) of the United Nations. Statistics Division. Report. 2014. http://www.fao.org/faostat/en/#data/QC, Accessed 11 September 2016.

Ghosh, P. K., Bandypadhyay, K. K., Wanjari, R. H., Manna, M. C., Mishra, A. K., Mohanty, M. and Rao, A. S. (2007). Legume effect for enhancing productivity and nutrient use efficiency in major cropping systems – an Indian perspective: a review. *Journal of Sustainable Agriculture.*30:59-86. https://doi.org/10.1300/J064v30n01_07

Ghosh, P. K., Bandypadhyay, K. K., Wanjari, R. H., Manna, M. C., Mishra, A. K., Mohanty, M. and Rao, A. S. (2007). Legume effect for enhancing productivity and nutrient use efficiency in major cropping systems – an Indian perspective: a review. *Journal of Sustainable Agriculture.* 30:59-86. https://doi.org/10.1300/J064v30n01_07Gitari, H. I. Nyawade, S. O., Kamau, S. Karanja, N. N., Gachene, C. K. K. Raza, M. A. Maitra, S. and Schulte-Geldermann, E. (2020) Revisiting intercropping indices with respect to potato-legume intercropping systems. *Field Crops Res*. 258:107957.

Ibeawuchi, I. I., Nwufor, M. I., Obasi, P. C and Onyeka, U. P. (2005) Sustainable Agriculture a tool for poverty Alleviation: a review of strategies for crop production in Southeastern Nigeria. *JASR* 2005a; 5(2): 11 - 19.

Jabro, J.D., Stevens, W.B., Evans R.G. and Irversen, W.M (2009). Tillage effects on physical properties in two soils of the Northern Great Plains. Appl Engin Agric. 25:377-382.

Maitra, S., Hossain, A., Bre skalicky,, Ondrisik, P ., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P. and Palai, A. (2021) Intercropping- A Low input Agricultural strategy for food and environmental security. *Agronomy*.

Nnamani, C. V. Ajayi S. A., Oselebe, H. O., Atkinson, C. J. Adewale, B. D., Igwe, D. O and Akinwale, R. O. (2018) Updates on Nutritional Diversity in *Sphenostylis stenocarpa* (Hoechst ex. A. Rich.) Harms. for Food Security and Conservation. *American Journal of Agricultural and Biological Sciences.* 13:38 - 49 DOI: 10.3844/ajabssp.2018.38 -49

Norman, P.E., Whyte, J.B.A., Samura, A.E., Massaquoi, A., Sesay, L.,Dixon, A.G.O., Fonba, S.N., Benya, N.T. and Sowa, M.M. (2015) Effect of Staking and Non-staking Systems on Disease Severity, Yield and Quality Attributes of Yams (Dioscorea alata) Article in Journal *of Agriculture and Ecology Research* International · January 2015 DOI: 10.9734/JAERI/2015/14713.

Obidiegwu, J. E. and Akpabio, M. E. (2017) The geography of yam cultivation in southern Nigeria: Exploring its social meanings and cultural functions. *Journal of Ethnic Foods*; 4(1): 28-35

Ojuederie O, Balogun M, Abberton M. (2016) Mechanism for pollination in African yam bean. *African Crop Science Journal*; 24: 405-416.

Okogbe, A.T. (2023) Grain yield potentials of African yam bean (*Sphenostylis stenocarpa* [Hochst Ex. A. Rich] Harms) under sole and intercrop with white yam. MSc Thesis, Federal University, Oye-Ekiti Nigeria.

Peter, K. D. & Umweni, A. S. (2021) "Evaluation of land suitability for citrus cultivation in Khana Local Government Area of Rivers State, Southern Nigeria", Ilmu Pertanian (Agricultural Science) 6 (2021) 1, http://dx.doi.org/10.22146/ipas.60307

Silwana, T. T. and Lucas, E. O. (2002) The effect of planting combinations and weeding and yield of component crops of maize bean and maize pumpkin intercrops. *Journal of Agricultural Science*; 138:193–200.

Sullivan, P., (2003) Intercropping principles and production practice. Agronomy Systems Guide. Appropriate Technology Transfer for Rural Areas (ATTRA). 1-12p. Available on: www.attra.necta.org

Verter, N. and Beˇcv´aˇrov´a, V. (2015) "An analysis of yam production in Nigeria", Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 63: 659.

Zemba, A.A., Kefas, J & Hamza, A. (2018), "Suitability analysis for decision-making in cassava (Manihot Spp.) cultivation in southern part of Adamawa state, Nigeria", 16 https://doi.org/10.4314/gjass.v16i1.1

Table 1: Analysis of variance showing sources of variations for some traits performances of selected yam landraces

Sources of variation	DF	TYld/Ha(kg)	NYV/P	TY/Plot(kg)	TW/P(kg)	ANT/P	TC/P(cm)
		Mean Squares					
Reps	2	4074418ns	1.50*	2.98ns	0.61ns	0.30ns	18.42ns
Treatments	17	9.8E+07***	0.94**	41.87***	1.63***	0.63***	41.49***
Years	1	2.0E+09***	0.37ns	781.70***	16.61***	0.17ns	89.38**
Treatment * Years	17	9.7E+07***	0.82**	43.66***	2.07***	0.13ns	42.79***
Error	78	1.2E+07	0.36	3.26	0.35	0.13	12.73
Mean	-	20519.60	1.5725	12.82	3.35	1.61	35.17
CV (%)	-	16.67	38.04	14.08	17.71	22.39	10.14

Note: *, **, *** = level of significance at 0.5, 0.01 and 0.001 levels of probability.

TYld/Ha - tuber yield per hectare, NYV/P - number of yam vines per plant, TW/P - tuber weight per plant, TC/P - tuber circumference, ANT/P - number of tubers per plant and CT/P - tuber yield per plot

Table 2: Mean performances of the three yam landraces and the 15 treatment combinations with African yam bean for six traits

Treatments	TYld/Ha(kg)	NYV/P	TY/Plot(kg)	TW/P(kg)	ANT/P	TC/P(cm)
	Sole cropping					
Benue	20180c-g	1.18b	13.08b-d	3.97a-c	1.31b	31.45bc
Gambari	27335ab	1.25b	15.95ab	4.42a	1.68ab	34.62a-c
Uwala	24778a-c	2.17ab	14.55bc	3.46a-d	1.64ab	36.39a-c
Mean	**24097.7**	**1.675**	**14.52667**	**3.95**	**1.54333**	**34.15333**
	Intercropping					
BAYB1	22426a-e	2.59a	14.44bc	3.68a-d	1.33b	31.77bc
BAYB2	28323a	1.21b	18.93a	4.02ab	1.37b	33.79a-c
BAYB3	20021c-g	1.22b	12.22b-f	3.41a-d	1.32b	35.01a-c
BAYB4	20386b-g	1.22b	12.38b-e	2.72d	1.21b	33.18a-c
BAYB5	20010c-g	1.21b	11.99c-f	2.83b-d	1.28b	35.03a-c
GAYB1	14781fg	1.61ab	8.85ef	2.74cd	1.65ab	30.56c
GAYB2	13841g	1.19b	8.47f	2.93b-d	1.34b	38.12ab
GAYB3	17629c-g	1.61ab	11.47c-f	3.31a-d	1.77ab	37.09a-c
GAYB4	16457d-g	1.76ab	10.04d-f	2.69d	1.57ab	31.96bc
GAYB5	17929c-g	1.26b	11.44c-f	3.23a-d	1.26b	37.27a-c
UAYB1	21859a-f	1.91ab	14.66bc	3.46a-d	2.13a	38.39ab
UAYB2	21031b-f	1.72ab	12.77b-d	3.67a-d	2.14a	39.47a
UAYB3	23466a-d	1.86ab	15.13bc	3.48a-d	2.13a	36.04a-c
UAYB4	15855fg	1.72ab	10.05d-f	2.53d	1.93ab	35.16a-c
UAYB5	23045a-d	1.61ab	14.27bc	3.56a-d	1.86ab	37.73a-c
Mean	**19803.93**	**1.58**	**12.47**	**3.22**	**1.62**	**35.37**

Benue – Sole cropping of *Benue* landrace; BAYB1 - *Benue* landrace intercropped with DSs4; BAYB2 - *Benue* landrace intercropped with TSs357A; BAYB3 - *Benue* landrace intercropped with TSs69; BAYB4 - *Benue* landrace intercropped with TSs84; BAYB5 - *Benue* landrace intercropped with TSs217A; *Gambari* - Sole cultivation of *Gambari* landrace; GAYB1 - *Gambari* landrace intercropped with DSs4; GAYB2 - *Gambari* landrace intercropped with TSs357A; GAYB3 - *Gambari* landrace intercropped with TSs69; GAYB4 - *Gambari* landrace intercropped with TSs84; GAYB5 - *Gambari* landrace intercropped with TSs217A; *Uwala* - Sole cultivation of *Uwala* landrace; UAYB1 - *Uwala* landrace intercropped with DSs4; UAYB2 - *Uwala* landrace intercropped with TSs357A; UAYB3 – *Uwala* landrace intercropped with TSs 69; UAYB4 – *Uwala* landrace with intercropped TSs84 and UAYB5 – *Uwala* landrace intercropped with TSs217A.
TYld/Ha - tuber yield per hectare, NYV/P - number of yam vines per plant, TW/P - tuber weight per plant, TC/P - tuber circumference, ANT/P - number of tubers per plant and CT/P - tuber yield per plot

Table 3: Pooled mean performances and comparison of the sole and intercropped conditions over two years of the experiment

Landrace	TYld/Ha (tonnes)	NYV/P	TY/Plot(kg)	TW/P(kg)	ANT/P	TC/P(cm)
Int_AYB1	24.71bc	2.034a	13.8b	3.38b	1.7039	3.7ab
Int_AYB4	26.48b	1.57ab	14.5ab	3.66ab	1.6194	3.5b
Int_AYB3	24.01c	1.57ab	11.9b	3.42b	1.7439	2.7c
Sole	20.28d	1.53ab	10.6c	2.56c	1.5761	4.2a
Int_AYB2	24.59bc	1.37b	13.7b	3.21b	1.4711	3.6b
Int_AYB5	31.18a	1.36b	15.3a	3.96a	1.5486	3.8ab

Int_AYB1 – Intercropping of the three white yam landraces with DSs4, Int_AYB2 - Intercropping of the three white yam landraces with TSs357A, Int_AYB3 - Intercropping of the three white yam landraces with TSs69, Int_AYB4 - Intercropping of the three white yam landraces with TSs84 and Int_AYB5 - Intercropping of the three white yam landraces with TSs217A.
TYld/Ha - tuber yield per hectare, NYV/P - number of yam vines per plant, TW/P - tuber weight per plant, TC/P - tuber circumference, ANT/P - number of tubers per plant and CT/P - tuber yield per plot

Table 4: Year effect on the six measured traits of yam landraces in 2022 and 2023

Years	TYld/Ha(kg)	NYV/P(n)	TY/Plot(kg)	TW/P(kg)	ANT/P(n)	TC/P(cm)
2022	24.32b	1.63a	12.65b	2.97b	2.1a	1.9b
2023	30.57a	1.51b	13.57a	3.76a	1.9b	2.1a

TYld/Ha - tuber yield per hectare, NYV/P - number of yam vines per plant, TW/P - tuber weight per plant, TC/P - tuber circumference, ANT/P - number of tubers per plant and CT/P - tuber yield per plot

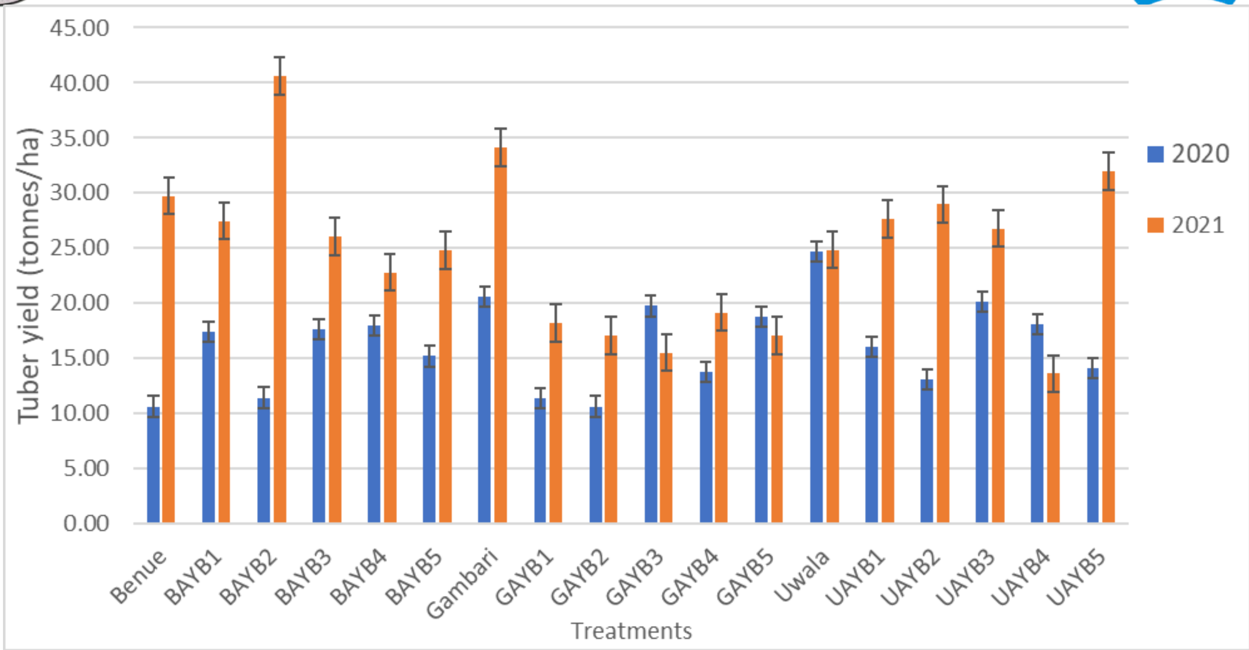

Figure 1: Significant performances of tuber yield/hectare for three white yam landraces (sole) and the 15-intercrop combination with AYB in years 2022 and 2023.

Benue – Sole cropping of *Benue* landrace; BAYB1 - *Benue* landrace intercropped with DSs4; BAYB2 - *Benue* landrace intercropped with TSs357A; BAYB3 - *Benue* landrace intercropped with TSs69; BAYB4 - *Benue* landrace intercropped with TSs84; BAYB5 - *Benue* landrace intercropped with TSs217A; *Gambari* - Sole cultivation of *Gambari* landrace; GAYB1 - *Gambari* landrace intercropped with DSs4; GAYB2 - *Gambari* landrace intercropped with TSs357A; GAYB3 - *Gambari* landrace intercropped with TSs69; GAYB4 - *Gambari* landrace intercropped with TSs84; GAYB5 - *Gambari* landrace intercropped with TSs217A; *Uwala* - Sole cultivation of *Uwala* landrace; UAYB1 - *Uwala* landrace intercropped with DSs4; UAYB2 - *Uwala* landrace intercropped with TSs357A; UAYB3 – *Uwala* landrace intercropped with TSs 69; UAYB4 – *Uwala* landrace with intercropped TSs84 and UAYB5 – *Uwala* landrace intercropped with TSs217A.

EVALUATION OF PLANTING DATES ON GROWTH, YIELD AND YIELD COMPONENTS OF WHEAT (*Triticum aestivum* L.) VARIETIES IN SAHEL SAVANNA, JIGAWA STATE, NIGERIA

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ABSTRACT

Field experiments were conducted in 2021/2022 and 2022/2023 dry season at Flour milling Association of Nigeria Research Farm, Ringim LGA, in Jigawa state situated in the Sahel Savannah agro-ecological zone Nigeria to evaluate the effect of planting dates on growth, yield and yield components of wheat varieties. Experimental treatments consisted of 4 treatments with 2 control plots imposed on two varieties (Norman and Borlaug). The treatments include (Planting 25th October, 5th November, 1st December and 1st January with 15th November and 15th December as control plot) laid out in randomized complete block design and replicated three times. Soil data (pre planting and postharvest) were taken and plant data were taken on establishment count (no of seedling per M^2), days to 50% heading, Number of spike per M^2, No of fertile grains/spike, Plant height, Days to 50% maturity and grain yield adjusted to 12.5% moisture content. All best field agronomic practices for wheat production were adhered. The result indicated that the variation due to sowing date were highly significant for number of spikes/m^2, 50% heading, number of grain/spikes, grain yield. The result also showed sowing date on 15th November recorded the highest values for number of spikes/m2, spike length, number of seed per spike and grain yield. It could be concluded that planting of wheat from 15th November to 30th November coupled with either Borlaug or Norman variety sown give the best wheat yield in the study area. It could also be concluded that Borlaug is more tolerant than Norman when planted late.

Keywords: Planting dates; Sahel; Wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) being world first ranked grain crop is the mainstay of the agricultural economy known as ‘King of cereals and wheat is the second most important staple food crop of the world after rice. In Nigeria, Wheat is a crop of major interest as it is the main component of bread and other wheat-based products such as cakes, biscuits, macaroni, spaghetti, pasta, etc. The demand and consumption of wheat in Nigeria is increasing consistently and this can be attributed to increasing population and change in diet pattern. However, most of the sowing date demonstrations results have been presented in the form of yield and economic advantages and hence, quantification of yield gap minimized because of such demonstrations becomes an important area of investigation. The increasing demand for wheat at global level, on the one hand, and the challenges facing wheat production such as climate change, increased cost of inputs, increased intensity of abiotic (drought, heat) and biotic (diseases and pests) stresses, on the other hand, make the wheat demand-supply chain very volatile and at times lead to social unrest. Wheat, being a winter cereal, requires favorable environmental conditions for better growth and yield (Dabre *et al.*, 1993) and is more vulnerable if exposed to high temperatures during reproductive stages (Kalra *et al.*, 2008). Too early sowing produces weak plants with poor root system, which leads to irregular germination, frequent death of the embryo and decomposition of endosperm due to activities of bacteria or fungi (Paul, 1992). While, late planting affects germination, growth, grain development (Haq & Khan, 2002) and produces poor tillering due to winter injury in low temperature (Tahir *et al.*, 2009). Timely sowing of wheat provides optimum growing period for the crop growth which can accumulate more biomass and finally results in higher grain and biological yield. Wheat breeders are continuously trying to improve the wheat yield under different conditions but paying less attention on its quality characteristics. The quality of wheat grains greatly affects the quality of flat breads (Rehman *et al*., 2009). Therefore, the objective of the present study was to determine the appropriate planting window for wheat, and the potential yield loss with every two weeks delay in planting.

MATERIALS AND METHODS

Experimental site and description: A field experiment was performed to evaluate the effect of various planting windows using two different varieties and potential yield loss in every two weeks delay in planting on growth, yield and yield component of wheat at Flour milling Association of Nigeria (FMAN) Research Farm, Ringim LGA, in Jigawa state situated in the Sahel Savannah agro-ecological zone, (latitude 12^{o} 17'N and longitude 9^{o} 28'E). The experiments were conducted during the two succeeding seasons of 2021-2022 and repeated in 2022-2023. Before sowing, soil samples were taken from the experimental site in both study seasons for estimating the physical and chemical analyses.

Experimental design and layout: The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental entries consisted of 4 treatments with 2 control plots imposed on two varieties (Norman and Borlaug). The treatments include (Planting 25th October, 5th November, 1st December and 1st January with 15th November and 15th December as control plot) all treatments were replicated 3 times on a plot size plot size of 5m x 3m, totaling 36 plots (12 treatment by 3 replicate). The crop was sown with a hand drill on a well prepared seedbed using a seed rate of 100kg/ha. All other agronomic practices were kept normal and uniform for all the treatments. Wheat was manually harvested at physiological maturity.

Data collection: Data was taken on plant height, days to 50% flowering, Days to 50% maturity, spike length, number of grains per spike, 1000 grain weight and grain yield. All best field agronomic practices for wheat production were adhered to.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) and significant differences were tested. While mean were separated using Student Newman-Keulas test (SNK)

RESULTS AND DISCUSSION

Days to 50% flowering: Table 1 showed that flowering date differed significantly among the sowing date and variety such that the planting dates affected the duration of the period from sowing date to flowering date, as it gave the first six treatment (Norman) the longest possible period to reach 50% flowering, which ranged from 65 to 69 days, while the last six treatment (Borlaug) gave the shortest period, ranging from 55 to 58 days. The result also indicated short flowering period at the first planting date is due to the increase in climatic changes rates from high temperatures and an increase in light intensity, which led to the accumulation of heat units needed for flowering. This result agreed with what was reached by the mechanism of (Aglan *et al.* 2020) who found a significant difference between planting dates in this trait.

Physiological maturity: Table 1 indicated that physiological maturity showed significant difference among the sowing date and variety such that the planting dates affected the duration of the period from sowing date to maturity date as it gave the first six treatment (Norman) the longest possible period to reach physiological maturity, which ranged from 115 to 120 days, while the last six treatment (Borlaug) date gave the shortest period, ranging from 103 to 106 days. The result also indicated that the first six faithful Norman row took the longest period of 120days with a significant difference within the variety, while the Borlaug row recorded the lowest period of 105 days and this is varieties of response to environmental conditions temperature and photoperiod requirements.

Number of spike/m^2: Table 2 showed that the planting dates had a significant impact on the number of spikes, as the treatment of the third sowing date gave the highest number of spikes/m^2, while the treatment of the sixth sowing date recorded the lowest number of spikes/m^2, the reason for this is due to the late planting date, which affected the growth of the vegetative total, especially the number of straws, which mainly affects the number of spikes.

Plant height: Table 2 indicated that plant height showed significant difference among the sowing date and variety. The plant height was higher in Norman compared to Borlaug in all the sowing date from 15th November to 1st of December. These finding is in line with Madhu *et al*. (2008), who observed the highest plant height of wheat was measured with all the varieties sown on 15th November and lowest plant height was found on 30th December.

Number of grain/spike: Table 3 showed that number of grain/spike differed significantly among the sowing dates and the variety, as the third sowing date gave the highest numbers of grains/spike, while the sixth sowing dates recorded the lowest number of grains/spike. The reason for the decrease in the number of grains in the late dates is due to the high temperature during that period, which negatively affected the number of grains in the spike. This result agreed with (Al-Jiashi and Jassim *et al.* 2010) who found a significant difference in the different sowing dates for the number of grains characteristic. The results also showed a significant difference between the varieties of the experiment in the trait of the number of grains, as the Borlaug variety significantly outperformed Norman variety by recording the highest number of grains/spike, while Norman variety recorded the lowest number of grains/spike.

Spike length: Table 3 showed that there was significant difference in spike length affected by different wheat variety and sowing date, such that spike length decreased as the sowing date was delayed from 15th December. The third sowing date produced the longest plant length while the last sowing date produced the least.

1000grains weight: Table 4 results showed that 1000grains weight differed significantly in this result and the result also revealed that planting dates affected the trait of the weight of a thousand grains, as the treatment of the third planting date gave the highest grain weight, while the treatment of the sixth sowing date recorded the lowest grain weight. The reason for the decrease in the weight of the grains with the delay in planting dates was due to the short duration of the grain's filling period due to its coincidence with high temperatures and consequently the lack of accumulated materials and its low weight. This result agreed with (Al-Jiashi and Alam *et al.* 2011).

Grain yield*:* Table 4 result showed that there is significant difference of grain yield among the treatment of the sowing date and variety, such that the planting dates affected the yield, as the treatment of the third sowing date gave the highest tons/ha with high significant difference with the second sowing date, while the sixth planting date gave the lowest tons/ha. The reason for the superiority of the third planting day may be due to the formation of a sufficient number of fertile ears and the number of grains which was positively reflected on the weight of one thousand grains, which led to an increase in yield, agreed with (Shaker *et al*. 1998).

CONCLUSION

Based on the results of this study, it could be concluded that planting of wheat from 15th November to 15th December gave the best wheat yield result in the study area. It could also be concluded that Borlaug yield higher than Norman and is more tolerant even when planted late.

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REFERENCE

Akhtar, M., Khan, M. A., Zubair, M., Ali, S., and Ahmad, S. (2006). Effect of sowing dates and seed rate on wheat yield and its components in Pakistan *Journal of Botany*, 38(3), 607- 613.

Aglan .M A., E.A., Abd EL- Hamid and A.M.,Morsy. (2020) Effect of Sowing date on yield and Its components for some breads wheat genotypes Zagazig . Agric. Res., 47: 117-122.

Alam Md. P., S. Kumar, N. Ali, R. P. Manjhi, N. Kumari, R. K. Lakva and T. Izhar (2013) Performance of Wheat Cultivaries under Different Sowing Dates in Jharkland. J. Wheat Res., 5 (2): 61-64.

Arain, M. A., Rajput, M. A., and Mahar, A. R. (1999). Evaluation of various wheat genotypes for late planting in Sindh. Pakistan *Journal of Biological Sciences*, 2(4), 1101-1103.

Dabre, W. M., Chaudhari, M. B., and Zode, N. G. (1993). Effect of different levels of nitrogen on the growth and yield of wheat in relation to sowing dates. *Journal of Agricultural Science*, 120(2), 113-120.

De, R., Singh, S., and Bhatia, C. R. (1983). Effects of sowing time on grain yield of wheat under late-sown conditions. *Indian Journal of Agricultural Sciences*, 53(5), 283-288.

Easterling, W. E., Aggarwal, P. K., Batima, P., Brander, K. M., Erda, L., Howden, S. M., and Tubiello, F. N. (2007). Food, fibre and forest products. Climate Change 2007: Impacts, Adaptation and Vulnerability, 273-313.

Haq, I., and Khan, M. (2002). Effect of sowing time on yield and yield components of wheat cultivars. *Asian Journal of Plant Sciences*, 1(5), 522-524.

Jassim, Shaker Rahma, Tariq, Kazem, Maya, and Adnan Jassim Thabet (2016) Effect of planting dates on growth, yield and components of wheat (Triticum aestivum L.). *Maysan Journal of Academic Studies*, (29): 176-185.

Jessop, R. S., and Ivins, J. D. (1970). The influence of day length and temperature on the growth and yield of wheat. *Annals of Botany*, 34(1), 69-78.

Kalra, N., Chakraborty, D., Sharma, A., Rai, H. K., Jolly, M., Chander, S., and Aggarwal, P. K. (2008). Effect of increasing temperature on yield of some winter crops in northwest India. *Current Science*, 94(1), 82-88.

Mirbahar, A. A., Sial, M. A., and Arain, M. A. (2009). Genetic architecture of yield and its components in bread wheat under normal and late planting environments. Pakistan *Journal of Botany*, 41(5), 2227-2235.

Mullarkey, M. and Jones, P. D. (2000). Temperature variation and variability in six seasonal series of extreme daily temperatures in Ireland. *International Journal of Climatology*, 20(9), 1049-1067.

Paul, N. K. (1992). Effect of different dates of sowing on the growth and yield of four wheat cultivars. *Bangladesh Journal of Agricultural Research*, 17(1), 56-63.

Radmehr, M., Stapper, M., & Fischer, R. A. (2003). Crop management for wheat. Agricultural Systems, 78(2), 101-115.

Rehman, S., Anwar, J., & Rehman, A. (2009). Quality characteristics of wheat varieties grown at different sowing dates. *International Journal of Agriculture and Biology*, 11(2), 1 151-55.

Rosegrant, M. W., & Agcaoili, M. (2010). Global food demand, supply, and price prospects to 2050. International Food Policy Research Institute Discussion Paper.

Sial, M. A., Arain, M. A., & Khanzada, S. D. (2001). Evaluation of wheat breeding lines for their yield and yield components under normal and late sowing conditions. *Pakistan Journal of Botany*, 33(2), 41-48.

Sial, M. A., Arain, M. A., & Rajput, M. A. (2005). Yield and yield components of bread wheat under different sowing dates. *Pakistan Journal of Botany*, 37(2), 297-302.

Solh, M., Nazari, K., & Tadesse, W. (2012). Tackling the threat of climate change and other challenges in the global wheat supply. Euphytica, 179(1), 3-17.

Stapper, M., & Fischer, R. A. (1990). Genotype and management effects on pre-anthesis growth, yield components and grain yield of wheat. *Field Crops Research*, 25(3-4), 99-120.

Shaker A. M., M. M. Salih., AL-Salim. S. H. F. (2019) Study of certified wheat (Triticum aestivum L) cultivars response to different planting date to evaluate the active products and yield. Plant Archives, 19(1): 142-145.

Tahir, M., Ali, A., Nadeem, M. A., Hussain, F., and Khalil, S. K. (2009). Effect of sowing dates on growth and yield of wheat (Triticum aestivum L.) cultivars. *Pakistan Journal of Life and Social Sciences*, 7(1), 66-69.

Wardlaw, I. F., Dawson, I. A., and Munibi, P. (1980). The effects of high temperature on kernel development in cereals. *Australian Journal of Agricultural Research*, 31(4), 389-401.

Table 1: Effect of Sowing Date and Varieties on Flowering Date and Physiological maturity

Treatment	2021		2022	
	Flowering Date	Physiological maturity	Flowering Date	Physiological maturity
Norman Planted 25th October	69^{b}	112^{bc}	66^{c}	110^{c}
Norman Planted 5th November	75^{a}	110^{bc}	75^{ab}	120^{a}
Norman Planted15thNovember	71^{ab}	118^{a}	77^{a}	121^{a}
Norman Planted 1st December	73^{ab}	115^{b}	74^{b}	119^{ab}
Norman Planted15thDecember	75^{a}	111^{bc}	73^{b}	117^{b}
Norman Planted 1st January	60^{d}	108^{c}	65^{cd}	113^{bc}
Borlaug Planted 25th October	58^{de}	101^{e}	64^{d}	101^{e}
Borlaug Planted 5thNovember	60^{d}	105^{d}	62^{de}	105^{d}
Borlaug Plante15thNovember	62^{d}	104^{d}	63^{d}	106^{d}
Borlaug Planted 1st December	64^{c}	106^{cd}	61^{e}	104^{de}
Borlaug Planted 15thDecember	63^{cd}	103^{de}	60^{e}	107^{cd}
Borlaug Planted 1st January	59^{d}	99^{ef}	58^{f}	100^{e}
LSD	4.65	5.82	5.32	6.78

Means followed by the same letter(s) are not significantly different at 5% level of probability using

SNK

Table 2: Effect of Sowing Date and Varieties on Number of Spike/m^2 and Plant height

Treatment	2021		2022	
	No. of Spike/ M^2	Plant height	No. of Spike/ M^2	Plant height
Norman Planted 25th October	215^{ef}	88	275^{e}	88.5
Norman Planted 5th November	255	90.5	370^{c}	100
Norman Planted15thNovember	380^{a}	95	428^{b}	95
Norman Planted 1st December	290^{b}	93	338^{e}	87
Norman Planted15thDecember	280^{bc}	91	315^{d}	88
Norman Planted 1st January	220^{e}	90	254^{ef}	82
Borlaug Planted 25th October	240^{de}	75	224^{f}	68
Borlaug Planted 5thNovember	260^{d}	83	410^{b}	78
Borlaug Plante15thNovember	395^{a}	97	450^{a}	99
Borlaug Planted 1st December	275^{c}	85	406^{bc}	77
Borlaug Planted 15thDecember	265^{cd}	82	337^{cd}	80
Borlaug Planted 1st January	210^{f}	77	284^{e}	69
LSD	18.3	3.56	19.63	4.21

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

Table 3: Effect of Sowing Date and Varieties on Number of grain/m^2 and Spike length

	2021		2022	
Treatment	No. grain/ Spike	Spike length	No. grain/ Spike	Spike length
Norman Planted 25th October	310de	6.5	354de	8
Norman Planted 5th November	340^{bc}	7.5	370^{cd}	9
Norman Planted15thNovember	450^{a}	9.5	458^{ab}	11
Norman Planted 1st December	360^{b}	8	408^{b}	10.5
Norman Planted15thDecember	355^{bc}	8.5	394^{c}	10
Norman Planted 1st January	290^{f}	7.5	304^{f}	8.5
Borlaug Planted 25th October	320^{d}	7	354de	8
Borlaug Planted 5thNovember	380^{b}	8.5	350^{d}	10
Borlaug Plante15thNovember	470^{a}	9	480^{a}	10.5
Borlaug Planted 1st December	410^{ab}	9.5	426^{ab}	9.5
Borlaug Planted 15thDecember	430^{ab}	8.5	447^{ab}	9
Borlaug Planted 1st January	305^{e}	8	314^{f}	8.5
LSD	18.45	2.45	19.56	3.78

Means followed by the same letter(s) are not significantly different at 5% level of probability using

SNK

Table 4: Effect of Sowing Date and Varieties on 1000grain weight and Grain yield

	2021		2022	
	Traits			
Treatment	1000grain weight	Grain yield	1000grain weight	Grain yield
Norman Planted 25th October	35.5	1800^{ef}	37.5^{d}	2733.3^{de}
Norman Planted 5th November	40^{d}	2500^{d}	43.5^{c}	3933.3^{bc}
Norman Planted15thNovember	49.5^{ab}	4200^{a}	52^{a}	4533.3^{ab}
Norman Planted 1st December	43^{c}	3000^{c}	48^{b}	4066.7^{b}
Norman Planted15thDecember	42.5^{cd}	3500^{ab}	43^{c}	3433.3^{cd}
Norman Planted 1st January	32^{e}	1200^{f}	34^{e}	2000^{f}
Borlaug Planted 25th October	36de	1600^{f}	37^{d}	2733.3
Borlaug Planted 5thNovember	39.5^{d}	3300^{c}	42^{cd}	3600.0^{c}
Borlaug Planted15thNovember	51^{a}	4300^{a}	53.5^{a}	4933.3^{a}
Borlaug Planted 1st December	47^{b}	3700^{ab}	49.5^{ab}	4200.0^{b}
Borlaug Planted 15thDecember	45^{bc}	3200^{cd}	45^{bc}	3333.3^{d}
Borlaug Planted 1st January	33^{e}	1900de	36de	2234.0^{e}
LS	0.75	65.7	1.34	70.6

Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK

PERFORMANCE OF OKRA (*Abelmoschus esculentus* [L.] MOENCH) VARIETIES AS AFFECTED BY PLANT GROWTH REGULATORS UNDER DRY SEASON IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was carried out to evaluate the performance of okra (*Abelmoschus esculentus* [L.] Moench) as affected by exogeneous application of plant growth regulators (PGRs) in Sudan Savanna of Nigeria. Two PGRs, Four concentrations each (50, 100, 150 and 200ppm) of gibberellic acid (GA_3) and indole-3-butyric acid (IBA) with a control were used and three okra (Basanti, Kirikou f_1 and Yar balle) varieties. This was laid out in a split-plot design and replicated three times. The results revealed that the PGRs increased plant height and LAI and the highest yield was recorded at 200ppm of GA_3 (45,477kg/ha and 53,691kg/ha) in both locations. Similarly, the plant height, LAI and fruit yield of were significantly affected by the varieties with Basanti producing the higher yield (15,630kg/ha and 24,657kg/ha) in both locations. Application of GA_3 influenced growth and yield better than IBA hence, application of GA_3 at 200ppm and using Basanti can be adopted for better fruit yield in Okra under dry season production in the study areas.

Key Words: Okra, plant growth regulators, variety

INTRODUCTION

Okra (*Abelmoschus esculentus* [L.] Moench) is a self-pollinating fruit vegetable crop belonging to the family Malvaceae (Oppong-Sekyere *et al*., 2011). The tender fruits contain minerals especially calcium, magnesium, iron, and phosphorus, protein, vitamin A, K and C including riboflavin as well as high mucilage that can be used as food additives (Dubey and Mishra, 2017). Plant growth regulators are organic compounds (other than nutrients which supplies either carbon and energy or essential mineral elements) that in small amount (less than 1mm) promotes, inhibits, or quantitatively modifies growth and development (Arteca, 2015). Among the several growth substances, GA_3 and IBA are found to be very promising, and these are being used in fruit and vegetable crops. Production constraints of okra in Nigeria have been attributed to low input supply system, where green fruit yields, in most instances, have been low (Ibrahim *et al*., 2012).

Similarly, the productivity and yield in okra is also affected by lack of location specific varieties and the scarcity of these improved varieties with important desirable end-user traits contributes to yield decline (Kumar *et al*., 2010). Gibberellic acid (GA_3) has potential to control growth and flowering process and also its application increase petiole length, leaf area (Mehraj *et al*., 2013) and delayed petal abscission (Khan *et al*., 2006). However, there is little information available on the effect of growth regulators on growth and yield of okra. The investigation was aimed to evaluate the effect of gibberellic acid (GA_3) and indole-3-butyric acid (IBA) on growth and yield of Okra.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted at the Orchard of the Department of Agronomy, Bayero University, Kano (11°58'N, 8°24'E) 470.9m a.s.l and Teaching and Research Farm, Aliko Dangote University of Science and Technology, Wudil (11°52' N and 09° 20'E) 475m a.s.l in Wudil local government area of Kano State.

Treatments and Experimental Design

The experimental treatments consisted of plant growth regulators (PGR's) which comprised four levels of GA_3 (50, 100, 150 and 200ppm), four levels of IBA (50, 100, 150 and 200ppm) and a control with three Okra varieties (Basanti, Kirikou F_1, and Yar balle (local). These treatments were laid in a split plot design with three replications. The PGR's occupied the main plot while the varieties were assigned to the sub plots.

Varietal Description

Basanti is a mid-early, long slim, dark green colored with high tolerance to mosaic disease and high yielding. It has a maturity period of 45-50 days. Kiri is a medium green, long slender with a maturity period of 50-55 days. It is also a high yielding variety that is resistant to disease. Yar balle is characterized by thick fresh pods, short and mature at 45-50days and largely used by subsistent farmers.

Cultural Practices

Ploughing and harrowing were carried out to obtain a fine soil tilth. The gross plot (3.6 x 2.4 m) consisted of six ridges (0.60m apart), while the net plot (2.4 x 1.2 m) consisted of two inner ridges. Seeds were sourced from East-west (Basanti) and Technisem (Kirikou F_1), r while the local was obtained from neighboring farmers. Three seeds per hole with a depth of 2-3cm were sown with inter and intra row spacing of 60×40cm respectively. NPK 20:10:10 was applied using side placement method at the rate of 100kg N, 40kg P_2O_5 and 40kg K_2O at 3 weeks after sowing (WAS) while the remaining N was applied at 6WAS using urea (46% N). Weeding was done manually at 3 and 6 weeks after sowing (WAS). No incidence of pests and diseases was encountered during the research. Mature tender fruits were harvested by cutting off the fresh fruit with knife from the plant. The first picking (harvest) was done at 45 days after sowing (DAS) while the subsequent pickings followed at an interval of 4 days respectively avoid being fibrous.

Treatment Imposition

A 2000 ppm stock solution of the PGR's was prepared by dissolving 125 mg (0.125 g) of their crystals in a 60 ml distilled water (John, 1987). The stock solutions were serially diluted and applied at the rates of 50, 100, 150 and 200 ppm as foliar spray at 30DAS, while the control plots were not sprayed.

Data Collection and Analysis

Five stands from the net plots were randomly tagged and data on plant height, LAI at 45 DAS and total number of pods and total fresh pod yield (kg/ha) at harvest. These were subjected to analysis of variance using GenStat 17th edition. Significant treatment means were separated using Student Newman's Keul (SNK) method at 5% level of probability.

RESULTS AND DISCUSSION

Table 1 shows the effect of PGRs and varieties on plant height of Okra at BUK and Wudil. The result showed significant difference among the PGRs for plant height of okra at BUK and Wudil. At both locations , application of 200ppm GA_3 recorded the tallest plants. This was followed by 200ppm IBA and 150ppm IBA in the same locations. However, application of 50ppm IBA recorded the shortest plant and was significantly at par with 100ppm IBA and control. However, the control recorded the shortest plants and was significantly at par with 50IBA. The increase in plant height by PGRs particularly GA_3can be due to the increase in the rate of mineral uptake (N, P and K) and transportation by root system to the aerial parts of plants (Khandaker *et al*., 2018). The result agrees with the findings of Rani *et al*. (2013), who reported that application of PGRs increased plant height due to enhancement in the cell division and cell elongation at shoot apex. Basanti produced the tallest plants while Yar balle recorded the shortest at BUK and Wudil. Umesh (2012) had earlier reported varietal effect on plant height and number of leaves when sprayed with PGRs. Table 2 shows the interaction between PGRS and varieties on plant height of Okra at Wudil. The interaction between Basanti×200GA_3 produced the tallest plantwhile Yar balle×50IBA produced the shortest plant but was significantly at par with Yar balle×Control and Kiri F1×50IBA.

The effects of PGRs and varieties on LAI of Okra at BUK and Wudil also revealed significant difference among the PGRs for LAI of Okra at both locations (Table 1). Application of 200GA_3 produced the highest LAI at BUK, followed by 200IBA and 150IBA . The least LAI was recorded by 50IBA across the locations. Similar trend was observed at both locations where 200GA$_3$ recorded the highest LAI and was significantly at par with 150GA$_3$, whereas 100IBA recorded the least LAI at Wudil. GA$_3$ act by cell elongation resulting to increased plant height, number of leaves which led to increased leaf area and subsequently the LAI. This agrees with the findings of Chowdhury *et al*. (2014) on the growth parameters of okra. Basanti produced the highest LAI at BUK and Wudil while Yar balle recorded the least LAI atthe same locations. Table 2 shows the interaction between PGRs and varieties on LAI of Okra at Wudil. The interaction between Basanti×200GA$_3$ produced the highest LAI followed by Kiri F1×200GA$_3$, Basanti×150GA$_3$ and Kiri F1×150GA$_3$. The least LAI was however obtained from the interaction of Yar balle×Control across the locations.

The number of pods of Okra at BUK and Wudil were also significantly affected by variety and PGR's. The results showed that 200GA$_3$ produced the highest number of pods at BUK and Wudil and was significantly at par with 200IBA. Application of 50GA$_3$ produced the highest number of pods and was significantly at par with 150IBA. The least number of pods were recorded by 50IBA across the locations and was significantly similar with the control at Wudil. The control recorded the lowest number of pods at Wudil and was significantly at par with 50IBA. This agrees with the findings of earlier researchers who have explained that the application of GA$_3$ increased the number of fruits per plant (Mahesh and Sen, 2005). Basanti produced the highest number of pods at BUK and Wudil while Yar balle recorded the least number of pods across the locations. The interaction between PGRs and varieties for number of pods of okra at Wudil are presented in Table 2. The interaction between Basanti×200GA$_3$ produced the highest number of pods of Okra and was significantly the same as Kiri F1×200GA$_3$. The interaction between Basanti×150GA$_3$ recorded number of pods and was significantly at par Basanti×200IBA and Kiri F1×150GA$_3$. The lowest number of pods was however obtained from the interaction of Yar balle×Control which was significantly similar to Yar balle×50IBA.

The fruit yield of okra was significantly influenced by variety and PGR's at both locations in this investigation. The results indicated that application of 200GA$_3$ produced the highest fruit yield across the locations. Consequently, application of 50IBA produced the lowest fruit yield at BUK. However, it was significantly the same as all other PGRs including the control in the same location. Similarly, at Wudil, 200GA$_3$ also produced plants with the highest fruit yield followed by 200IBA and 150GA$_3$. The control produced the lowest fruit yield at Wudil and was significantly at par with 50IBA. The application of GA$_3$ had a significant influence on the total fruit yield per hectare and this could be attributed to the increase in the morphological traits and growth parameters due to the application of PGRs. The yield depends on the accumulation of photo assimilates and partitioning into different plant parts and this agrees with the reports of Nawalkar *et al*. (2007). Basanti produced the highest fruit yield at BUK and Wudil and was significantly at par with Kiri F1. Yar balle produced plants with the least fruit yield. Similar trend was observed at Wudil. The higher fruit yield obtained from Basanti can be attributed to its genetic make up. Kishan *et al*. (2001) had earlier reported the increase is due to greater mobilization of reserved food material to fruits and seeds, which ultimately increase the fruit length, width and number of seed. Table 2 shows interaction between PGRs and varieties for pod yield of Okra at BUK and Wudil. The interaction between Basanti ×2 00 GA_3 produced the highest pod yield followed by Kiri F1×200GA_3 in both locations. The lowest fruit yield was however obtained from Yar balle×Control which was significantly at par with Yar balle×50IBA. Similar trend was obtained for interaction between PGRs and varieties for pod yield at Wudil.

CONCLUSION

The PGRs ($GA_3$and IBA) have significant effect in increasing growth and yield of Okra. In addition, foliar application of GA_3 at 200ppm was most effective in ultimately enhancing the yield of okra in both locations. Furthermore, Basanti and Kirikou F1 gave higher yield than Yar Balle. Basanti outperformed Kirikou F1 resulting in the higher yield in both locations.

REFERENCES

Arteca, R. N. (2015). Olericulture. *Introduction to Horticultural Science, 2nd edition. Nelson Education.* page. 189, 494-496.

Chowdhury M. S., Hasan Z., Kabir K., Jahan M. S. and Kabir M. H. (2014). Response of okra to growth regulators and Organic manures the agriculturists. *A Scientific Journal of Krishi Foundation*. 12(2):56-63.

Dubey, P. and Mishra S. (2017). A review on: Diabetes and Okra (*Abelmoschus esculentus* [L.] Moench). *Journal of Medicine and Plants Studies*. 5 23-26.

FAOSTAT (2020). Food and Agricultural Organization. http://www.fao.org/faostat/en/£data/QCL.

Ibrahim, U., Danji, L. Z and Hamma, L. L. (2012). Effects of poultry manure and apical clipping on growth and yield of Okra (*Abelmoschus esculentus* [L] Moench) in Samaru, Zaria Nigeria *NSUK Journal of Science and Technology*, 2(1&2):91-96.

John, M. R. (1987). Gibberellic acid for fruit set and seed formation, California rare fruit growers. *CFRG Journal* 19(1):10-12. *Retrievedfrom www.actohort.org*

Khan, M. M. A., C. Gautam, F. Mohammad, M.H. Siddiqui, M. Naeem, and M.N. Khan. (2006). Effect of gibberellic acid spray on performance of tomato. *Turkey Journal of Botany*, 30:11-16.

Khandaker M. M., Azam H. M., Rosnah J., Tahir D. and Nashriyah M. (2018). Effects of application of exogenous IAA and GA_3 on the physiological activities and quality of okra (*Abelmoschus esculentus* [L.] Moench). *Pertanika Journal of Tropical Agricultural Science*. 41(1):209-224.

Kishan, S. T. V., Sharma, R. S. and Attri, B. L. (2001). Effect of Alpha Napthalene Acetic Acid and 2-4-D on Growth Quality and Yield of Tomato Varieties. *Madras Agriculture Journal.* 30(10 12): 723- 726.

Kumar, S., Dahnoko, S., Haougui, A., Ratnadass, A., Pasternak, N. and Kouame, C. (2010). Okra (*Abelmoschus spp.)* in west and central Africa: Potential and progress on its improvement. *African Journal Agricultural Research*, 25, 3590-3359.

Mahesh, K. and Sen, N. L. (2005). Effects of zinc, boron and gibberellic acid on growth and yield of Okra (*Abelmoschus , esculentus* [L.] Moench). Department of Horticulture, Maharana Pratap University of Agriculture and Technology, Udaipur 313 001.

Meena, R. S. (2008). Effects of GA_3 and NAA on growth, yield and quality of tomato. (*Lycopersicon esculentum* Mill.). *Current Agriculture* 32 (1&2): 83-86.

Mehraj H., Taufique, T., Ona, A. F., Roni, M.Z.K. and JarmalUddin, A. F. M. (2013). Effect of spraying frequency of gibberellic acid on growth and flowering in Gerbera. *Journal of Experimental Biosciences*, 4(2):7-10.

Mishra S.N., Dash S.N. and Mishra D. (2001). Multivariae analysis of genetic divergence in Okra (*Abelmoschus esculentus* L.). *Indian Journal of Agricultural Science.* 68(5): 461-464.

Nawalkar, L. R., Khiratkar, S. D., Badge, S. A, Chopde, N. K. and Dadgal, S. S. (2007). Effects of biofertilizers and growth regulator with reduced doses of NPK on growth and yield of okra. *Journal of Soils and Crops*, 17(1): 145-149.

Oppong-Sekyere D., Akromah R., Nyamah E. Y., Brenya E. and Yeboah S. (2011). Characterization of okra (*Abelmoschus spp.* L.) germplasm based on morphological characters in Ghana. *Journal of Plant Breeding Crop Science.* 3, 368-379.

Umesh, K. A (2012). Early Okra production with plant growth regulators in Nepal. Nepal Agricultural Research Council. *https://www.reasearcgate.net/publication/257835851*

Table 1: Growth and fruit yield of Okra as affected by PGRs and Varieties at BUK and Wudil in 2022 dry season.

Treatment	BUK				Wudil			
	Plant Height (cm)	Leaf Area Index	Total Number of Pods	Total Fruit Yield (kg/ha)	Plant Height (cm)	Leaf Area Index	Total Number of Pods	Total Fruit Yield (kg/ha)
PGRs								
Control	9.61c	0.13c	20.6c	2,796b	9.10g	0.31d	36.37e	5,633d
50GA$_3$	12.61bc	0.24c	53.0b	9,576b	11.76ef	0.27d	50.14d	8,374cd
100GA$_3$	10.42bc	0.20c	39.4bc	7,140b	17.47c	0.47c	61.78c	11,960c
150GA$_3$	12.33bc	0.45bc	41.6bc	12,477b	22.43b	1.02a	77.34b	26,093b
200GA$_3$	22.66a	1.48a	92.7a	45,477a	26.89a	1.34a	93.63a	53,691a
50IBA	6.78c	0.12c	12.9c	2,359b	9.29g	0.22d	38.89e	5,872d
100IBA	8.23c	0.16c	37.5bc	5,589b	10.32fg	0.20d	48.89d	8,364cd
150IBA	13.11bc	0.56bc	51.2b	9,640b	13.07e	0.52b	58.99c	1,0604c
200IBA	16.71b	0.75b	58.0b	10,244b	15.90d	0.93b	76.06b	26,358b
Prob.L	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE±	1.665	0.12	7.49	2856.7	0.533	0.04	1.250	1073.6
Variety(V)								
Yar balle	9.99c	0.27c	32.4b	5,528b	10.60c	0.309c	40.57c	6,265c
Basanti	14.66a	0.62a	52.5a	15,630a	18.12a	0.748a	71.64a	24,657a
Kiri F1	12.84b	0.48b	50.7a	13,939a	16.69b	0.651b	68.49b	21,395b
Prob L	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE±	0.293	0.01	0.76	569.9	0.218	0.01	0.507	674.6
Interaction								
PGR X C	1.000	0.919	1.000	0.007	<.001	<.001	<.001	<.001

Means followed by the same letter(s) are not significantly different at 5% of probability using SNK.

Table 2: Interaction between PGRs and Varieties on plant height (cm), leaf area index, total number of pods and pod yield of Okra at BUK and Wudil in 2022 dry season.

PGRs	Variety								
	Plant Height (cm)			Leaf Area Index			Number of Pods		
	Yarballe	Basanti	Kiri F1	Yarballe	Basanti	Kiri F1	Yarballe	Basanti	Kiri F1
200 GA$_3$	18.10e	31.97a	30.60ab	0.80e	1.72a	1.48b	62.80ef	111.00a	107.10a
150 GA$_3$	13.80gh	28.87b	24.63c	0.55fgh	1.35bc	1.17cd	52.00hi	91.13b	88.90b
100 GA$_3$	12.03hi	21.40d	18.97de	0.22jkl	0.68ef	0.50f-i	37.00l	74.33c	74.00c
50 GA$_3$	8.90jk	13.77gh	12.60ghi	0.11kl	0.38g-j	0.33h-k	37.83kl	58.93fg	53.67gh
200 IBA	12.27hi	18.47e	16.97ef	0.60efg	1.15cd	1.05d	51.67hi	90.70b	85.80b
150 IBA	10.40ij	15.07fg	13.73gh	0.26jkl	0.69ef	0.61ef	38.40kl	71.93cd	66.63de
100 IBA	11.77hi	12.37hi	6.83k	0.09l	0.26jkl	0.25jkl	35.77l	56.53gh	54.37gh
50 IBA	6.37k	10.97ij	10.53ij	0.10l	0.28i-l	0.27i-l	25.20m	46.90ij	44.57j
Control	6.73k	10.20ij	10.37ij	0.07l	0.22jkl	0.19jkl	24.43m	43.30jk	41.37jkl
SE±		0.89			0.07			2.10	

Means followed by the same letter(s) are not significantly different at 5% of probability using SNK

Table 2 continues

PGRs	Variety					
	BUK			Wudil		
	Yarballe	Basanti	Kiri F1	Yarballe	Basanti	Kiri F1
200 GA_3	16,929c	67,377a	52,106b	11,651f-i	79,823a	69,599a
150 GA_3	5,417c-f	15,617cde	16,397cd	8,781g-l	36,744cd	32,755de
100 GA_3	3,233c-f	9,051c-f	9,136c-f	5,363klm	15,085f	15,432f
50 GA_3	6,088c-f	11,875c-f	10,764c-f	5,517j-m	10,432f-k	9,174g-l
200 IBA	6,512c-f	12,438c-f	11,782c-f	8,719g-l	39,637c	3,0718e
150 IBA	5,887c-f	10,370c-f	12,662c-f	5,687j-m	13,966fg	12,160fgh
100 IBA	3,318c-f	7,022c-f	6,427c-f	4,977lm	10,764f-j	9,352g-l
50 IBA	1,227 f	3,009ef	2,840def	2,963m	7,654h-m	6,998h-m
Control	1,142f	3,912c-f	3,333def	2,724m	7,809h-m	6,366i-m
SE±		4699.7			1,878.5	

Means followed by the same letter(s) are not significantly different at 5% of probability using SNK

GROWTH PERFORMANCE OF GRAPEVINE (*Vitis vinifera L.*) VARIETIES WITH DIFFERENTIAL RESPONSE TO FOLIAR APPLICATION OF GIBBERELLIC ACID

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ABSTRACT

Grapevine (*Vitis vinifera* L.) cultivation in semi-arid regions like Northern Nigeria faces challenges related to suboptimal growth conditions, which can hinder early development and reduce crop yield potential. This study was conducted during the 2022 dry season at the Training and Research Farm of the Centre for Drylands Agriculture, Bayero University, Kano, to evaluate the effects of gibberellic acid (GA_3) on the early growth of three grapevine varieties: Black Hamburg, Muscat Alexandria, and Crimson Seedless. Gibberellic acid was applied at three concentrations: 0, 100, and 200 mgl^{-1}. The experiment was laid in a split-plot design, with grapevine variety assigned to the main plot and GA_3 concentration to the sub-plot, replicated three times. Vegetative growth data were collected at 3, 4, and 5 months after transplanting (MAT) and analyzed using SAS software. Results revealed that Black Hamburg showed superior growth performance in plant height, number of leaves per plant, leaf chlorophyll content, stem diameter, leaf area, and leaf area index, in comparison to Muscat Alexandria, and Crimson Seedless. Application of 200 mgl^{-1} GA_3 significantly enhanced all growth parameters measured compared to 100 mgl^{-1}, with the least growth observed in the control group (0 mgl^{-1}). Significant interactions were observed, particularly between Black Hamburg and 200 mgl^{-1} GA_3, which recorded the highest growth values. The study demonstrates that foliar application of GA_3 can enhance grapevine growth in the challenging environmental conditions of Northern Nigeria.

INTRODUCTION

Grapevine (*Vitis vinifera* L.) is a global fruit crop with approximately 80.1 million tons produced annually, significantly valued for its use in fresh consumption, juice production, and raisins. Its production is widespread, with varied climatic requirements that influence its growth, development, and yield. Grape being a semiarid subtropical crop, it requires warm and dry summer and cool winter, tolerating to thrives well in regions with a temperature ranges from 4.5^{0}C to 45^{0}C. Most of fruit drink industry heavily depends on the grape fruit juice, increased production of fruits, fruit size and fruit weight becomes a vital marketing parameter for commercial grape farmers. Improving grape production and fruit yield through chemical treatments would improve the economic benefits for both the farmers and the juice processors. In recent years, the application of plant growth regulators, particularly gibberellic acid (GA_3), has been explored as a means to enhance grapevine growth, fruit set, and overall productivity (Khan *et al*., 2015). Gibberellic acid is known to influence cell elongation, leaf expansion, and internode length, which can significantly improve vegetative growth and fruit quality in different crops (Eriksson *et al*., 2011). Several common promising chemicals that are widely used to improve fruit set, yield and fruit quality include micronutrients (zinc, and boron, iron,), plant growth regulators such as gibberellic acid (GA_3) and auxins, and carbohydrates such as sucrose (Lovatt, 2013). Gibberellins, as phytohormones, have an essential role in promoting the change from vegetative to reproductive development in angiosperms with key functions in flower development, fertilization and fruit development (Plackett and Wilson, 2016).

Foliar application of nutrient solutions or liquid fertilizer directly on the leaves encourages and enhances critical points in tree phenology, including flowering, fruiting and seed formation and this method have become an essential feature in the production of fruits for commercial purposes globally (Lovatt, 2013). Advantages of foliar fertilization include well time of application throughout the growing season, precision: spraying of requires quantities of nutrients appropriate to specific requirements, faster uptake of nutrients through foliage compared to soil, and quick correction of physiological disorders due to nutrient-deficiency (Ali *et al*., 2019; Amaro *et al*., 2020). Combination application of boric acid (BA) + GA + sucrose as foliar nutrients resulted to increase fruiting and fruit yield for various fruits trees (Perica *et al*., 2001; Ebeed and El-Migeed, 2005; Aliyu *et al*., 2011; Krishna *et al*., 2017; Souza *et al*., 2017). Use of GA as a foliar nutrient resulting in increased flower buds and fruiting has been stated for coffee plants in Nigeria (Rodrigues and Rodrigues, 2016). However, different concentration of GA via foliar applications have not been reported so far.

In Northern Nigeria, agriculture is the backbone of the economy, with a strong focus on cereal crops and livestock. However, there is growing interest in diversifying agricultural production by introducing high-value horticultural crops such as grapes. Northern Nigeria's semi-arid climate, characterized by hot days and cooler nights, presents a unique environment for grape production. With proper management, including the use of growth regulators like GA_3 , grapevine cultivation could become a viable agricultural practice in the region (Abubakar *et al*., 2020). The foliar application of GA_3 offers the potential to overcome some of the region's key challenges, such as poor soil fertility and erratic rainfall, by promoting more vigorous growth and increasing tolerance to environmental stresses (Hameed *et al.*, 2014). However, limited studies have been conducted on the effects of gibberellic acid on grapevine growth in Northern Nigeria, particularly regarding the region's suitability for different varieties. This study aims to explore the influence of foliar application of different concentrations GA_3 on the growth performance of various grapevine varieties, contributing to the knowledge base needed for the successful introduction of this crop in Northern Nigeria.

MATERIALS AND METHODS

The field experiment was conducted at the Training and Research Farm of the Centre for Drylands Agriculture, Bayero University, Kano, Nigeria (11° 58' N, 8° E, 475 m above sea level). Seedlings were propagated from cuttings of three grape vine varieties: Crimson Seedless, Muscat Alexandria, and Black Hamburg were raised in polythene seedling bags. Prior to transplanting, soil samples were randomly collected from the experimental site at a depth of 0-15 cm using a soil auger for routine analysis. The experimental field was prepared by clearing debris and harrowing to prevent waterlogging. Transplanting holes (40 cm^3) were dug at a spacing of 2.5 m within rows and 3.5 m between rows. Each hole was refilled with topsoil mixed with farmyard manure in a 3:1 ratio, and the soil around the transplanted vines was compacted. The young vines were supported with sticks for structural stability.

The experiment consisted of three concentrations of synthetic gibberellic acid (GA_3) application; 0, 100, and 200 mgl^{-1}, across the three grapevine varieties. The treatments were arranged in a split-plot design with three replications, where the grapevine varieties were assigned to the main plot and GA_3 concentrations to the subplots. GA_3 was applied as a foliar spray at 20 ml per vine using a knapsack sprayer in the late afternoon, starting one month after transplanting and continuing at monthly intervals. Control vines were sprayed with water, and each vine served as an individual plot unit. The vines were irrigated regularly using a drip irrigation system. Weeding was performed manually to maintain weed-free conditions. Farmyard manure was applied in a 90 cm radius around each vine at a rate of 15 kg per plant, and NPK fertilizer (15:15:15) was applied at a rate of 250 g per plant in five split doses at monthly intervals. Bamboo sticks, 2 m tall, were used to support the young vines. To control insect pests, the plots were sprayed with Imiforce (Imidacloprid) at 30 g per 15 liters of water using a knapsack sprayer. Fungal diseases were managed by applying a mixture of Carbendazim 12% and Mancozeb 63%, with spraying commencing two weeks after transplanting. Data on vegetative growth were collected as follows: Plant Height were Measured from the base of the plant to the uppermost leaf using a meter rule. Number of Leaves were determined by counting the number of leaves per plant. Chlorophyll Content were assessed using a SPAD-502 chlorophyll meter (Minolta). Stem Diameter were Measured using a digital vernier caliper. Leaf Area measured using a digital leaf area meter (YMJ-A Model) from three tagged plants and lastly Leaf Area Index (LAI) were Calculated as LA/GA, where LA represents leaf area and GA represents ground area. Data were collected at 3, 4, and 5 months after transplanting (MAT) and analyzed using analysis of variance (ANOVA), as described by Snedecor and Cochran (1967), with the help of SAS statistical software. The Student-Newman-Keuls (SNK) test was employed to compare treatment means at a 5% probability level.

RESULTS AND DISCUSSION

The soil sample from the study site was characterized as sandy loam with a slightly acidic pH of 5.97. Chemical analysis indicated high organic carbon, moderate nitrogen (0.048%), moderate available phosphorus (6.43 mg/kg), and low potassium content (0.19 cmol/kg). These characteristics provide a moderately fertile environment for grapevine growth, although the low potassium levels could be a limiting factor for optimal development, as potassium is crucial for fruit quality and plant vigor (Basiouny *et al*., 2016). Supplementary fertilization may be necessary to enhance overall grapevine productivity, hence, NPK 15:15:15 was supplied. The effect of gibberellic acid (GA_3) on the plant height of different grapevine varieties was significant (Table 1). Among the varieties, 'Black Hamburg' consistently exhibited the tallest plants, followed by 'Muscat Alexandria' and 'Crimson Seedless,' indicating a genetic advantage in height growth for 'Black Hamburg' under the trial conditions. The higher growth rate of 'Black Hamburg' may be attributed to its adaptability to the warm climate of northern Nigeria, as suggested by previous studies (Ahmed *et al*., 2012). In contrast, 'Crimson Seedless' produced the shortest plants, which could be linked to its late-maturing nature and reduced adaptability to the warmer climate, as corroborated by Michael (2010). The application of GA_3 significantly influenced plant height across all varieties, with the height increasing as GA_3 concentration increased. The highest plant were recorded with the 200 mgl^{-1} GA_3 treatment, while the control group exhibited the shortest plants. This suggests that GA_3 plays a critical role in enhancing vertical growth by promoting cell elongation and division (Amanda *et al*., 2020). The interaction between variety and GA_3 was significant, with 'Black Hamburg' treated with 200 mgl^{-1} GA_3 producing the tallest plants, while 'Crimson Seedless' in the control group had the shortest plants (Table 2). This supports findings by Ali *et al*. (2019), who reported that GA_3 application significantly increased the growth and development of grapevines.

Varietal differences were also significant in terms of leaf production, with 'Black Hamburg' producing the highest number of leaves, followed by 'Muscat Alexandria' and 'Crimson Seedless' (Table 1). The increased leaf count in 'Black Hamburg' may contribute to enhanced photosynthetic capacity and improved overall plant vigor. GA_3 application had a positive effect on the number of leaves, with the 200 mgl^{-1} GA_3 treatment resulting in significantly higher leaf counts compared to the control. This effect was more pronounced at 4 and 5 months after transplanting (MAT), with GA_3 promoting increased leaf production, likely due to its role in enhancing cell division and leaf area expansion (Magdalena *et al*., 2017). The interaction between variety and GA_3 concentration was significant, with 'Black Hamburg' treated with 200 mgl^{-1} GA_3 producing the highest number of leaves, while 'Crimson Seedless' in the control group produced the least (Table 2). This result aligns with previous studies, which have shown that GA_3 improves canopy development and overall vine productivity by increasing leaf number and area (Ali *et al*., 2019). The chlorophyll content of grapevine leaves varied significantly between the varieties, with 'Black Hamburg' consistently showing the highest chlorophyll content, followed by 'Muscat Alexandria' and 'Crimson Seedless' (Table 3). This suggests that 'Black Hamburg' has a greater photosynthetic potential, which could lead to enhanced growth and yield. GA_3 application significantly increased chlorophyll content, particularly at 4 and 5 MAT, with the 200 mgl^{-1} GA_3 treatment resulting in the highest chlorophyll levels. This increase in chlorophyll content may be linked to the ability of GA_3 to enhance photosynthetic efficiency by improving the activity of enzymes involved in carbon fixation (Amanda *et al*., 2020). A significant interaction between variety and GA_3 concentration was observed, with 'Muscat Alexandria' treated with 200 mgl^{-1} GA_3 producing the highest chlorophyll content, while 'Crimson Seedless' in the control group exhibited the lowest chlorophyll levels (Table 4). These findings support previous research by Magdalena *et al*. (2017), which reported that GA_3 application enhances photosynthesis and overall vine growth. The stem diameter of grapevines was significantly affected by varietal differences, with 'Black Hamburg' producing the widest stems, followed by 'Muscat Alexandria' and 'Crimson Seedless' (Table 3). A wider stem diameter is indicative of a stronger and more vigorous plant structure, which can support greater water and nutrient transport, contributing to overall plant health and productivity (Basiouny *et al*., 2016). GA_3 application had a similar effect, with the 200 mgl^{-1} treatment resulting in significantly wider stems than the control, further supporting the positive role of GA_3 in enhancing plant growth. The interaction between variety and GA_3 concentration was significant, with 'Black Hamburg' treated with 200 mgl^{-1}

GA_3 producing the widest stems, while 'Crimson Seedless' in the control group had the smallest stems (Table 4). This interaction highlights the potential of GA_3 to improve structural growth in grapevines, particularly in varieties like 'Black Hamburg' that are more responsive to the hormone.

Leaf area and LAI were significantly affected by both variety and GA_3 application (Table 5). 'Black Hamburg' produced the largest leaf area and highest LAI, followed by 'Muscat Alexandria' and 'Crimson Seedless'. This suggests that 'Black Hamburg' has a greater photosynthetic surface area, which can enhance biomass accumulation and yield potential. GA_3 application significantly increased leaf area and LAI, with the 200 mgl^{-1} treatment producing the largest leaf areas and highest LAIs. This result is consistent with previous studies, which have shown that GA_3 promotes leaf expansion and enhances canopy development (Amanda *et al*., 2020). The interaction between variety and GA_3 concentration was significant, with 'Black Hamburg' treated with 200 mgl^{-1} GA_3 producing the largest leaf area and highest LAI, while 'Crimson Seedless' in the control group had the smallest leaf area (Table 6). These findings further confirm the positive role of GA_3 in enhancing vegetative growth, particularly in varieties like 'Black Hamburg', which are more responsive to its application. The results of this study align with previous findings, highlighting the potential of GA_3 to enhance grapevine growth and productivity through its action on cell division, elongation, and photosynthetic efficiency (Ali *et al*., 2019; Magdalena *et al*., 2017).

CONCLUSION

This study demonstrates the significant positive effects of GA_3 on the growth and development of grapevine varieties, particularly 'Black Hamburg', which consistently outperformed 'Muscat Alexandria' and 'Crimson Seedless' in terms of plant height, leaf number, chlorophyll content, stem diameter, and leaf area. The use of GA_3 , especially at 200 mgl^{-1}, can substantially improve the vegetative growth and physiological efficiency of grapevines, making it a valuable tool for grapevine cultivation in warm climates like northern Nigeria. However, 'Crimson Seedless' showed less responsiveness to GA_3 , indicating that this variety may require additional management practices or be less suitable for such environments without interventions. Future research should explore the long-term effects of GA_3 on yield and fruit quality to fully understand its impact on grapevine production.

REFERENCES

Abubakar, M., Gana, A., & Kolo, M. G. (2020). Agricultural diversification in Northern Nigeria: Prospects for viticulture. *Journal of Horticultural Research*, 12(1), 25-31.

Ahmed, N., & Ali, A. (2012). Performance of grapevine cultivars under different environmental conditions in Northern Nigeria. *Journal of Agricultural Science*, 56(3), 129-135.

Ali, A. A., Agric, F., & Mohsen, F. S. (2019). Foliar spray of Gibberellin (GA3) and Urea to improve growth, yield, bunch and berry quality of Red globe grapevine. *Current Science International*, *8*(1), 193–202.

Ali, A., Ahmed, M., & Zubair, M. (2019). The impact of gibberellic acid (GA3) on the growth and development of grapevine. *International Journal of Plant Research*, 9(2), 56-62.

Aliyu, O. M., Adeigbe, O. O., Awopetu, J. A., Olasupo, F. O., & Ugese, F. D. (2011). Foliar application of the exogenous plant hormones at pre-blooming stage improves flowering and fruiting in cashew (Anacardium occidentale L.). *Journal of Crop Science and Biotechnology*, 14(1), 9–17. https://doi.org/10.1007/s12892-010-0104-9

Amanda, R., Thompson, J., & Smith, K. (2020). Influence of plant growth regulators on photosynthetic efficiency in grapevines. *Journal of Horticultural Science*, 85(4), 451-458.

Amaro, A. C. E., Souza, E. R., Santos, L. S., Baron, D., Ono, E. O., & Rodrigues, J. D. (2020). Foliar application of plant growth regulators to “Crimson Seedless” grapevine influences leaf age. *Australian Journal of Crop Science*, *14*(3), 422–430. https://doi.org/10.21475/ajcs.20.14.03.p1874

Basiouny, M., Ahmed, M., & Hussein, M. (2016). The role of potassium in improving the growth and fruit quality of grapevine varieties. *Horticultural Journal*, 21(5), 90-98.

Ebeed, S. M., El-Kareem, A. E. A., & Attia, F. A. (2005). Effect of spraying sucrose and some nutrient elements on Fagri Kalan mango trees. *Journal of Applied Sciences Research*, 1(1), 18–21.

Eriksson, M. E., Israilsson, E., & Moritz, T. (2011). Gibberellin signaling in plant growth regulation. Annual Review of Plant Biology, 62, 10.1-10.25.

Hameed, A., Khan, A. A., & Ashraf, M. (2014). Role of foliar application of gibberellic acid in plant growth under environmental stress conditions. Environmental and Experimental Botany, 98, 1-9.

Khan, N., Bano, A., & Babar, M. (2015). Role of gibberellins in improving plant growth and productivity. Plant Growth Regulation, 76(3), 173-188.

Krishna, G. V., Kalyan, B. B., & Reddy, Y. N. (2017). Foliar chemicals application impact on flowering and yield of mango cv. Banganpalli. *International Journal of Pure and Applied Bioscience*, 5(6), 162–168. https://doi.org/10.18782/2320-7051.6006

Lovatt, C. J. (2013). Properly timing foliar-applied fertilizers increases efficacy: A review and update on timing foliar nutrient applications to citrus and avocado. *HortTechnology*, 23(5), 536–541. https://doi.org/10.21273/HORTTECH.23.5.536

Magdalena, P., Katerina, M., & Petr, R. (2017). Effects of gibberellic acid on photosynthetic rate, vine length, and yield of grapevine cultivars. *Scientia Horticulturae*, 218(4), 107-113.

Michael, T. (2010). Late maturity and high storability of Crimson Seedless grapevine variety in temperate and tropical regions. *Vineyard Research Journal*, 45(3), 223-230.

Perica, S., Brown, P. H., Connell, J. H., Nyomora, A. M., Dordas, C., Hu, H., & Stangoulis, J. (2017). Foliar boron application improves flower fertility and fruit set of olive. *HortScience*, 36(4), 714-716. DOI: 10.21273/HORTSCI.36.4.714.

Plackett, A. R. G., & Wilson, Z. A. (2016). Gibberellins and plant reproduction. In *Annals of Plant Reviews* (Vol. 49, pp. 323-367). DOI: 10.1002/9781119312994.apr0490111.

Rodrigues, A., & Rodrigues, Y. (2016). The role of boron in coffee production. Retrieved from https://ecofriendlycoffee.org/role-of-boron-in-coffee-production/.

Snedecor, G. W. and Cochran, W. G. (1967). *Statistical Methods*, 6th edition, Lowa State University Press, Lowa, U.S.A. pp. 607.

Souza, M. F., Teixeira, G. H., Marques, V. B., & Lima, G. P. (2017). Boron and nitrogen effects on the production and quality of sweet potato. *Brazilian Journal of Agriculture*, 92(2), 153-160. DOI: 10.1590/0001-3765201720150473.

Table 1: Effect of GA3 on Plant Height (cm) and Number of Leaves of Grapevine Varieties.

Treatment	Plant Height (cm) 3 MAT	4 MAT	5 MAT	Number of Leaves Per Plant 3 MAT	4 MAT	5 MAT
Variety (V)						
Black Hamburg	101.62^{a}	142.52^{a}	181.78^{a}	44.03^{a}	56.19^{c}	91.15^{a}
Muscat Alexandria	83.80^{b}	112.00^{b}	152.66^{b}	35.65^{b}	64.56^{b}	78.83^{b}
Crimson Seedless	63.26^{c}	96.48^{c}	120.63^{c}	36.56^{b}	71.79^{a}	74.30^{c}
P value	<0.0001	<0.0001	<0.0001	0.0010	<0.0001	0.0040
SE ±	2.362	3.046	3.114	0.833	0.673	2.246
GA_3 (G)						
0 mgl^{-1}	69.83^{c}	96.31^{c}	122.52^{c}	33.60^{b}	50.81^{c}	64.38^{c}
100 mgl^{-1}	83.87^{b}	120.00^{b}	155.07^{b}	40.04^{ab}	66.23^{b}	83.37^{b}
200 mgl^{-1}	93.98^{a}	134.69^{a}	177.48^{a}	42.59^{a}	75.50^{a}	96.53^{a}
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
SE ±	1.148	1.292	2.389	0.449	0.614	0.845
Interaction						
V x G	0.0020	<0.0001	0.0380	<0.0001	0.1110	<0.0001

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK).

Table 2: Interaction between GA3 and Variety on Plant Height (cm) and Number of Leaves of Grapevine

	Plant Height (cm)									Number of Leaves					
	3 MAT			4 MAT			5 MAT			3 MAT			5 MAT		
GA_3 (mgl^{-1})	0	100	200	0	100	200	0	100	200	0	100	200	0	100	200
Black H.	85.50^{d}	104.32^{b}	115.04^{a}	120.90^{c}	149.80^{b}	156.80^{a}	148.10^{cd}	183.70^{b}	213.5^{a}	37.03^{de}	46.72^{b}	48.33^{a}	69.69^{e}	94.82^{b}	108.93^{a}
Muscat A.	69.78^{ef}	83.50^{d}	95.11^{c}	101.00^{d}	115.40^{c}	119.60^{c}	125.00^{e}	155.50^{c}	177.40^{b}	32.11^{f}	36.50^{e}	38.33^{d}	65.22^{e}	78.00^{d}	94.00^{b}
Crimson	54.22^{g}	63.78^{f}	71.78^{e}	81.20^{f}	101.20^{e}	107.00^{d}	94.4^{f}	126.00^{e}	141.40^{d}	31.67^{f}	36.89^{de}	41.11^{c}	58.22^{f}	77.28^{d}	86.67^{c}
SE±		2.866			3.551			4.058			1.047			2.544	

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK).

Table 3: Leaf Chlorophyll Content and Stem Diameter (mm) of Grapevine Varieties as Affected by Foliar Application of GA_3

	Leaf Chlorophyll Content			**Stem Diameter (mm)**		
	3	**4**	**5**	**3**	**4**	**5**
		MAT			**MAT**	
Treatment						
Variety (V)						
Black Hamburg	46.48^{a}	71.13^{a}	40.15^{b}	6.035^{a}	7.965	9.238^{a}
Muscat Alexandria	40.59^{b}	45.97^{b}	46.58^{a}	5.606^{b}	7.558	8.219^{c}
Crimson Seedless	34.92^{c}	37.66^{c}	37.87^{c}	5.060^{c}	7.286	8.586^{b}
P value	<0.0001	0.0020	0.0002	0.1070	0.1070	0.0015
SE ±	0.544	1.213	0.931	0.096	0.238	0.190
GA_3 (G)						
0 mgl^{-1}	36.16^{c}	41.64^{c}	37.51^{c}	4.930^{c}	6.724^{c}	7.742^{c}
100 mgl^{-1}	41.85^{b}	55.05^{ab}	42.08^{b}	5.727^{b}	7.782^{b}	8.877^{b}
200 mgl^{-1}	46.97^{a}	58.07^{a}	45.01^{a}	6.044^{a}	8.303^{a}	9.524^{a}
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
SE ±	0.421	0.776	0.628	0.052	0.069	0.090
Interaction						
V x G	0.9310	<0.0001	<0.0001	0.0004	0.0010	0.0130

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK).

Table 4: Interaction between GA_3 and Varieties on Leaf Chlorophyll Content and Stem Diameter (mm) of Grapevine

	Leaf Chlorophyll Content									Stem Diameter (mm)					
	4 MAT			3 MAT			5 MAT			4 MAT			5 MAT		
GA_3 (mgl^{-1})	0	100	200	0	100	200	0	100	200	0	100	200	0	100	200
Black Hamburg	37.09^{d}	39.53^{cd}	40.59^{c}	5.43^{e}	6.24^{ab}	6.43^{a}	38.17^{d}	39.89^{d}	42.38^{c}	7.01^{de}	8.34^{ab}	8.54^{a}	8.14^{d}	9.37^{b}	10.20^{a}
Muscat Alexandria	38.42^{cd}	47.23^{b}	52.10^{a}	5.06^{f}	5.77^{d}	5.99^{bc}	40.60cd	46.90^{b}	52.24^{a}	6.56^{e}	7.74^{bc}	8.37^{a}	7.56^{e}	8.64^{cd}	9.56^{b}
Crimson Seedless	30.38^{e}	36.63^{d}	37.29^{cd}	4.30^{g}	5.17^{ef}	5.72^{c}	33.76e	39.44^{d}	40.40^{cd}	6.60^{e}	7.26^{cd}	7.99^{ab}	7.52^{e}	8.32^{d}	8.81^{c}
SE±		1.635			0.121			1.287			0.257			0.231	

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK).

Table 5: Effect of Foliar Application of GA_3 on Leaf Area (cm^2) and Leaf Area Index of Grapevine Varieties

	Leaf Area			Leaf Area Index		
Sampling period (MAT)	**3**	**4**	**5**	**3**	**4**	**5**
Variety (V)						
Black Hamburg	49.48^{a}	71.13^{a}	81.70^{a}	0.056^{a}	0.081^{a}	0.093^{a}
Muscat Alexandria	40.59^{b}	45.97^{b}	50.06^{b}	0.046^{b}	0.052^{b}	0.057^{b}
Crimson Seedless	34.92^{c}	37.66^{c}	39.89^{c}	0.040^{c}	0.043^{c}	0.045^{c}
P value	0.0040	0.0020	<.0001	0.0040	0.0020	<.0001
SE ±	1.929	3.671	2.442	0.0022	0.0042	0.0027
GA_3 (G)						
0 mgl^{-1}	36.16^{c}	41.64^{c}	47.04^{c}	0.041^{c}	0.047^{c}	0.054^{c}
100 mgl^{-1}	41.85^{b}	55.05^{b}	60.22^{b}	0.048^{b}	0.062^{b}	0.069^{b}
200 mgl^{-1}	46.97^{a}	58.07^{a}	64.39^{a}	0.054^{a}	0.066^{a}	0.073^{a}
P value	<.0001	<.0001	<.0001	<.0001	<0.0001	0.0017
SE ±	0.775	1.049	1.494	0.0009	0.0012	<.0001
Interaction						
V x G	0.00511	<.0001	<.0001	0.0501	<.0001	<.0001

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK).

	Leaf Area (cm^2)						Leaf Area Index					
		4			5			4			5	
GA_3 (mgl^{-1})	0	100	200	0	100	200	0			0	100	200
BH	50.46^{b}	79.67^{a}	83.26^{a}	59.25^{c}	90.03^{b}	95.82^{a}	0.058^{b}	0.091^{a}	0.095^{a}	0.068^{c}	0.103^{b}	0.109^{a}
MA	40.90^{b-f}	46.97^{b-d}	50.03^{bc}	45.91^{ef}	49.80^{de}	54.47^{cd}	0.046^{b-f}	0.054^{b-d}	0.057^{bc}	0.052^{ef}	0.057^{de}	0.062^{cd}
CS	33.55^{f}	38.50^{d-g}	40.93^{b-e}	35.96^{g}	40.84^{fg}	42.88^{ef}	0.038^{f}	0.044^{d-g}	0.047^{b-e}	0.041^{g}	0.047^{fg}	0.049^{ef}
SE±		3.959			3.229			0.0045			0.0037	

Means followed by the same letter(s) are not significantly different at 5% level of significance using Student Newman's Kleus (SNK). BH= Black Hamburg, MA= Muscat Alexandria and CS= Crimson Seedless

EFFECTS OF NITROGEN AND INTER ROW SPACING ON GROWTH AND DEVELOPMENT OF PUMPKIN (*Cucurbita maxima* L.) VARIETIES IN SUDAN SAVANNAH ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT
Nitrogen and inter-row spacing are important agronomic factors in Pumpkin (*Cucurbita maxima* L.*)* production. A field experiment was conducted during the 2023 rainy season at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University, Kano and Bunkure, located in the Sudan Savannah of Nigeria. The study was aimed at determining the effect of nitrogen and inters row spacing on the growth of pumpkin varieties (*Cucurbita maxima* L.) in the study area. The treatment consisted of four levels of nitrogen (0, 40, 80, and 120kg N ha^{-1}), three inter-row spacing (1, 1.5, and 2 m), and two varieties (Yar-Madina and Ex-Ajiwa). Repeated three times in a split-split plot design (SSPD). Nitrogen was allocated to the main plot, inter-row spacing was in the subplot, and varieties were in the sub-sub plot. The result revealed that pumpkin treated with 80 kg N recorded significantly higher dry weight and CGR which is superior to the control. The result also indicated that row spacing had a significant effect on some growth characters of pumpkin, such as the number of leaves. The responses of varieties to most of the growth characters evaluated were not significant. However, there were few significant differences at some sampling periods, with Yar-Madina being superior over Ex-Ajiwa with respect to number of leaves and leaf area. Based on the results obtained in this study, it could be concluded that the application of 80kg N and a 1m row spacing interval is recommended for optimum growth of pumpkin in the Sudan Savannah ecological zone of Nigeria.
Keywords: Pumpkin, spacing, nitrogen, varieties, Sudan savanna

INTRODUCTION

Pumpkin (*Cucurbita maxima* L.*)* is an important crop in the tropics, where it is grown for its large, fibrous but palatable fruit. In many African countries like Niger, Cameroun, Mali, Uganda and Nigeria (John, 2004). Pumpkin is cultivated and consumed widely among the rural dwellers in Northern Nigeria, Niger where the mature fruits serve as food security during the dry season because of its long shelf life. In 2019, global production of *Cucurbita* species(*Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita pepo*)was estimated at 22,900,826 mt (FAOSTAT, 2019). According to the same source, African production is estimated at 2,793,530 mt. This vegetable is cultivated for several purposes ranging from nutritional to medicinal purposes, nutritionally, pumpkin seeds kernels contain moderate concentrations of several minerals among which are; potassium, phosphorus and magnesium, (Alfawaz, 2004). The fleshy mesocarp of the fruit is used as an ingredient for making soup, it is especially good for thickening soups with or in the absence of tomato and pepper and other relatively more expensive ingredients (Lawan *et al.*, 2009).

In Nigeria, Pumpkin is a traditional vegetable crop, grown mainly for it leaves fruits and seeds and, consumed either by boiling the leaves and fruits, or by roasting or baking the seeds. Thus, pumpkin production in Africa is very low when compared with other continents, there is need to popularize this underutilized crop but potentially rich in nutrients in order to feed the growing population in a sustainable manner. With the increasing pressure on farm land for infrastructure development, limited land is available for this crop that requires large expanse of area for its cultivation. Pumpkin vines can spread beyond 15 meters from its stand and covers the land within 45 days of planting (Oloyede, 2011). Hence, due to limited land resource, farmers now plant this crop on intensively cultivated lands, with inappropriate proper inter row spacing which increase the need for land with wider spacing and limit its total yield with limited crawling area. Farmers now use fertilizer to improve the yield of the crop due to Pumpkin serial harvesting and the use of depleted soils. The three major fertilizer elements known to be deficient in most Nigerian soils due to intense pressure on land as a result of continuous cropping are N, P and K. **(**Aduayi *et al.*, 2002). Nitrogen plays an important role in plant growth (Weinhold *et al.*, 1995). This nutrient is a component of protein and nucleic acid and when the N amount in the soil is not optimal, growth is reduced (Weinhold *et al.*, 1995). Therefore, the objective of this research is to assess the growth response of pumpkin to nitrogen and inter-row spacing in the Sudan savanna of Nigeria.

MATERIALS AND METHODS

The experiment was conducted during the rainy season of 2023 at the Teaching and Research Farm Faculty of Agriculture, Bayero University, Kano. ($11^0$58 ′ N, $08^0$24′ E) 470.9m above sea level and Bunkure (11^0 50′ 05″ N, $8^0$35′ 53 ″E) and 444M above sea level. Both locations are in the Sudan savannah agroecological zone of Nigeria. The treatment consisted of three levels of inter-row spacing (1.0 m, 1.5 m, and 2.0 m), Four levels of Nitrogen (0 kg N/ha, 40 kg N/ha, 80 kg N/ha and 120 kg N/ha and two varieties (Yar-Madina and Ex-Ajiwa). Each plot was 72 m^2, 12 m wide and 6 m long. The two innermost rows were the net plot which is 3m x6m ($18m^2$). The experiment was laid out in split split plot (SPD). The land was harrowed and then marked into $72m^2$ plots and then the different rows were marked manually. Nitrogen was allocated to the main plot inter-row spacing subplot while varieties in sub subplot. Half of the Nitrogen (50%) was applied before sowing while the remaining half was applied at 3 WAS. Data were collected on the following number of leaves, number of branches, leaf area and crop growth rate using standard procedures.

RESULTS AND DISCUSSIONS

Effect of Nitrogen: Except at Bunkure at 6 WAS, number of leaves, number of branches, leaf area index and crop growth rate were not affected in the two locations (Tables 1 - 4). The non-significant response could be because the N status of the soil was optimum for the crop. Many studies have observed similar results adding that the non-response response of crops to fertilizer was due to the soil's mineralogical composition (Jones *et al.,* 2013, Batjes, 2011 & Towett *et al*., 2015). Gudeta *et al.* (2022) observed that the risks of no-crop response to fertilizers were significantly higher on soils with low-activity clays and high P fixation capacity. According to Kihara *et al.* (2016), no crop response to fertilizers was due to moderate fertility status of the soil and or the soil composition. However, the lower crop growth rate at the control at Bunkure at 6 WAS attested to the significance of nitrogen in pumpkin growth and development, and that under low N status, pumpkin growth is depressed. Interestingly, Waseem *et al.* (2007) working on cucumber obtained maximum fruit length, fruit weight, and vine length with application of 0 to 100 kg N ha^{-1}. From the conflicting reports, therefore, it is evident that the response of pumpkin growth to N fertilization is highly dependent on the soil properties (Gudeta *et al*., 2022).

Effect of row spacing: The effect of row spacing on pumpkin was significant on number of leaves at Bunkure with the highest value recorded at 1.0 and 1.5 m. The higher number of leaves at the narrower spacing could be due to plant response to overcome stress enforced by intense competition for limited resources. However, the highest leaf area value was recorded at 1.5 and 2.0m across the location and sampling stages. This shows that leaf area development requires wider spacing which due to limited competition for growth resources, could support greater growth and higher growth characters. Moazzen *et al.* (2006) demonstrated that with reducing plant density, due to increasing spacing for each plant, the availability of nutrients and other growth factors increase which in turn increased the plant height and other vegetative characters compared with high planting density. This agrees with the report of Dean *et al.* (2004) who indicated that in wider plant spacing plant growth was better due to less competition for growth requirements and also to adequate light interception for photosynthesis resulting in to production of pumpkin with wider leaf areas and superior growth attributes.

Varietal performance: Varietal differences with respect to number of leaves were significant at 4 and 6 WAS at BUK, and 4 WAS at Bunkure with Yar-Madina producing a greater number of leaves than Ex-Ajiwa had the least values (Tables 1 to 4). Mujibu (2021) and Lassa (2019) recorded similar superior performance of Yar-Madina over Ex-Ajiwa with respect to number of leaves per plant. According to them the superiority of Yar-Madina was probability because it is an improved variety. Furthermore, the effect on leaf area and number of branches was also significant only at Bunkure 6 WAS with Yar-Madina having a significantly larger leaf area than Ex-Ajiwa which recorded a smaller leaf area during the period. This also confirms the superiority of Yar-Madina with respect to growth performance.

CONCLUSION

The results of this study showed that the growth of pumpkin varieties was significantly influenced by the application of nitrogen and row spacing in the study areas. Based on the results obtained in this study application of 80kg N resulted in higher in most of the growth characters and a 1m row spacing interval compared with others. The finding also revealed that Yar-Madina was superior to Ex-Ajiwa in growth and growth attributes.

REFERENCE

Aduayi, E. A, Chude V.O, Adebusuyi BA and S.O, Olayiwola Fertilizer use and management practice for Crops in Nigeria. Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja Nigeria. 200 2; Pp16.

Aissami, M. B. (2005). Growth and Yield of Four Varieties of Squash Pumpkin (*Cucurbita maxima* L.) in Response to Varying Rates of N.P.K. Compound Fertilizer. (Unpublished B. Agric Project). Ahmadu Bello University, Zaria Nigeria.

Alfawaz, MA. Chemical composition and oil characteristics of pumpkin (*Cucurbita maxima*) seeds Kernels. **Res. But**. 2004; 129:5-18.

Batjes, N.H. (2011). *Global Distribution of Soil Phosphorus Retention Potential*. Wageningen: ISRIC—World Soil Information (with Dataset), ISRIC Report 2011/06. Available at https://library.wur.nl/WebQuery/wurpubs/fulltext/185289 (accessed 26 August 2021).

Dean, B. (2004). Effect of Intra-row Spacing on Muskmelon Growth and Yield. Institute for Agriculture and Tourism, Carla Huguesa 8, 52440 Porec, Croatia.

FAOSTAT (2019). Available online: http://faostat3.fao.org/home/E (Accessed 8th February 2021).

Gudeta, W. S., J. Kihara, L. Tamene, B. Vanlauwe, E. P. and B. Jama (2022). Unravelling causes of poor crop response to applied N and P fertilizers on African soils. *Experimental Agriculture*, vol. 58, e7, 1–17 doi: 10.1017/S0014479721000247

John, K. K. (2004). Crop rotation in Kerala. A case study of Kaduthruthy Block, Kerala Research Programme on Local Level Development, Centre for Development Studies, Prasanth Nagar, Ulloor;

Jones A., Breuning-Madsen H., Brossard M., Dampha A., Deckers J., Dewitte O., Hallett S., Jones R., Kilasara M., Le Roux P., Micheli E., Montanarella L., Spaargaren O., Tahar G., Thiombiano L., Van Ranst E., Yemefack M. and Zougmore R. (2013). **Soil Atlas of Africa**. Luxembourg: European Commission.

Kihara, J., Nziguheba, G., Zingore, S., Coulibaly, A., Esilaba, A., Kabambe, V., Njoroge, S., Palm, S. and Huising, J. (2016). Understanding variability in crop response to fertilizer and amendments in sub-Saharan Africa. *Agriculture, Ecosystems and Environment* 229, 1–12. doi: 10.1016/j.agee.2016.05.012

Lassa, I. (2019). Integrated use of fertilizer and intra row spacing in the performance of pumpkin (*Curcubita* maxima L.) varieties in Sudan savanna ecological zone of Nigeria. Unpublished PhD. Thesis Department of Agronomy, Bayero University, Kano.

Lawal, A. B., Aissami, B. M. and Lawan, H. M. (2009). Influence of Mineral Fertilizer on Productivity and Growth of Four Varieties of Squash Pumpkin (*Cucurbita maxima* L.) *Advances in Horticultural Science*, **23**(3): 201-204.

Moazzen S.H., Daneshian J., Valadabad S.A., Baghdadi H. 2006. Study of plant population and phosphate fertilization on some agronomic characters and seed and fruit yield of pumpkin (*Cucurbita pepo* L.). *Iranian Journal of Medicinal and Aromatic Plants*, 22(4): 397-409. (In Persian with English Summary).

Mujibu, G. B. (2021). Response of pumpkin (*Curcubita maxima* L.) varieties to moringa leaf extract and sowing date in Sudan savannah ecological zone of Nigeria. Unpublished M.Sc. Thesis Department of Agronomy, Bayero University, Kano.

Oloyede, F. M. (2011). Agronomic traits and Nutritional values of pumpkin (Cucurbita pepo Linn.) as influenced by NPK fertilizer. An unpublished Ph.D. Thesis submitted to the Department of Plant Science, Obafemi Awolowo University, Ile-Ife, Nigeria.

Statistix. Analytical Software (2006). Statistix 8.1 **User's Manual**. Analytical Software, Tallahassee, Florida 2006.

Towett, E.K., Shepherd, K.D., Tondoh, J.E., Winowiecki, L.A., Lulseged, T., Nyambura, M., Sila, A., Vågenb, T.G. and Cadish, G. (2015). Total elemental composition of soils in Sub-Saharan Africa and relationship with soil forming factors. Geoderma Regional 5, 157–168. doi:10.1016/j.geodrs.2015.06.002

Waseem, K., Q.M. Kamran and M.S. Jilani, 2008. Effect of different levels of nitrogen on the growth and yield of Cucumber (Cucumis sativus L.). *J. Agric. Res*., 46: 259–266.

Weinhold, B. J., Todd, P. T., Reichman, G. A. (1995). Yield and nitrogen efficiency on irrigated corn in northern Great Plans. *Agronomy Journal* 87: 842-846.

Table 1: Effect of Nitrogen and row spacing on number of leaves per pumpkin plant at BUK and Bunkure during the 2023 rainy season.

Treatment	BUK			Bunkure		
	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
Nitrogen (Kg/ha)						
0	6.6	10.2	16.7	7.5	18.5	22.0
40	6.5	10.9	18.6	8.3	20.0	24.5
80	7.7	11.7	16.7	8.0	17.9	21.5
120	7.6	11.1	16.0	8.5	17.8	22.0
Probability level	0. 310	0.774	0.406	0.433	0.442	0.395
SE ±	0.54	1.00	0.85	0.43	1.02	1.25
Row spacing (m)						
1.0	7. 3	11.1	17.2	8.6a	18.7	22.5
1.5	6.9	10.8	18.0	8.0ab	18.9	23.4
2.0	7.2	11.1	16.7	7.6b	17.9	21.7
Probability level	0. 331	0.891	0.490	0.043	0.441	0.483
SE ±	0.21	0.56	0.79	0.38	0.57	0.98
Variety (V)						
Yar-Madina	7.9a	12.1a	17.7	8.5a	18.8	22.6
Ex-Ajiwa	6.3b	9.9b	16.9	7.6b	18.3	22.4
Probability level	<.001	<.001	0.364	0.012	0.450	0.835
SE ±	0.19	0. 35	0.64	0.82	0.49	0.62
Interaction						
N*I	0.159	0.170	0.989	0.083	0.233	0.834
N*V	0.260	0.120	0.442	0.102	0.230	0.223
I*V	0.159	0. 356	0.478	0.179	0.364	0.106
N*I*V	0.009	0.618	0.905	0.757	0.821	0.845

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using SNK.

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Table 2: Effects of Nitrogen and row spacing on number of branches plant^{-1} of pumpkin at BUK and Bunkure during 2023 rainy season.

Treatment	BUK			BUNKURE		
	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
Nitrogen (KgN/ha)						
0	0.20	1.07	4.15	0.65	4.63	6.25
40	0.30	1.30	6.17	1.11	5.44	8.46
80	0.20	1.69	5.28	0.43	4.24	7.70
120	0.30	1.19	6.41	0.89	4.46	8.61
Probability level	0.925	0.135	0.479	0.165	0.233	0.422

SE ±	0.137	0.219	1.058	0.191	0.382	1.080
Row spacing (m)						
1.0	0.29	1.32	5.61	0.85	4.91	8.07
1.5	0.33	1.29	5.72	0.83	4.92	7.92
2.0	0.13	1.19	5.08	0.63	4.25	7.49
Probability level	0.093	0.679	0.715	0.445	0.507	0.788
SE ±	0.066	0.104	0.617	0.135	0.457	0.790
Variety (V)						
Yar-Madina	0.32	1.82a	5.61	0.93	4.85	7.93
Ex-Ajiwa	0.18	0.72b	5.39	0.61	4.54	7.72
Probability level	0.144	<0.001	0.687	0.104	0.357	0.725
SE ±	0.069	0.098	0.387	0.132	0.237	0.405
Interaction						
N*I	0.085	0.002	0.690	0.501	0.621	0.596
N*V	0.361	0.929	0.168	0.291	0.430	0.422
I*V	0.412	0.849	0.665	0.861	0.854	0.922
N*I*V	0.405	0.030	0.401	0.960	0.422	0.665

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using SNK

Table 3: Effects of Nitrogen and row spacing on total leaf area (cm^2) of pumpkin at BUK and Bunkure during 2023 rainy season.

Treatment	BUK		Bunkure	
	6 WAS	8 WAS	6 WAS	8 WAS
Nitrogen (Kg/ha)				
0	936	1982	3323	3573
40	1134	1807	3521	3398
80	2889	7652	5231	9183
120	1521	3080	3907	4671
Probability level	0.373	0.341	0.406	0.354
SE ±	788.8	2488.1	804.3	2363.8
Row spacing (m)				
1.0	1842b	2783b	3882b	4143b
1.5	2162a	6062a	5222a	8102a
2.0	2679a	4800a	6725a	7475a
SE ±	500.6	1343.0	510.9	1344.4
Probability level	0.004	0.014	<0.001	<0.001
Variety (V)				
Yar-Madina	1896	4304	4283a	5895
Ex-Ajiwa	1344	2956	3708b	4517
Probability level	0.063	0.116	0.045	0.111
SE ±	199.9	584.2	191.9	588.0
Interaction				
N*I	0.666	0.430	0.720	0.432

N*V	0.293	0.685	0.211	0.700
I*V	0.327	0.219	0.259	0.229
N*I*V	0.613	0.542	0.491	0.573

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using SNK. WAS = Weeks after sowing

Table 4: Effects of Nitrogen and row spacing on pumpkin crop growth rate ($gm^{-2}wk^{-1}$) at BUK and Bunkure during the 2023 rainy season.

Treatment	BUK		Bunkure	
	6 WAS	8 WAS	6 WAS	8 WAS
Nitrogen (Kg/ha)				
0	86.6	107.7	73.8b	115.2
40	71.4	92.2	89.1a	99.7
80	85.0	106.1	87.4a	113.6
120	79.9	100.9	82.2ab	108.4
SE ±	3.12	3.21	3.13	3.21
Probability level	0.050	0.050	0.049	0.050
Row spacing (m)				
1.0	80.1	101.1	82.6	108.6
1.5	80.4	103.3	82.8	108.9
2.0	81.6	102.7	84.0	110.2
SE ±	5.33	5.58	5.33	5.48
Probability level	0.977	0.977	0.978	0.977
Variety (V)				
Yar-Madina	83.9	105.0	86.4	112.5
Ex-Ajiwa	77.9	98.4	79.9	105.9
SE ±	2.42	2.49	2.42	2.49
Probability level	0.072	0.072	0.071	0.072
Interaction				
N*I	0.868	0.868	0.868	0.867
N*V	0.367	0.376	0.370	0.367
I*V	0.747	0.747	0.748	0.746
N*I*V	0.284	0.284	0.284	0.284

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using SNK. WAS = Weeks after sowing

YIELD AND YIELD ATTRIBUTES OF WHEAT (*Triticum aestivum L.*) AS INFLUENCED BY RATES AND TIME OF NITROGEN APPLICATION UNDER IRRIGATION

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ABSTRACT

Field trial was conducted during 2020/2021 dry season at the research farm of Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria. The aim is to study the 'Yield and yield attributes of wheat (*Triticum aestivum L.*) as influenced by rates and time of nitrogen application in Northern Guinea Savannah of Nigeria'. The treatments consisted of factorial combination of five nitrogen (N) rates (0, 40, 80, 120 and 160 kg N ha^{-1}) and two times of basal application (at sowing and tillering), laid out in a randomized complete block design (RCBD) and replicated four times. The results showed that nitrogen rates significantly affected almost all the yield characters such as, days to 50% heading and 50% physiological maturity, spike length, number of spikelets per spike^{-1}, number of grains per spike^{1}, grain yield and harvest index. Results obtained at 120 kg N ha^{-1} nitrogen application gave the best response. Nitrogen applied at sowing produced the highest values of all parameters studied with the exception of harvest index that had similar value to application at tillering. Based on the obtained results, application of nitrogen at 120 kg N ha^{-1} combined with application time at sowing produced the maximum yield of wheat.
Key words: Wheat, nitrogen, time of application, sowing, irrigation

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to the family *Poacea (Gramineae*), reported to be cultivated about 6000 years ago in the Mesopotamian Fertile Crescent, and it apparently spread to the Middle East, North Africa, Asia and ultimately Europe (Harlan, 1982). Wheat spread to the Americas and Southern Africa around 1500 AD, and it was introduced into Australia in 1790. Today, wheat is widely and diversely grown food crop in the world (Vinod and Jag, 2010). Wheat requires well drained soils that have low acid and saline levels (Anonymous, 2016), pH between 6.0 - 7.0, while 6.4 should be optimum for micronutrient availability and wheat growth. The optimum mean daily temperature range for ideal germination is 20 - 25°C while that of accelerated growth is 20 - 23°C whereas mean daily temperature in the range of 23 - 25°C is suited for proper grain filling (Samra and Gurbachan, 2004). Irrigated wheat in Sudan, Zimbabwe and Nigeria generally receives a total of 450 - 600 mm of irrigation water (Elsadig, 2006). In 2020, the total global production of wheat was 760 million tons. China is the largest single wheat producer in the world with over 134 million metric tons while, Egypt is Africa's largest producer with over 9 million metric tons (FAO, 2022). Nigeria was estimated to produced only 63,000 metric tons (about 1%) of the 5 to 6 million metric tons of the commodity consumed annually, hence the enormous demand-supply gap is bridged with over $2 billion spent annually on importation (Anonymous, 2021).

Wheat production is hampered with many challenges, especially poor cultural practices that affected the performance of the crop particularly nutrients supply and the time of application. Infact, unbalanced application of inorganic fertilizers such as nitrogen by the farmers due to lack of knowledge about the proper method of application where it is applied irrespective of the crop demand shows that no specific nitrogen rate is applied at a proper time. Excessive levels of nitrogen decrease grain yield slightly when compared with sufficient levels of nitrogen through enhancement of vegetative growth at expense of grain production (Gardner and Jackson, 1976). There is a little knowledge among farmers on the time of N fertilizer application. Wrong timing of fertilizer application cannot meet the needs of anticipating changes in growth and nutrient demand of the crop, hence it affects the overall performance of the crop and subsequently yield. This becomes necessary to determine the optimum time of nitrogen application for efficient development to obtain higher yield.

A lot of research has indicated that wheat production can be improved through adequate nitrogen rate and appropriate time of application, whereas the optimum response of the crop to such factors may differ with variety and weather condition. Inview of the above, this study was conceived to determine the effect of different nitrogen levels and varied time of application on some selected yield parameters of wheat for optimum yield.

MATERIALS AND METHODS

Field trial was conducted during the dry season of 2020/2021, at research farm of Institute for Agricultural Research, Samaru (11^o 11 N, 07^o 38 E, 686 m above sea level) in the Northern Guinea Savanna agro-ecological zone of Nigeria. Basin method of irrigation was adopted and all the basins (plots) were flooded at weekly interval. The treatments consisted of five nitrogen rates (0, 40, 80, 120 and 160 kg ha^{-1}) and two times of basal application (at sowing and tillering). They were factorially combined and laid out in a randomized complete block design (RCBD) and replicated four times. Gross plot size was 9 m^2 (3 × 3 m). There was an alley of 0.5 m between the plots and 1 m between the replicates.

LACRIWHIT-6 (Reyna-28) was used in this study and was sown on 3rd of December, 2020 by drilling method maintaining line to line at a rate of 100 kg ha^{-1} at 25 cm inter-row spacing. Seed was treated against soil borne diseases with Apron Star TM 42 WS at a rate of 10 g per 2.5 kg before sowing. Prior to land preparation, herbicide (Glyphosate as Roundup 360EC) was applied at 1.8 kg a.i. ha^{-1} as initial weed control. Then hoe weeding at 4 WAS and also supplementary hand pulling was carried out at 7 WAS to control sedges. The first irrigation was done immediately after seeding and subsequent irrigations were observed at 7 days interval.

Urea fertilizer (46%N) was used to supply half dose of each N rate required (20, 40, 60 and 80 kg N ha^{-1}) and entire Phosphorus and Potassium requirement (50 kg ha^{-1} each) using Single Super Phosphate (20% P_2O_5) and Muriate of Potassium (60% K_2O) respectively were applied basal (at sowing). The remaining half (second dose) of N rates (20, 40, 60, and 80 kg N ha^{-1}) were later applied at 6 WAS (top dressing) using Urea (46%N) according to treatments. There was no incidence of insects and diseases occurrence during the period. All plants in each net plot were manually harvested at full physiological maturity using sickle and were bundled in sheaves, sun dried in the field, threshed and winnowed on 13th of March, 2021. Data were collected on number of days to 50% heading and 50% physiologically maturity, spike length, number of spikelets per spike^1, number of grains per spike^1 and harvest index. Grain yield was recorded when the entire harvested grain within the net plot was weighted and expressed into kg ha^1.

Data collected were subjected to Analysis of Variance (ANOVA) to test the significance difference and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

RESULTS

The effect of nitrogen rates and time of application on number of days to 50% heading and 50% physiological maturity of wheat was presented in Table 1. Nitrogen application has significantly affected days to 50% heading and 50% physiological maturity of wheat. Application of nitrogen at a rate of 120 N ha^{-1} delayed both heading and maturity, beyond which no increase was observed, while the lowest values were obtained from the control plots.

Significant difference was recorded in the time of nitrogen application (Table 1) where nitrogen applications at sowing delayed heading and maturity than at tillering stage. There was no significant interaction between the factors observed.

The effect of nitrogen rates and time of application on spike length of wheat was presented in Table 1. Varying the rate of nitrogen resulted in significant effect of the spike length of wheat at all the sampling periods. Application of 120 kg N ha^{-1} resulted in longer spike length, beyond which no significant increase was noted while shorter spikes were recorded in the control plots.
Time of nitrogen application on spike length was significant (Table 1) where nitrogen applied at sowing produced significantly longer spikes than nitrogen applied at tillering. There was no significant interaction between the factors observed.
The effect of nitrogen rates and time of application on number of spikelets per spike^{-1} of wheat was presented in Table 1. Nitrogen rates had significantly affected the number of spikelets per spike^{-1} .The highest number of spikelets per spike^{-1} was obtained at application of 120 kg N ha^{-1}, beyond which no further increase was observed. The least number of spikelets per spike^{-1} were obtained in the control plots.
(Table 1) where nitrogen applied at sowing produced significantly higher values by nitrogen applied at tillering. There were no significant interactions between the factors observed.
Time of nitrogen rates application was significant on number of spikelets per spike^{-1} of wheat
The effect of nitrogen rates and time of application on number of grains per spike^{-1} of wheat was presented in Table 2. From the result, it showed that, significant interaction was recorded consistently with respect to different nitrogen rates on number of grains per spike^{-1}. Enhancing the rate of nitrogen at 120 kg N ha^{-1} resulted in a progressive increase in number of grains per spike^{-1} which was the highest, beyond which no further increase was observed while the lowest values were obtained from the control plots.
Time of nitrogen application was significant (Table 2) where nitrogen applied at sowing have greater number of grains spike^{-1} than application at tillering. There were no significant interactions between the factors observed.
The effect of nitrogen rates and time of application on grain yield of wheat was presented in Table 2. There was a significant positive and interaction when nitrogen was applied at 120 kg N ha^{-1}

hence, produced highest grain yield, beyond which there was no increase. However, lowest grain yield was recorded from the control plots.

Time of nitrogen application was significant on grain yield of wheat (Table 2) where nitrogen applied at sowing resulted in significantly highest grain yield than application at tillering. There was no significant interaction between the factors observed.

The effect of nitrogen rates and time of application on harvest index of wheat during 2020/2021 dry season was shown in Table 2. Harvest index was significantly affected and increased to the highest when nitrogen was applied at a rate of 120 kg N ha^{-1}. Further increase to 160 kg N ha^{-1} decreased the harvest index. However, lowest harvest index was recorded in control plot.

There was no significant difference between the time of nitrogen application at sowing and tillering (Table 2). No significant interaction recorded between the factors observed.

DISCUSSION

The general performance of yield components of wheat crop was optimum. Cereal crops respond favourably to the application of nitrogenous fertilizers. Nitrogen taken up by the crop is utilized for vegetative growth, thereafter; additional absorbed nitrogen was diverted to the accumulation of assimilates to grain filling processes. Improvement in wheat yield and it's components under the acceptable increasing N rates were reported by Sticksel *et al.* (2000).

The progressive increase in yield of wheat at both locations was as a result of intensifying the rate of nitrogen up to 120 kg N ha^{-1}, however, further increase up to 160 kg N ha^{-1} resulted to a decrease of grain yield. This was similar to the findings of Belete *et al.* (2018) who observed that increasing the rate of nitrogen beyond 120 kg N ha^{-1} decreased nitrogen use efficiency traits.

Bassionny (1979) and Bello, (1983), findings revealed that the longer the spike, the higher the number of spikelets spike^{-1}. Masood (2002) revealed grain yield increased with increase in fertilizer levels from 80 - 120 kg N ha^{-1}.

Nitrogen fertilizer applied basal at sowing significantly influenced almost all the studied yield characters of wheat in both locations with variation in nitrogen rates. Vanchev (1971) findings revealed nitrogen applied at sowing or tilling as a full dose gave greater response than application at flowering. Elsadig (2006) revealed increase in mean number of spikelets spike^{-1} with application of nitrogen in two equal doses, at sowing and flowering (13.4) and full dose at sowing (11.6) compared to decrease in the control (11.2) and full dose at flowering (11.1). Elsadig (2006) found the highest yield obtained by nitrogen application as split in two equal doses; at sowing and flowering (533.5 kg ha^{-1}) and full dose at sowing (492.88 kg ha^{-1}). The lowest was obtained from control plot (30.8 kg ha^{-1}) and full dose at flowering which produced (90.0 +kg ha^{-1}).

CONCLUSION

Based on the results obtained from the present study, application of nitrogen rate of 120 kg N ha^{-1} at sowing could be suggested for both Samaru and Galma for higher yield of the crop under irrigation.

REFERENCES

Anonymous, (2016). How best to grow wheat IAR Director. *Daily Trust*. *https://dailytrust.com/how-best-to-grow-wheat-iar-director/*

Anonymous, (2021). CBN kick start process of wheat production in Plateau. Vanguard.https://vanguardngr.com/2021/11/cbn-kick-start-process-of-wheat-production-in-plateau/amp/

Bassiouny, A.H.M. (1979). Effect of methods and rates of seeding as related to nitrogen fertilization on growth and yield of wheat. Unpublished M.Sc Thesis, Faculty of Agriculture, Zagazig University, Egypt

Belete, F., Dechassa, N., Molla, A. and Tana, T (2018). Effect of nitrogen fertilizer rates on grain yield and nitrogen uptake and use efficiency of bread wheat (Triticum aestivum L.) varieties on the Vertisol of central highland of Ethiopia. Agriculture and food security, 7:78 https://doi.org/10.1186/s40066-018-0231-z

Bello, U.B. (1983). Effect of water stress at grain development stages of wheat (*Triticum aetivum L.*) under different levels of nitrogen and phosphorus fertilizers. Unpublished M.Sc Thesis, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria. Pp 126

Duncan, D.B. (1955). Multiple Range and Multiple F Test Biometrics. 2: 1-42

Elsadig, I. (2006). Effect of time of nitrogen application on growth and yield of wheat (*Triticum aestivum L.*) cultivars. Unpublished M.Sc. Thesis, University of Khartoum, Sudan. pp 12-41

Food and Agricultural Organization (FAO) (2022). International wheat production statistics. Wikipedia. *https://en.m.wikipedia.org/wiki/international_wheat_production_statistics*

Gardner, B. and Jackson, E. (1976). Fertilization, nutrient composition and yield relationship in irrigated spring 1. *Agronomy Journal, 68(1): 75-78.*

Harlan, J.R. (1982). The early history of wheat. Earliest traces to the Rome. In wheat science today and tomorrow (L. T. Evans and W. J. Peacock, eds). Cambridge University Press, Cambridge, UK. Pp 19

Masood, M., Jan, M.T. and Shamsi, I.H. (2002). Impact of nitrogen fertilizer, their levels application times and weeding methods on yield and yield components of wheat. *Asian Journal of Plant Science. 1(4): 361-363.*

Samra, J.S. and Gurbachan, S. (2004). Heat wave of March, 2004: Impact on Agriculture. New Delhi ICAR 2004. Desc 32. DDC classification 632.1 Pp 11 *SAM/HE https://library.kau.in/*-7

Sticksel, E., Maidl, X-L,l., Retzer, F., Dennert, J., Fischbeck, G. (2000). Efficiency of Grain Production of Winter Wheat as Affected by Fertilization Under Particular Consideration of Single Culm Sink Size. *Euro J. Agron. 13: 287–94.*

Vanchev, N. (1971). Effect of date of application of ammonium nitrate to wheat grown in South Bulgaria. *Ramstemev "dni Nauki* 8 (7): 124-132

Vinod, T. and Jag, S. (2010). Growth and Production of Wheat. *Soils, Plant Growth and Crop Production. Encyclopedia of Life Support Systems* (EOLSS) 1: 3

Table 1: Effect of nitrogen rates and time of application on days to 50% heading and days to 50% physiological maturity, spike length and number of spike per spikelet of wheat during 2020/2021 dry season at Samaru

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS=Not significant WAS=Weeks after sowing

	Days to 50% heading	**Days to 50% physiological maturity**	**Spike length**	**Number of Spikelets per Spike^{-1}**
Treatment				
Nitrogen rate (N) kg ha^{-1}				
0	43.87e	75.50e	5.68e	9.25e
40	46.00d	78.12d	7.37d	10.25d
80	47.87c	81.12c	8.37c	11.25c
120	52.50a	87.87a	10.68a	13.62a
160	50.12b	84.46b	9.68b	12.25b
SE±	0.154	0.347	0.154	0.190
Time of Application (T)				
At sowing	49.20a	82.80a	8.91a	11.80a
At tillering	46.95b	80.10b	7.81b	10.85b
SE±	0.097	0.219	0.097	0.120
Interactions				
N × T	NS	NS	NS	NS

Table 2: Effect of nitrogen rates and time of application on number of grains per spike, grain yield and harvest index of wheat during 2020/2021 dry season at Samaru

	Number of Grains per Spike^{-1}	Grain Yield (kg ha^{-1})	Harvest Index (%)
Treatment			
Nitrogen rate (N) kg ha^{-1}			
0	19.75e	1618.75e	30.98e
40	22.62d	1987.50d	33.71d
80	27.25c	2462.50c	37.23c
120	33.25a	3387.50a	41.06a
160	30.00b	2850.00b	39.31b
SE±	0.455	13.404	0.235
Time of Application (T)			
At sowing	27.70a	2510.00	36.64
At tillering	24.45b	2412.50b	36.28
SE±	0.287	8.477	0.148
Interactions			
N × T	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS=Not significant WAS=Weeks after sowing

MODERN APPROACHES IN INTEGRATED SOIL, PESTS AND DISEASES MANAGEMENT FOR SUSTAINABLE CROP PRODUCTION AND FOOD SECURITY

VALIDATION ON THE PERFORMANCE OF IMPROVED GROUNDNUT VARIETIES AND HERBICIDES AS AN INTEGRATED WEED MANAGEMENT STRATEGY IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2023 rainy season at the Dryland Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto The experiment consisted of six groundnut varieties (Samnut 21, 22, 23, 24, 25 and 26) and four weed control options (Pendimethalin at 1.5Kg a.i. ha^1, Butachlor at 1.5 Kg a.i. ha^1), two hoe-weeding and a weedy-check. The treatments were factorially combined to make a total of twenty four treatments combination which was laid out in a Randomized Complete Block Design (RCBD) with three replications. The results showed lowest days to 50% flowering (35.58), highest number of pods per plant (20.18) and highest pod yield of (1.30 t $h\text{-}^1$) was recorded inSamnut 24. In the weed control treatments, average pod weight of (1.27 t $h\text{-}^1$) was recorded in pendimethalin @ the rate of 1.5kg a.i. ha^1. However, in the interaction means, highest number of pods per plant (25.00), pod yield (1.53 t h^1) was recorded in Samnut 24 + pendimethalin @ 1.5kg a.i. ha^1. Thus, Samnut 24 + pendimethalin @ the rate of 1.5kg ai $ha^1$is recommended as integrated weed management for groundnuts cultivation in Sokoto Sudan savanna Agro-ecological zone of Nigeria

Keywords: Groundnut, herbicides, variety, Sudan savannah, weeds management, Samnut 24

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) also known as peanut is one of the world's principal oilseed crops which belong to the family Fabaceae. It ranks fourth in oil production after soyabean (*Glycine max* L.), cotton seed (*Gossypium* spp.) and rape seed (*Brassica napus* L.) (FAOSTAT, 2022). Groundnut is an annual crop commonly grown by smallholder farmers. The name groundnut can be confusing as the plant is not typically a nut. The plant itself grows above the ground while the nuts (pods) develop and mature underground. It originated from Central America, and its cultivation spread to the rest of the world as an oil-seed crop. In Nigeria, pyramid-like structures made of groundnut sacks were common features in several locations up to the 1970s. The historic groundnut pyramids of Northern Nigeria and contributions of the crop to export revenue of Nigeria before the discovery of crude oil established an exceptional link between the crop and socio-cultural as well as economic growth of the country (Vabi, *et al*. 2019).

Groundnut is undoubtedly the most popular legume crop in the farming system of many developing countries including Nigeria. Unlike other cereals and legumes, all parts of the plant are valuable (Vabi *et al*. 2019). Groundnut has contributed immensely to the development of Nigeria until 1969. Nigeria used to be the third largest exporter of groundnuts after India and China but now it is a net importer of vegetable oil due to decline in groundnut production. Conventionally, groundnut cultivation in Nigeria is carried out mostly by smallholder farmers during the wet season under rainfed conditions with limited inputs.

Peanut is cultivated in the semi-arid and subtropical regions of the world. It is grown in nearly 100 countries on six continents on nearly 34.6m ha. Asia, Africa, Americas, Europe and Oceania producing 19.3m ha, 12.4m ha, 2.4m ha, 0.4m ha and 0.1m ha respectively (FAOSTAT, 2023). Worldwide production stands at 63,111,119 metric tons with Asia, Africa, Americas, Europe and Oceania producing 34,444,111 metric tons (54.5%), 18,333,819 metric tons (29.1%) 8,444.489 metric tons (13.4%), 1,444,935 metric tons (2.3%) and 143,817 metric tons (0.2%) respectively. China, India and Nigeria are the leading groundnut producing countries in the world. China with 17.3 metric tons, India with 14,650,000 metric tons and Nigeria with 3.4 metric tons holds maximum global groundnut production (FAOSTAT, 2023). Developing countries in Asia, Africa and South America account for over 97% of world groundnut area and 95% of total production. However, the average productivity of Africa 1,833kg ha^{-1} is poor as compared to China 3,433kg ha^{-1} (FAOSTAT, 2023). Across the world, the crop is widely cultivated and continues to be a major commercial crop in China, India, Africa and the United States of America (USA). While many varieties grown by small scale farmers takes between 120 to 150 days to mature, however, improved varieties namely: Samnut 21, 22, 23, 24, 25 and 26 take between 85-90 days. Production costs and profit margins can vary depending on knowledge, skills, farm management and disease/pest pressure and environmental factors notably rainfall and temperature. Overall, returns on investment can be reasonable in cases where appropriate seeds and accompanying crop management practices are adopted (Vabi, *et al*. 2019).

A total of thirty-two (32) improve groundnut varieties have been registered and released for commercial production in Nigeria since 1990. Depending on resistance to disease pressure, grain and haulm yield potentials as well as adaptation to the main agro-ecological zones of Nigeria, six of these varieties are popularly grown by smallholder farmers. Upon registration and release, the key features of improved groundnut varieties are: high grain yields-estimated at 2-2.5 tons/ha instead of less than 1 ton ha[1]; high haulm yields estimated to be between 2.5-3tons ha[1], early maturity estimated at between 80-95 days, high oil contents estimated to be at least 45%, resistance to popular groundnut diseases notably early and late leaf spot diseases and the rosette virus, small to medium size pods, and tan in color. These features make them satisfy both consumer and market preferences (Vabi, *et al*. 2019). Improve varieties of groundnut Samnut namely: 21, 22, 23, 24, 25, 26, 27, 28 and 29 were with specific recommendations having been released in Nigeria. (Hakeem *et al*. 2020)

All parts of the groundnut plant are valuable and useful. The kernel can either be used as seeds or fed directly to domesticated birds (chickens). Groundnut haulms (also known as fodder) are regularly used to feed sheep, goats and cattle and as fuel for heating. Groundnut is also one of the most valuable feeds for compounding livestock and poultry feeds. In industry, groundnut has a variety of uses; groundnut oil contributes to making paint, varnish, lubricating oil, leather dressings, polish, insecticides, etc. Soap is also made from groundnut sludge and many cosmetics contain groundnut oil and or its derivatives. Similarly, groundnut shells are used in the manufacture of plastics, wallboards, abrasives, cellulose and glue. Before harvesting, the roots of groundnut fix atmospheric nitrogen and therefore have the potentials of reducing the extent of chemical fertilizers required to boost crop production (Vabi, *et al*. 2019).

Weeds constitute a major production constraint in groundnut production to a great extent through competition for moisture, nutrients, sunlight, space and other biochemical interferences or Allelopathy. Weeds are known to produce and release harmful substances such as high level of nitrates and some poisonous alkaloids into the roots of host plant. Groundnut crop is highly susceptible to weed infestation because of its slow growth in the initial stages up to 40 days, short plant height and underground pod bearing habit. Groundnut weeds comprise diverse plant species from grasses to broad-leaf weeds and sedges, and causes substantial yield losses (15 – 75%) which are more in rainfed Spanish bunch type than in irrigated Virginia type groundnut (Jat *et al.* 2015). Selective herbicides are used for controlling weeds in groundnut; the maximum benefit can be achieved by combining herbicides with manual supplementary hoe weeding.

Considering the numerous importance of groundnut and the adverse effect of weed infestation on the crop, there is the need to keep the crop weed free for optimum yield. Weeds pose a serious challenge to crop production especially in crops with slower juvenile development like groundnut which are widely grown but sensitive to weed infestation (Akobundu, 1987). The common weed control methods used by farmers are manual hoe-weeding and hand pulling which are laborious, time consuming and expensive especially during the first 3-6weeks after sowing (Yero, 2016). To achieve optimum yield of groundnut in the tropics, weeds must be controlled. Selective pre emergence herbicide such as, Butachlor and Pendimethalin were reported to be effective and are often used in the control of weeds in groundnut (Akobundu, 1987). The combined use of herbicides for weed control and one or two manual weeding followed by hand pulling of isolated weeds would help save farmers time and resources which could be used to expand groundnut production. Therefore, there is a need to carry out research on alternative weed control methods such as use of appropriate dose of herbicides that can selectively give season long weed control in groundnut, reduce drudgery and crop injury associated with manual weeding, reduce cost of weed control and ultimately increase crop yield (Musa, 2012)

The main objective of the study was to evaluate the performance of improved groundnut varieties under Sudan savanna agro-ecological zone, while the specific objectives were; to study the effect of some pre-emergence herbicides as integrated weed management in groundnut, to study the effect of some pre-emergence herbicides on weeds of groundnut and to study the interaction between variety and weed control.

MATERIALS AND METHODS

Nigeria has a total of five agro-ecological zones primarily due to variations in altitude, temperature and rainfall. These zones are: the Tropical High Forest, the Derived Guinea Savanna, the Guinea Savanna, the Sahel and the Sudan savanna (Bagudo *et al*. 2024). The Sudan savanna is estimated to cover a total land surface area of 9.45 million hectares (about 27% of the country's land area) and receives an annual rainfall of between 600-1000mm per annum. This zone is mainly associated with groundnut, sorghum, cowpea and millet cultivation.

The experiment was conducted during 2023 rainy season at the Dryland Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto. Sokoto lies on latitude 13^0 01'′ N and longitude 5^0 15'′ E and at an altitude of about 350m above sea level. The area is characterized with erratic and scanty rainfall (Yakubu, 2016). The average temperature is between 18^0C to 40^0C during the coldest and hottest season of the year. The vegetation of the area is semi-arid with average rainfall of 650mm (SERC, 2022/2023).

The treatments of six groundnut varieties (SAMNUT 21, SAMNUT 22, SAMNUT 23, SAMNUT 24, SAMNUT 25, and SAMNUT 26), Four weed control options (Pendimethalin at the rate of 1.5Kg a.i. ha^1, Butachlor at the rate of 1.5 Kg a.i. ha^1, all followed by supplementary hoe weeding at 6WAS), two hoe-weeding at 4 and 8WAS and a weedy check). The treatments were factorially combined to make a total of twenty four treatments combination which were laid out in a Randomized Complete Block Design (RCBD) with three replications.

The experimental site was harrowed using a tractor, and leveling was done manually using hoe. The plot size measuring 3m x 5m ($15m^2$) and net plot area of 4.8m x 1.5m ($7.2m^2$) were demarcated manually and ridged at 75cm inter row spacing with three replications. There were 0.5m path between the adjoining plots and 1m distance between the replicates. Each plot consisted of four ridges spaced 75cm apart. Sowing was carried out in June when the rain was fully established. It was done in rows by dibbling. Two (2) seeds were planted per hole, at a depth of 3cm and at inter and intra-row spacing of 75cm and 20cm respectively. Gap filling was done on the missing stands at 2WAS. Weeding was carried out manually by hand hoeing as per treatment in other to ensure good crop establishment. SSP fertilizer was applied at the rate of 150kg ha^{-1} which was applied immediately after sowing. Termites, White grubs, earwigs, leaf miner, caterpillars, armyworm, bollworm, thrips, aphids, blister beetle, groundnut rosette, early leaf spot, late leaf spots, rust and aflatoxin are the major pests and diseases of groundnut. Cypermethrin 10% EC) was applied at the rate of 75mls to 15 liters of water in hand operated knapsack sprayer to control insect, pest and disease of groundnut. Harvesting was done at physiological maturity when the leaves turn to yellow. The tap root below the pod bearing layer were severed at a depth of 10-15 cm, the plants were pulled gently out of the ground.

Data were collected on the following parameters viz: Emergence count, days to 50% flowering, canopy spread, days to maturity, number of pods per plant, pod yield, haulm yield, weed identification, weed dry weight at harvest, harvest index etc

Data collected were subjected to analysis of variance (ANOVA) using GenStat ® 16th edition. Where ‘F’ test shows significant difference among the treatments means, Duncan Multiple New Range Test (DMNRT) was used to separate the treatment means

RESULTS AND DISCUSSION

Weed flora composition and growth form

The weed flora composition found at the experimental sites were different weed species based on the prevailing weather factors of the Sudan savannah. The common weeds at the experimental site collected from 4WAS to until harvest were to assess the types of weed species which were differentiated into grasses, broadleaved and sedges. The cumulative weed flora composition comprised of 24 weed species distributed across nine (9) plant families that comprised of grasses, broad leaved weeds, and sedges. A complete list of weeds species found at the site with their growth form was presented in Table 1. For sedges, five species were identified which includes: *Cyperus rotundus* L, and *Cyperus difformis*. *Cyperus esculentus, Cyperus compressus* and *Cyperus tenuispica.* Predominant broad leaved include: *Amaranthus hybridus, Alternanthera sessilis, Boerhavia diffusa, Trianthema portulacastrum*, The broad leaved weed species in groundnuts may be attributed to the ecological adaptation and dominance of the weed species in sandy loam soils of Sudan savannah region. The grasses includes: *Imperata cylindrical, Cynodon dactylon, Panicum maximum, Echinochloa crus-galli, Cenchrus biflorus*.

Weed spectrum recorded in this study is characterized by tropical agro-ecosystem where frequent soil disturbance creates safe sites for weed emergence, growth and survival. Also the use of herbicides for controlling of grass weeds leads to advertently to the resurgence and dominance of broad leaved species especially in the study area. Weeds that are closely related to crops are particularly important in harboring insects that attack those crops. The impact of weeds on the yield of crops varies with the characteristics of the crop¸ the weed species, weed density, the environment, the stage of growth and duration of the crop and exposure to weed competition. The relatively low incidence of weeds in herbicides controlled treatments could be attributed to more photosynthetic active radiation interception. This finding corroborates the results of Iyagba *et al*. (2012).

Stand count

Performance of improved groundnut varieties, weed control and interaction on stand count at 3WAS is presented in Table 2. Samnut 24 recorded the highest stand establishment count and differed significantly with the other treatments. However, there was no significant difference among the weed control treatments, but significance effects were recorded on the interaction between variety and weed control. Non significance differences recorded on weed control treatments is as a result of varietal influence with herbicides treatments coupled with initial application of herbicides at planting which suppressed weed emergence and varietal resistance to weeds. Weed-free condition from an initial stage of plant growth and establishment in groundnut is an essential step towards getting maximum yield. High emergence count recorded in all the treatments could be as a result of environmental factors such as available moisture and soil type that are conducive for plant growth in the study area

Days to 50% flowering

Performance of improved groundnut varieties, weed control and interaction on days to 50% flowering at Sokoto during 2023 rainy season were presented in Table 2. There was no significant (P>0.05) effect of variety on days to 50% flowering of groundnut on weed control treatments. However, significance effects were recorded on variety and in the interaction (P<0.05). The longest days to 50% flowering (36.83) were recorded in Samnut 25 treatment but were at par with the rest of the other treatments with the exception of Samnut 23 and Samnut 24 which recorded the least.

Flowering is a very important physiological process in the development of the groundnut crop and has a profound effect on the final yield. Mukhtar, *et al.,* (2013). Early flowering recorded by treatment Samnut 23 and 24 is due to the genetic variation of the variety and effective weed control using pendimethalin @ 1.5 kg a.i. ha$^{1.}$ This corroborate with the findings of Kaihan *et al* (2011), who reported that genotypes which flower early show greater synchrony and those which produce most of the flowers during first 3 weeks of flowering period produce greater numbers of pods.

Canopy spread

Performance of improved groundnut varieties, herbicides and interaction on canopy spread at 6 and 12WAS is presented in Table 2. The results indicated a significant (P<0.05) effect of varieties, weed control and in the interaction on canopy spread at both 6 and 12WAS. Samnut 24 recorded the highest mean canopy spread at both weeks with 45.85cm and 63.97cm respectively, while Samnut 22 produced the least mean canopy spread of 25.94cm and 42.54cm at 6 and 12 WAS respectively. However, in weed control treatments, weedy-check recorded the least canopy spread (25.10cm and 42.67cm) and differed significantly with the rest of other treatments. The other treatments are statistically similar.

Higher canopy spread recorded on Samnut 24 is due to the strength of Samnut 24 which is a spreading type in producing a wider canopy spread and could be attributed to their genetic make-up and environmental interaction, which facilitates the production of more number of leaves than the rest of the varieties. Weed infestation, on the other hand, may also hinder canopy spread due to poor weed management which gave rise to underground competition for space, nutrients, and moisture, leading to shorter canopy as observed in the weedy-check treatments. Groundnuts have spreading and semi-spreading groundnut varieties and they differ in their potential productivity.

Weed dry weight at harvest

Performance of improved groundnut varieties, herbicides and interaction on weed dry weight at harvest is presented in Table 2. There is no significant difference (P>0.05) on variety, however, significance differences were observed on weed control treatments and in the interaction. The weedy-check consistently resulted in significantly higher weed dry weight than all the other herbicides treatments including the two hoe-weeding control. The moderate result recorded in pendimethalin at the rate of 1.5kg a.i. ha^1, and butachlor at the rate of 1.5kg a.i. ha^1 may be as a result of higher rainfall which occurred one day after the pre-emergence herbicides application. This may have washed away and leeched the herbicides molecules beyond action zone or runoff which reduce the phytotoxic effect of the applied herbicides treatment on weeds, particularly the noxious weeds such as *Cynodon dactylon* and *Cyperus spp* which were observed on the plots. This result confirms the earlier observation by Das, (2008), who reported that heavy rainfall may wash away both foliar-active as well as soil-active herbicides and enhance their loss and reverse selectivity.

Weedy-check treatment recorded higher weed dry matter (2.51 t ha^1) is because weed biomass decreases with increasing period of weed-freeness and increased with increase in period of weed-infestation. This corroborate with the findings of Bagudo *et al.* (2024). The high weed dry weight recorded could also be as a result of the presence of a large weed seeds present in the soil from previous years of cultivation.

Number of pods per plant

The effect of variety, weed control and interaction on number of pods per plant at Sokoto during 2023 cropping season were presented in Table 3. The number of pods per plant was significantly affected by variety, weed control treatments and in the interaction. Samnut 24 recorded the highest number of pods but was at par with the rest of the varieties with the exception of Samnut 21, 22 and 23 which recorded 9.92, 14.25 and 13.42 numbers of pods per plant respectively. All the treatments under weed control were statistically similar with the exception of weedy-check which produced the least number of pods per plant and differ significantly with the rest of the other treatments.

Samnut 24, 25 and 26 varieties which recorded higher number of pods compared to other varieties could be said to exhibit genetic stability in the study area. The varietal differences in terms of number of pods per plant recorded could be attributed to variations in their genetic makeup and gene interaction with the environment (moisture, abundant sunshine, and soil fertility) as well as crop management. This is in line with the findings of Mouri, *et al*. (2018) who reported that the significant effect recorded from the growth component of two groundnut varieties (Samnut 25and 26) was due to genetic differences of those varieties.

Also, the relatively lower pods production recorded in weedy-check could be attributed to competition between weeds and the plants for environmental resources such as sunlight, moisture, nutrients, air and space. However, higher number of pods recorded in controlled weed treatments is due to less weed-crop competition. Our findings were corroborated by Ferdous *et al.* (2017), who observed an increase in crop growth and vigor due to less weed-crop competition by reducing the allelopathic effect of weeds on crops. As a result, there is more room for root growth and development. The result further corroborated with those of Vaziritabar *et al*. (2014) who stated that herbicide efficacy in the field is influenced by factors such as rainfall, temperature, soil etc

Days to maturity

The effect of varieties, weed control and interaction on days to maturity at Sokoto during 2023 cropping seasons was presented in Table 3. The mean days to maturity of the groundnut varieties indicated a significant ($P<0.05$). Samnut 25 matured as early as 87.25 days after sowing followed closely by Samnut 24 and Samnut 26 with 89.25 and 92 days respectively. Samnut 21 and 22 varieties on the other hand matured late at 110.83 and 110.50 days after sowing respectively. On weed control treatments, weedy-check recorded the longest number of days to maturity (115.67)

Ndjeunga *et al*. (2013) reported that days to maturity of Samnut 23 to be 90-100 days, while Samnut 24, Samnut 25 and Samnut 26 to be 80-90 days. Bahu *et al.* (2004) stated that number of days taken to attain maturity varied with varieties due to inherent genetic variation.

Pod yield

The effect of variety, weed control and interaction on pod yield at Sokoto during 2023 cropping season was presented in Table 5. The results indicated that there was no significant difference (P>0.05) due to effect of variety. However, significant differences were observed on weed control treatments and in the interaction (P<0.05). The highest pod yield of 1.30 t h^{1} was recorded on Samnut 24 variety which was higher than all the varieties, even though they were statistically similar. In weed control treatments, pod yield was significantly higher in Pendimethalin @ 1.5kg ai ha^{1} (1.27 t h^{1}) than the rest of the treatments but statistically similar with butachlor @ 1.5kg a.i. ha^{1} (1.22 t h^{1}) and manual hoe-weeding (1.23 t h^{1}) while weedy-check recorded the least (0.39 t h^{1}).

The high pod yield produced by Samnut 24 compared to other varieties is because of its shorter growth cycle, phosphorus extraction and the variety's genetic composition converting the numerous flowers into pegs and pods which might favor larger and heavier pods due to seed size. This is in line with the findings of Fohse et *al*. (1998). Paul & Giller (2002) also observed species and varietal differences in the ability of legumes to extract soil P. This may depend upon the potential of roots to absorb P in their active life time, the amount of root per unit of shoot, and the nature of organic acid exude by roots. This makes it an attractive variety for the Sudan savanna agro-ecological zone of Nigeria. The result also corroborates with the finding of Gilbert *et al*. (2020) who reported that varieties of a particular crop differ greatly in the number of days they require to produce a reasonable yield for a particular variety, the growth duration may differ depending upon the soil chemical composition and time the crop is planted.

Haulm yield

The effect of variety, weed control and interaction on haulm yield at Sokoto during 2023 cropping seasons was presented in Table 3. Haulm yield was significant amongst the varieties tested. Maximum haulm yield was recorded by Samnut 22 (1.72 t h^{1}) and resulted to significantly higher haulm yield than the other varieties with the exception of Samnut 21 which were at par (1.59 t h^{1}). In weed control treatments, haulm yield was significantly higher in pendimethalin @ 1.5kg a.i ha^{1} (1.61 t h^{1}) than the rest of the treatments but statistically similar with butachlor @ 1.5kg a.i ha^{1} and manual hoe-weeding (1.58 and 1.50 t h^{1}) respectively, while weedy-check recorded the least (1.14 t h^{1})

All the varieties showed increased haulm yield due to the application 150kg h[1] of SSP dose because phosphorus is reported to increase leaf area and increase accumulation of dry matter (Kamara *et al* 2011). However, the high haulm yield produced by Samnut 22 may be due genetic constitution of the variety and SSP fertilizer applied as phosphorus is mainly active in carbohydrate metabolism as a result of leaf and stem growth during the vegetative phase and combination of kernel and pod growth concurrent with shift in leaf and stem mass during reproductive stage (Kausale *et al*,. 2007). This result disagrees with the findings of Oyewole, (2017) who recorded a non-significant effect of varieties of groundnut on haulm yield. (Wandahwa *et al*. 2006) added that one of the important factors influencing the production of haulm in the tropics is as a result of soil fertility and the genetic makeup. However, Samnut 21 and Samnut 24 which produced appreciable sufficient fodder for livestock are also appropriate for the Nigerian Sudan savanna agro-ecological where livestock fodder is in high demand particularly between Januarys to May. The increase in the dry matter on weed control treatments could be attributed to weed competition for available environmental resources being reduced as a result of the effective weed control treatments (Shiitu *et al.* 2022)

Harvest Index (HI)

The effect of variety, weed control and interaction on harvest index at Sokoto during 2023 cropping season was presented in Table 3. The highest harvest index was recorded on Samnut 26 with 50.79%, followed by Samnut 25, Samnut 23 and Samnut 24 with 50.68%, 46.81% and 46.29% respectively. In weed control treatments, harvest index was significantly higher in manual hoe-weeding (45.19%) than the rest of the treatments but statistically similar with butachlor @ 1.5kg a.i. ha[1] and pendimethalin @ 1.5kg a.i. ha[1] (44.97% and 43.97%) respectively, while weedy-check recorded the least (24.30%)

Higher harvest index recorded in weed control treatments might be ascribed to effective weed management which allows the plants to fully utilize the environmental resources such as sunlight, nutrients, space, air and moisture. The findings corroborate with the assertion of Yadav *et al*. 2017), who claim that crops perform better when weeds are efficiently managed.

CONCLUSION

The varietal differences and weed control options recorded in this research showed that Samnut 24 had a better performance on growth and yield parameters when compared with the rest of the varieties. The number of pods per plant and pod yield produced by Samnut 24 compared to the other improved varieties could be explained by its shorter growth cycle, genetic makeup, gene interaction with the environment and potentials for phosphorus extraction, Samnut 24 emerged as an attractive variety for the Sokoto Sudan savanna agro-ecological zone of Nigeria. Thus, Samnut 24 + pendimethalin @ the rate of 1.5kg a.i. ha^1 are recommended for groundnuts cultivation under the Sokoto Sudan savanna Agro-ecological zone of Nigeria. Samnut 25 and Samnut 22 are also appropriate varieties worth promoting due to their pod yield and haulms yielding potentials.

REFERENCES

Bagudo, H. A., Alhassan, J. & Noma, S. S. (2024). Use of Soil Solarization and Herbicides as Sustainable Integrated Weed Management Strategies for Improved Irrigated Rice Production in Sokoto Rima Floodplain. *International Journal of Applied Research and Technology*. 13 (1): 3 – 14.

Bahu, C., Ramah, K. & Selvaraju, R. (2004). Heat Unit Requirement of Field Grown Groundnut Varieties. Madras *Agric. Journal*, 91:184-189.
Biology, 5(9): 2756-2760.

Das, M (2004). Use of soil-water balance components to assess yield of groundnut and sun flower under a high water table situation irrigation and drainage 53: 325- 333

FAOSTAT (2022) Food and Agricultural Organisation of the United Nations. On-line and multilingual database, http://faostat.fao.org

FAOSTAT (2023) Food and Agricultural Organisation of the United Nations. On-line and multilingual database, http://faostat.fao.org

Ferdous, J., Ali, M. H., Islam, M. S., Chowdhury, I. F., Haque, M. N. & Masum, S. M. (2017). Growth and yield of Soybean as affected by irrigation and weed control methods. *Bangladesh Journal of Weed Science*, 6 (1&2) 17-26.

Fohse, D., Classen, N. & Jumek A. (1998). Phosphorus efficiency of plant. *Plant and soil* 1100: 101-109.

Gilbert, N. N., Ifeoma, L. A. O. & Egwu, P. N. (2020). Growth and Yield Response of Groundnut (*Arachis hypogaea* L.)Varieties to Plant Density. *J. of Agric. Studies*, 8(3): 633-650.
growth and yield of sunflower cultivars as second crop. *Advances in Environmental*

Hakeem, A. A., Vabi, B. M., Inuwa, A., Tukur, A. & Akinseye, F. M. (2020). Handbook on Improved Agronomic Practices of Groundnut Production in North East Nigeria pp 2
International. Willingford, Oxen, UK. 323 pp .*International Journal of Agriculture and Forestry* 4(2): 106-111

Iyagba, A. G., Onuegbu, B. A. & Ibe A. E. (2012). Growth and yield response of okra (*Abelmoschus esculentus* (L) Moench) Varieties on weed interference in South Eastern Nigeria. *Global Journal of Science*. *Front. Res.Agric. Veterinary Science*.12, (7):22-29.

Jat, R. S., Meena, H. N., Singh, A. I., Jaya N. S. & Misra, J. B. (2015) Weed Management in groundnut (*Arachis hypogeae* L.) in India – A Review *Directorate of Groundnut Research, Agricultural Research Communication Centre*.PB 05, Ivnagar Road Junagadh 362 001, India

Kaihan, A., Mojtaba, J. K. & Asad, R. (2011). Effects of sowing date and planting density on

Kamara, E. G., Olympio, N. S. & Asibuo, J. Y. (2011). Effect of calcium and phosphorus on the growth and yield of groundnut (*Arachis hypogaea* L.). *International Research Journal of Agricultural Science and Soil Science*, 1(8), 326 – 331

Kausale, S. P., Patel, C. L., Kote, G. M., Lomte, D. M. & Awasarmal, V. B. (2007). Influence of different levels and source of phosphorus, press-mud and phosphorus solubilizing microorganisms on nodulation yield and quality of groundnut. *Bangladesh Journal of Agriculture* Res 32 (3):369-374

Mukhtar, A. A., Tanimu, B., Ibrahim, S., Mohammad, A. A. & Jaliya, M. M. (2013). Growth and development of three groundnut (*Arachis hypogaea* L.) varieties as affected by basin size and plant population at Kadawa Sudan savanna Nigeria. *International Journal of Advanced Biological Research.* VOL. 3(3) 2013: 336-340

Musa, A. (2012). 'Evaluation of Pre-emergence Herbicides on the Growth and Yield of Finger Millets' Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, 2012

Ndjeunga, J., Ntare, B. R., Ajeigbe, H., Echekwu, C. A., Ibro, A. & Amadou, A. (2013). Adoption and Impacts of Modern Groundnut Varieties in Nigeria. Diffusion and Impact of Improved Varieties in Africa (DIIVA), Objective 2 Report. *International Crops Research Institute for the Semi-Arid Tropics* (ICRISAT): Niamey, Niger.

Oyewole, J. (2017). Evaluation of Groundnut (*Arachis hypogaea* L.) Varieties for Grain and Forage Yield under Sokoto Agro-ecology. Unpublished Project Report, Department of Crop Science, Usmanu Danfodiyo University, Sokoto, Nigeria

Paul, E. & Giller, K. E. (2002), Nitrogen Fixations in Tropical Cropping Systems 2nd ed. CAB

SERC (2022/2023). Sokoto Energy Research Centre, Usmanu Danfodiyo University, Sokoto. Meteorological data 2023

Vabi, B. M., Mohammed, S. G., Echekwu, C. A., Mukhtar, A. A., Ahmed, B., Ajeigbe, H. A. & Eche, C. O. (2019). Best choices for enhancing groundnut productivity in Nigeria. ICRISAT, Patencheru, pp.30

Vaziritabar. Y., Paknejad, F., Golzardi, F. & Tafty, S. F. (2014). Investigation of bio-fertilizer and selective herbicides application on control of Chenopodium album and *Amaranthus retroflexus* in soybean. *Journal of Biodiversity and Environmental Science*, 4 (6), 269-277.

Wandahwa, P. I., Tabu, I. M., Kendagor, M. K. & Rota, J. A. (2006). Effects of Intercropping and Fertilizer Type on Growth and Yield of Soyabean (*Glyine max* L. merrill). *Journal of Agronomy*, 5:69-73.

Yadav, R., Bhullar, M.S., Kaur, S., Kaur, T. & Jhala, A. J. (2017). Weed control in conventional soybean with pendimethalin followed by imazethapyr + imazamox/quizalofop-p-ethyl. *Canadian Journal of Plant Science*, 97 (4), 654-664.

Yakubu, M. (2016). Genesis and classification of soils over different geological formations and surfaces in the Sokoto plains Nigeria. PhD Thesis. Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto

Yero, A.O. (2016) Effect of Weed Control on the Growth and Yield of Pearl Millet (*Pennicetum glaucum*) in Sokoto, Nigeria. An unpublished Project Report Submitted to the Department of Crop Science, Faculty of Agriculture, UDUS, 2016

Table 1: Weed flora composition at the experimental site during 2023 rainy season

Scientific name	Common name	Family	Growth form
Grasses			
Cenchrus biflorus	Indian sandbur	Poaceae	AG
Panicum maximum	Guinea grass	Poaceae	PG
Eleusine indica	Goose grass	Poaceae	PG
Cynodon dactylon	Bermuda grass	Poaceae	PG
Echinochloa crus-galli	Barnyard grass	Poaceae	AG
Imperata cylindrical	Cogon grass	Poaceae	PG
Digitaria horizontalis	Crab grass	Poaceae	PG
Dactyloctenium aegyptum	Crowfoot grass	Poaceae	AG
Eragrostis tremula	Love grass	Poaceae	PG
Broad leaved			
Amaranthus hybridus	Smooth Pigweed	Amaranthaceae	ABL
Acanthospermum hispidum	Bristly Starbur	Asteraceae	ABL
Alternanthera sessilis	Sessile Joyweed	Amaranthaceae	PBL
Commelina diffusa	Climbing Dayflower	Commelinaceae	PBL
Boerhavia diffusa	Spreading Hogweed	Nyctaginaceae	PBL
Trianthema portulacastrum	Horse Purslane	Aizoaceae	ABL
Emilia sonchifolia	Cupid's Shaving Brush	Asteraceae	ABL
Cleome viscose	Sticky Cleome	Cleomaceae	ABL
Ageratum conyzoides	Billygoat weed	Asteraceae	ABL
Crotalaria macrocalyx	Rattlebox flower	Fabaceae	PBL
Sedges			
Cyperus rotundus	Nutgrass	Cyperaceae	PS
Cyperus esculentus	Yellow Nutsedge	Cyperaceae	PS
Cyperus difformis	Small flower, Umbrella Sedge	Cyperaceae	AS
Cyperus compressus	Flat Sedge	Cyperaceae	AS
Cyperus tenuispica	Slender spiked sedge	Cyperaceae	AS

KEY: AG = Annual Grass, PG = Perennial Grass, AS = Annual Sedge, PS = Perennial Sedge, ABL = Annual Broad Leaved, PBL = Perennial Broad Leaved

Table 2: Performance of groundnut varieties, herbicides and interaction on stand count canopy spread, days to 50% flowering and weed dry weight during 2023 rainy season

Treatments	Stand Count at 3 WAS	Canopy spread at 6WAS	Canopy spread at 12 WAS	Days to 50% flowering	Weed Dry Weight at Harvest
Variety					
Samnut 21	34.50^{c}	29.42^{c}	46.66^{b}	36.42^{ab}	1.05^{a}
Samnut 22	35.00^{c}	25.94^{c}	42.54^{b}	36.08^{ab}	1.02^{a}
Samnut 23	35.58^{c}	29.94^{c}	46.62^{b}	35.92^{b}	1.10^{a}
Samnut 24	42.17^{a}	45.85^{a}	63.97^{a}	35.91^{b}	0.84^{a}
Samnut 25	38.08^{b}	44.36^{ab}	63.76^{a}	36.83^{a}	1.01^{a}

Samnut 26	38.17^{b}	38.96^{b}	60.49^{a}	36.17^{ab}	0.91^{a}
SE ±	±0.75	±3.10	±3.38	±0.43	±0.36
Significance	*	*	*	*	NS
Weed Control					
Pendimethalin @ 1.5kg ai ha^{1}	38.17^{a}	40.48^{a}	57.79^{a}	36.67^{a}	0.42^{c}
Butachlor @ 1.5kg ai ha^{1}	37.33^{a}	37.25^{a}	54.91^{ab}	36.50^{a}	0.68^{b}
Manual hoe weeding	38.17^{a}	39.16^{a}	58.22^{ab}	36.17^{a}	0.44^{c}
Weedy check	35.00^{a}	25.10^{b}	42.67^{b}	36.66^{a}	2.51^{a}
SE ±	±1.80	±5.71	±6.35	±0.63	±0.08
Significance	NS	*	*	NS	*
Interaction					
V x W	*	*	*	*	*

Means within a column followed by the same letter (s) are not significantly different at 5% level of probability (DMRT). * = Significance at 5% ($P \leq 0.05$); level of probability. NS = Not significant.

Table 3: Performance of groundnut varieties, herbicides and interaction on number of pods per plant, days to maturity, pod yield, haulm yield and harvest index of groundnut during 2023 rainy season

Treatments	Number of pods per plant	Days to maturity	Pod Yield (t h^{1})	Haulm yield (t h^{1})	Harvest Index (%)
Variety					
Samnut 21	9.92^{c}	110.83^{a}	1.02^{a}	1.59^{ab}	37.70^{b}
Samnut 22	14.25^{bc}	110.50^{a}	1.01^{a}	1.72^{a}	33.81^{b}
Samnut 23	13.42^{bc}	97.92^{b}	1.09^{a}	1.05^{c}	46.81^{a}
Samnut 24	20.08^{a}	89.25^{c}	1.30^{a}	1.40^{b}	46.29^{a}
Samnut 25	17.17^{ab}	87.25^{c}	1.20^{a}	1.05^{c}	50.68^{a}
Samnut 26	15.83^{ab}	92.00b^{c}	1.18^{a}	1.06^{c}	50.79^{a}
SE ±	±2.17	±2.45	±0.17	±0.10	±3.52
Significance	*	*	NS	*	*
Weed Control					
Pendimethalin @ 1.5kg ai ha^{1}	14.00^{a}	105.00^{b}	1.27^{a}	1.61^{a}	44.97^{a}
Butachlor @ 1.5kg ai ha^{1}	15.33^{a}	102.67^{b}	1.22^{a}	1.58^{a}	43.97^{a}
Manual hoe weeding	14.50^{a}	104.00^{b}	1.23^{a}	1.50^{ab}	45.19^{a}
Weedy check	6.33^{b}	115.67^{a}	0.39^{b}	1.14^{b}	24.30^{b}
SE ±	±1.29	±4.37	±0.10	±0.19	±4.51
Significance	*	*	*	*	*
Interaction					
V x W	*	*	*	*	*

Means within a column followed by the same letter (s) are not significantly different at 5% level of probability (DMRT). * = Significance at 5% ($P \leq 0.05$); level of probability. NS = Not significant.

Table 4: Interaction on the performance of groundnut varieties and herbicides on canopy spread, days to 50% flowering, weed dry weight. Number of pods per plant, days to maturity, pod yield, haulm yield and harvest index during 2023 rainy season

Treatment	Canopy spread at 12 WAS	Days to 50% flowering	Weed dry weight at harvest	Number of pods per plant	Days to maturity	Pod yield (t h^{1})	Haulm yield (t h^{1})	Harvest index (%)
S21 P1.5	52.22^{ef}	35.33^{def}	0.46^{hij}	11.66^{hi}	107.00^{b}	1.21^{def}	1.73^{bc}	41.22^{d}
S21 B1.5	48.47^{fgh}	37.33^{ab}	0.72^{e}	12.66^{h}	106.00^{b}	1.12^{f}	1.68^{cd}	40.00^{de}
S21 MW	47.54^{gh}	36.66^{abcd}	0.49^{ghij}	10.66^{ij}	108.67^{b}	1.24^{cdef}	1.67^{cd}	42.55^{cd}
S21 WC	38.40^{j}	36.33^{abcde}	2.52^{b}	4.66^{n}	121.67^{a}	0.52^{g}	1.28^{fgh}	27.01^{f}
S22 P1.5	40.84i^{j}	36.33^{abcde}	0.54^{fghi}	15.00^{g}	106.00^{b}	1.31^{cde}	2.03^{a}	39.14^{de}
S22 B1.5	42.39i^{j}	36.00^{bcdef}	0.67^{efg}	17.00^{ef}	105.00^{bc}	1.26^{cdef}	1.85^{b}	40.58^{de}
S22 MW	48.95^{fgh}	36.00^{bcdef}	0.43^{hij}	17.66^{ef}	106.33^{b}	1.17^{ef}	1.68^{cd}	41.01^{de}
S22 WC	37.96^{j}	36.00^{bcdef}	2.45^{bc}	7.33^{klm}	124.67^{a}	0.22^{h}	1.33^{f}	14.51^{g}
S23 P1.5	56.28^{e}	36.00^{bcdef}	0.42^{hij}	16.33^{fg}	98.33^{def}	1.30^{cde}	1.07^{hij}	54.91^{a}
S23 B1.5	50.75^{fg}	36.00^{bcdef}	0.54^{fghi}	16.66^{fg}	96.33^{efg}	1.28^{cde}	1.17^{ghi}	52.21^{ab}
S23 MW	47.75^{fgh}	34.66^{f}	0.56^{efgh}	15.00^{g}	95.67^{fg}	1.29^{cde}	1.17^{ghi}	52.33^{ab}
S23 WC	31.70^{k}	35.66^{cdef}	2.87^{a}	5.66^{mn}	101.33^{cd}	0.29^{h}	0.76^{k}	27.75^{f}
S24 P1.5	71.873^{a}	36.00^{bcdef}	0.34^{j}	25.00^{a}	87.00^{hi}	1.53^{a}	1.48e	50.61^{ab}
S24 B1.5	64.90^{cd}	35.00^{ef}	0.49^{ghij}	24.66^{ab}	88.67^{h}	1.50^{ab}	1.52^{e}	49.73^{ab}
S24 MW	68.53^{abc}	35.66^{cdef}	0.42^{hij}	23.00^{b}	85.00^{hi}	1.53^{a}	1.56^{de}	49.47^{ab}
S24 WC	50.56^{fg}	37.00^{abc}	2.10^{d}	7.66^{kl}	96.33^{efg}	0.57^{g}	1.04^{j}	35.35^{e}
S25 P1.5	66.37^{bc}	36.33^{abcde}	0.47^{hij}	18.66^{de}	87.00^{hi}	1.37^{bc}	1.17^{ghi}	53.86a
S25 B1.5	69.62^{ab}	36.66^{abcd}	0.67^{ef}	20.00^{cd}	85.00^{hi}	1.39^{abc}	1.18^{ghi}	54.12^{a}
S25 MW	69.56^{ab}	37.66^{a}	0.39^{hij}	21.00^{c}	84.00^{i}	1.36^{bc}	1.19^{ghi}	53.61^{ab}
S25 WC	49.46^{fgh}	36.66^{abc}d	2.48^{bc}	9.00^{jk}	93.00^{g}	0.46^{g}	0.67^{k}	41.12^{d}
S26 P1.5	67.37^{abc}	35.00^{ef}	0.37^{ij}	17.33^{ef}	86.67^{hi}	1.31^{cde}	1.16^{hij}	53.24^{ab}
S26 B1.5	61.52^{d}	37.00^{abc}	0.47^{hij}	19.66^{cd}	87.67^{hi}	1.35^{cd}	1.30^{fg}	50.81^{ab}
S26 MW	67.85^{abc}	36.66^{abcd}	0.47^{hij}	19.66^{cd}	93.67^{g}	1.33^{cd}	1.28^{fgh}	51.01^{ab}
S26 WC	45.22^{hi}	36.00^{bcdef}	2.32^{c}	6.66l^{m}	100.00^{de}	0.46^{g}	0.50l	48.09^{bc}
SE ±	2.26	0.80	0.08	0.90	2.14	0.07	0.06	2.84
Sign.	*	*	*	*	*	*	*	*

Means within a column followed by the same letter (s) are not significantly different at 5% level of probability (DMRT). * = Significance at 5% ($P \leq 0.05$); level of probability. NS = Not significant.

RESPONSE OF RAIN FED ORANGE FLESHED SWEET POTATO [*Ipomoea batatas* (L.) Lam] VARIETIES TO NITROGEN AND POTASSIUM COMBINATION

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ABSTRACT

Sweet potato responds positively to nitrogen (N) and potassium (K). To improve its productivity there is a need to standardize the optimum dose of these nutrients. The study was conducted during the rainy season of 2023 at the Federal College of Horticulture, Dadin-Kowa ($10^0$20'N and $10^0$30'E) in Sudan Savannah of Nigeria. It evaluated the performance of Oral Fleshed Sweet Potato varieties as influenced by Nitrogen and Potassium combinations (N: K), The experiment and laid out in a split-plot design with three replications. N: K combinations were assigned to the main plot (0:0, 45:60, 45:90, 45:120, 60:60, 60:90, 60:120, 75:90, 75:120 and 90:120 kg ha^{-1}) and Variety to subplot (King J, Lourdes, Solo Gold, and Local variety). Data collected were subjected to analysis of variance and means were ranked using Sidak at $p<0.05$. The results revealed that the growth characters differed significantly except vine weight at harvest due to variety. Application of 45:120 kg N: K ha^{-1} had significantly wider root diameter (10.9 cm), number of roots (7.0), and root weight (120.1 g), both marketable (17.8 t ha^{-1}) and total yield (19.7 t ha^{-1}). King J variety had the widest root (7.2cm) and it was at par with the Local variety. The Local variety produced significantly ($p<0.01$) higher number of storage roots per plant (5.5). The Local and King J varieties were significantly ($p<0.01$) higher on marketable yield (13.5 and 13.0 t ha^{-1}, respectively). N: K x variety interaction showed that Local and King J varieties fertilized with 45:120 and 60:120 kg N: K ha^{-1}, respectively had similar and highest marketable yield (18.8 t ha^{-1}). Application of 45:120 kg N: K ha^{-1} irrespective of the variety resulted in higher performance. Therefore the application of 45:120 kg N: K ha^{-1} and King J variety can be suggested for boosting production and productivity of the crop under rain-fed conditions in the study area.

Keywords; Nitrogen, potassium, orange-fleshed, sweet potato, variety, and yield.

INTRODUCTION

The sweet potato (*Ipomoea batatas* L Lam) is a food security and famine crop that belongs to the Morning Glory family Convolvulaceace (Motsa *et al*., 2015). Orange fleshed sweet potato (OFSP) has high carbohydrate content with low glycemic levels and is a good source of vitamin A and micronutrients (Burri, 2011). OFSP contains significant amounts of carotenoids which are known as provitamins A and ß-carotene (Allen *et al*., 2012). It is a food crop that has complete nutrition. Developing countries, characterized by intense population growth, saddled with a nutrition crisis will benefit much from adopting this famine crop (Endrias *et al.*, 2016). Although the crop is consumed in all parts of Nigeria, its yield is still low with an average yield of 2.4 t ha^{-1} compared to the world average of 11.8 t ha^{-1} (FAOSTAT, 2021). One of the main constraints among others in increasing yield ha^{-1} of sweet potato is the lack of varieties that are adapted to the specific condition of an area. Nitrogen (N) is an important factor in determining the yield and nutrient composition of root tubers, especially sweet potatoes (Ukom *et al.*, 2009). It is widely known that sweet potato requires high potassium (K) contents in the soil to promote tuber formation and development and it appears to be the most important nutrient in its production (O'Sullivan *et al.*, 1997). It is evident from the literature that sweet potato growth and yield respond positively to N and K. To improve the yield of sweet potatoes, there is a need to standardize the optimum dose of these nutrients (Sharath, 2020). As N and K are limiting factors when it comes to sweet potato cultivation, hence, it would be beneficial to conduct a study to find out the most beneficial dose of N and K combination for sweet potato cultivation and the response of different varieties. Therefore, the experiment aimed to evaluate the response of sweet potato varieties to N and K combinations and their productivity under rain-fed conditions.

MATERIALS AND METHODS

The experiment was conducted during the rainy season of 2023 at Federal College of Horticulture Dadin-Kowa located on latitude 10^0 20' N and longitude 10^0 30' E, Gombe State in Sudan Savannah of Nigeria. The design of the experiment was a split-plot design with three replications. N: K combinations were assigned to the main plot (45:60, 45:90, 45:120, 60:60, 60:90, 60:120, 75:90, 75:120, 90:120 kg ha^{-1} and the control 0:0) and varieties to subplot (King J, Lourdes, Solo Gold and Local variety) which were combined (10 x4) to give 40 treatment combinations. Gross plots of 3 x 3 m were constructed consisting of 4 ridges spaced 0.75 m apart. Vine cuttings of at least 30 cm in length with three nodes were sown at inter and intra-row spacing of 75 x 30 cm. Potassium fertilizer (MOP 60%K_2O) was applied during land preparation as per the treatments. Nitrogen in the form of Urea (46%N) was applied as per treatments in two equal split doses at planting and three weeks after planting (WAP). Phosphorous (P_2O_5) at a rate of 60 kg P ha^{-1} was applied during land preparation to all plots. All other cultural practices were carried out based on the standard requirements of the crop. Data collected were subjected to analysis of variance and means difference were separated at $p<0.05$ using Sidak.

RESULTS AND DISCUSSION

Growth characters

Application of N and K (N: K) at the rate of 60:90 kg ha^{-1} combination produced the highest number of leaves but at par with 75:90 kg ha^{-1} while 60:60 kg N: K ha^{-1} recorded significantly ($p<0.01$) lower number of leaves. The local variety had a significantly ($p< 0.01$) higher number of leaves followed by the King J variety while the Lourdes variety had the lowest number of leaves but at par with the Solo Gold variety (Table 1). Mukhtar *et al*. (2010) also reported variations in sweet potato varieties on number of leaves. A combination of 45:120 kg N: K ha^{-1} had a significantly ($p<0.01$) higher leaf area index while 45:60 kg N: K ha^{-1} resulted in a significantly lower leaf area index. All the varieties differed significantly ($p<0.01$) in leaf area index in the following order Local, King J, Lourdes, and Solo Gold variety. This could be attributed to the significant variation in number of leaves they produced (Table 1). Bhagsari and Ashley (1990) reported that LAI varies widely among sweet potato cultivars depending on the number of leaves. Similarly 45:120 kg N: K ha^{-1} produced the longest vine but it was at par with control, 45:60, 90:120, and 60:120 kg N: K ha^{-1} while 60:60 kg N: K ha^{-1} had the shortest vine but statistically similar to 75:90 kg N: K ha^{-1}. King J variety was significantly ($p<0.01$) longer in vine length followed by Local, Solo Gold, and Lourdes varieties accordingly. Control recorded significantly higher vine weight at harvest while non-significant differences were observed between all other N: K combinations. This could be due to their lower number of roots and mean root weight (Table 2) that favor accumulation of assimilates to the top instead of downward partitioning for bulking of roots. Liu *et al*. (2015) reported that early formation of storage roots is conducive to the inhibition of sweet potato overgrowth. King J variety recorded the heaviest vine but at par with the Local variety. The heavier vine observed on King J and the Local variety could be attributed to their large LAI (Table 1). This implies that maintaining large leaves may help in increasing the vine weight of sweet potato crops and this agrees with the view of Perey (2015) that among the contributory factors to high vine yield is the maintenance of large leaf area.

Yield and Yield Characters

The yield characters differed significantly ($p<0.01$) due to N: K combinations, variety, and their interactions. The control recorded a significantly higher number of pencil roots which could be due to nutrient stress as a result of non-application of fertilizer. Stathers *et al*. (2013) ascertained that pencil roots are formed instead of storage roots in sweet potatoes under stress or unfavorable conditions during root initiation. King J variety had a significantly higher number of pencil roots followed by the Lourdes variety while the Local variety had the lowest number of pencil roots. The significantly lower number of roots by the local variety could be attributed to its adaption to the study area. Lack of adaptation and acclimatization to the environment favors the formation of pencil roots instead of storage roots in sweet potatoes as reported by Stathers *et al.* (2013). Application 45:120 kg N: K ha^{-1} was found to have a significantly higher number of storage roots. The Local variety had a significantly higher number of storage roots followed by King J. This could be due to genetic variation among the sweet potato varieties in producing several storage roots. Huaman *et al*. (1999) reported that yield attributes are highly controlled by genetic constitution and are genetically inherited. The combination of 45:120 kg N: K ha^{-1} was significantly wider in root diameter followed by 90:120 kg ha^{-1} N: K. Application of 60:90 kg N: K ha^{-1} was significantly narrower in root diameter. King J variety had a significantly wider root diameter followed by Lourdes and Solo Gold varieties while the Local variety was significantly narrower in root diameter. Similarly, 45:120 kg N: K ha^{-1} recorded the heaviest root while the control had a significantly lighter root. The Local variety had significantly heavier roots but was at par with the King J variety while a non-significant difference was observed between other varieties. Application of 45:120 kg N: K ha^{-1} was statistically ($p<0.01$) higher in marketable yield followed by 60:90 and 60:120 kg N: K ha^{-1}. The control was significantly ($p<0.01$) lower in marketable yield but at par with 90:120 kg N: K ha^{-1}. The lower marketable yield obtained with the application of 90:120 kg N: K ha^{-1} could be due to high nitrogen. Taranet *et al*. (2017) showed that excessive N supply can restrict the utilization of photoassimilates during the period of storage root bulking, ultimately reducing storage root yield. The lowest marketable yield obtained by the control affirmed the findings of Pushpalatha *et al***. (**2017) who reported the lowest yield of sweet potato with no application of N and K and ascribed that to positive interaction between N and K in soil. The Local variety had the highest marketable yield but it was at par with King J variety which could be attributed to their higher mean root weight than the other varieties (Table 2). Lado *et al*. (2017) also found a non-significant difference between King J and Local variety on marketable yield in the semi-arid tropics of Nigeria under rain-fed conditions. The interaction of the N: K x variety on marketable yield (Table 4) showed that the Local and King J variety fertilized with 45:120 and 60:120 kg N: K ha^{-1}, respectively produced the highest similar marketable yield but at par with all other varieties fertilized with 45:120 and 60:90 kg N: K ha^{-1} except Solo Gold variety fertilized with 60:90 kg N: K ha^{-1}. Local variety under control had the lowest marketable yield. Irrespective of varieties, the application of 45:120 kg N: K ha^{-1} resulted in a higher marketable yield. This could be attributed to its low N and K ratio compared to other combinations. Botiwkamp and Hassan (1988) submitted that the greatest root enlargement occurred when the N: K ratio was low. The application of 45:120 kg N: K ha^{-1} also had a higher leaf area index (Table 1) that enabled the earlier provision of assimilate for bulking of root. This is supported by Steppler (1981) who viewed that large leaf area is among the contributory factors to the high yield of sweet potato. The control had a significantly higher non-marketable yield. The Lourdes variety was significantly ($p<0.01$) higher in non-marketable yield. Moreover, a similar trend was observed between total root yield and marketable yield. The variation among varieties on root yield might be ascribed to the genetic potential differences in producing several storage roots per plant and the weight of the storage roots. Nedunchezhiyan *et al*. (2007) reported wide variations among sweet potato clones for root yield performance due to genetic variation.

CONCLUSION AND RECOMMENDATION

Application of 45:120 kg N: K ha^{-1} resulted in higher performance irrespective of OFSP varieties. King J proved to be a better variety to complement the local variety grown in the study area. Hence application of 45:120 kg N: K ha^{-1} to all varieties and cultivation of King J variety with application of 60:120 kg N: K ha^{-1} could be suggested in the study area under rain-fed conditions. The experiment should also be conducted under irrigation conditions.

REFERENCES

Botiwkamp, J. C. and Hassan, M. N. M. (1988). Source-Sink Relationships in Sweet Potato. - *J. Am. Soc. Hort. Sci*., 113: 627-629.

Burri, B. J. (2011). Evaluating sweet potato as an intervention food to prevent vitamin A deficiency. *Compr. Rev. Food Sci. Food Saf*. 10 (2), 118–130.

Endrias, D., Negussie, R. & Gulelat, D. (2016). Comparison of three sweet potato (*Ipomoea batatas* (L.) Lam) varieties on nutritional and anti- nutritional factors. *Global Journal of Science Frontier Research: Agriculture and Veterinary*. 16(4). Available online at: http://www.fao.org/faostat/en/ (accessed December 4, 2022).

FAOSTAT. (2021). Database, http://apps.fao.org/.

Huaman Z., Aguilar C. and Ortiz, R. (1999). Selecting a Peruvian Sweet Potato Core Collection based on Morphological, Co- Geographical, and Disease and PestReaction Data. *Theoretical and Applied Genetics*, 98: 840-845

Lado, A., B. M. Auwalu, S. U. Yahaya, S. U. Abdulkadir and S. O. Afuape (2017). Quality and Yield Assessment of Sweet Potato Advanced Lines in Kano, Nigeria. International Journal of Scientific and Engineering Research. Vol.8, issue 5102. ISSN: 2229-5518

Laurie, S. M., Faber, M., Van Jaarsveld, P. J., Laurie, R. N., Du Plooy, C. P., & Modisane, P. C. (2012). β-Carotene yield and productivity of orange-fleshed sweet potato (Ipomoea batatas L. Lam.) as influenced by irrigation and fertilizer application treatments. *Scientia horticulturae*, *142*, 180-184.

Liu, H. J., Chai, S. S., Shi, C. Y., Wang, C. J., Ren, G. B., Jiang, Y. and Si, C. C. (2015). Differences in transport of photosynthates between high-and low-yielding *Ipomoea batatas* L. varieties. *Photosynthetica.* 2015;53:378–88

Motsa, N. M., Modi, A.T., & Mabhaudhi, T. (2015). "Sweet Potato" (Ipomoea batatas L.) As a Drought Tolerant and Food Security Crop." *South African Journal of Science* 111(11-12): 8.doi:10.17159/sajs.2015/20140252

Mukhtar, A. A., Tanimu, B., U. L. Arunah and B. A. Babaji (2010). Evaluation of the Agronomic Characters of Sweet Potato Varieties Grown at Varying Levels of Organic and Inorganic Fertilizer. *World Journal of Agricultural Sciences,* 6(4): 370-373.

Nedunchezhiyan, M., Byju, G. and Jata, S. K. (2011). Sweet Potato Agronomy. Fruit, Vegetable, Cereal Science and Biotechnology, 6(1). Global Science Books.

O'Sullivan, J. N., Asher, C. J., and Blamey, F. P. C. (1997). Nutrient Disorders of Sweet Potato Canberra, Australia: Australian Centre for International Agricultural Research, p. 53-54).

Perey, A. C. (2015). Evaluation of Selected Sweet Potato Genotypes for Drought Resistance under Greenhouse Condition. *International Journal of Current Research in Biological Sciences and Plant Biology*, 2(9): 104-114

Pushpalatha, M., P. H. Vaidya and P. B. Adsul (2017). Effect of Graded Levels of Nitrogen and Potassium on Yield and Quality of Sweet Potato (*Ipomoea batatas* L.) *Int. J. Curr Microbiol. App. Sci.* 6(5):1689-1696. doi: https://doi.org/10.20546/ijcmas.2017.605.183

Sharath. S. R, M. J. (2020). Effect of Nitrogen and Potassium on Growth, Yield and Quality of Orange Fleshed Sweet Potato (Ipomoea batatas Lam.). *Int. J. Curr. Microbiol. App. Sci*, *9*(03), 178-19

Stathers, T., Mwanga, R., Carey, T., Njoku, J., Malinga, J and Njoku, A., (2018). Everything You Ever Wanted to Know about Sweetpotato: Reaching Agents of Change ToT Manual. Topic 6: Sweetpotato Production and Management. International Potato Center. Nairobi (Kenya). ISBN 978- 92- 9060- 502- 7. 33 p. DOI 10.4160/9789290605027T6

Steppler, H. A. (1981). A Strategy for the International Council for Research in Agroforestry. ICRAF, Nairobi.

Taranet P, Harper S, Kirchhof G, Fujinuma, R. and Menzies N. (2017). Growth and yield response of glasshouse- and field-grown sweet potato to nitrogen supply. *Nutr Cyc. Agroecosys* 108:1–13.

UBRDA, (2023). Upper Benue River Basin Development Authority Dadin-kowa Station, *Annual Reports*

Ukom, A. O. (2009). Nutrient Composition of Selected Sweet potato [Ipomea batatas (L) Lam] varieties as influenced by different levels of nitrogen fertilizer application, ISSN 1680 5194. *Pak. J. Nutri*, *8*(11), 1791-1795

Table 1. Growth Characters of Sweet Potato Varieties as Influenced by Nitrogen and Potassium Combination during 2023 Rainy Season.

Treatments	Number of Leaves	Leaf Area Index LAI	Vine Length (cm)	Vine weight (g)
N: K (kg/ha)				
0:0	79.3c	4.0g	186.8a	514.8a
45:60	64.9e	3.5h	181.6a	227.3b
45:90	73.6d	4.3f	119.8d	273.1b
45:120	89.3b	7.0a	187.0a	303.6b
60:60	61.9e	3.0i	90.4e	229.9b
60:90	101.2a	6.0b	163.2bc	348.3b
60:120	83.6c	5.1e	179.0ab	285.0b
75:90	97.6a	5.9bc	106.0de	261.0b
75:120	79.5c	6.8cd	147.7c	232.3b
90:120	89.3b	5.7d	184.4a	284.6b
P<f	**	**	**	*
SE±	2.41	0.09	8.74	83.53
Variety (V)				
King J	100.9b	5.8b	266.3a	382.2a
Local	132.8a	10.6a	152.6b	375.3a
Lourdes	44.8c	2.1c	90.5d	193.6b
Solo Gold	46.5c	1.7d	108.9c	232.8b
P<f	**	**	**	**
SE±	1.52	0.06	5.53	52.82
Interaction				
N: K*V	**	**	**	NS

*=significant, **= highly significant and NS=not significant. Means followed with the same letter in a column are not significantly different using Sidak at a 5% level of probability.

Table 2. Yield Characters of Sweet Potato Varieties as Influenced by Nitrogen and Potassium Combination during 2023 Rainy Season.

Treatments	Number of Pencil Roots	Number of Storage Roots	Root Diameter (cm)	Average Root Weight (g)
N: K (kg/ha)				
0:0	5.5a	3.0e	5.4f	40.0f
45:60	2.9e	4.9c	5.8e	95.0bc
45:90	4.8b	6.0b	7.0d	98.1b
45:120	2.6ef	7.0a	10.9a	120.1a
60:60	2.2f	5.1c	7.4c	94.7bc
60:90	4.3c	6.0b	5.0g	94.9bc
60:120	3.8d	6.1b	5.8e	97.9b
75:90	3.8d	4.4d	5.9e	80.5d
75:120	3.8d	5.3c	4.6h	91.7c
90:120	2.5f	2.5f	9.0b	55.8e

P<f	**	**	**	**
SE±	0.26	0.33	0.19	2.33
Variety (V)				
King J	5.3a	5.1b	7.2a	92.0a
Local	2.6c	5.5a	6.4c	94.2a
Lourdes	4.1b	4.4c	6.9b	80.6b
Solo Gold	2.5c	5.1b	7.1a	80.8b
P<f	**	**	**	**
SE±	0.16	0.21	0.12	1.48
Interaction				
N: K*V	**	**	**	**

**= highly significant. Means followed with the same letter in the table are not significantly different using Sidak at a 5% level of probability.

Table 3. Yields of Sweet potato Varieties as influenced by Nitrogen and Potassium Combination during the 2023 Rainy Season.

Treatments	Marketable Yield t/ha	Non-Marketable Yield t/ha	Total Yield (t/ha)
N: K (kg/ha)			
0:0	3.8f	2.9a	6.7f
45:60	11.6de	0.5d	12.1de
45:90	12.8cd	2.1ab	14.9bc
45:120	17.8a	1.8bc	19.7a
60:60	12.7cd	1.0cd	13.7cd
60:90	14.8b	1.0cd	15.8b
60:120	15.2b	1.1cd	16.3b
75:90	10.0e	1.5bc	11.5e
75:120	13.7bc	1.6bc	15.3bc
90:120	5.1f	2.0b	7.1f
P<f	**	**	**
SE±	0.45	0.22	0.47
Variety (V)			
King J	13.0a	1.5ab	14.5a
Local	13.5a	1.2b	14.6a
Lourdes	10.7b	2.0a	12.8b
Solo Gold	10.7b	1.5ab	12.4c
P<f	**	**	**
SE±	0.25	0.20	0.18
Interaction			
N: K*V	**	**	**

**= highly significant. Means followed with the same letter in the table are not significantly different using Sidak at a 5% level of probability.

Table 4. Result of Nitrogen and Potassium Combination Interaction with Variety on Marketable Yield (t/ha) during 2023 Rainy Season.

Treatments	Variety			
N:K (kg/ha)	King J	Local	Lourdes	Solo Gold
0:0	3.7l	3.3l	3.9l	4.2l
45:60	12.9d-k	12.8d-k	11.0ijk	9.7k
45:90	13.9c-i	14.0c-i	12.0f-k	11.2ijk
45:120	17.8ab	18.8a	18.1ab	16.8abc
60:60	13.5c-j	15.0b-h	10.7jk	11.6g-k
60:90	16.0a-e	15.9a-e	15.4a-f	11.8g-k
60:120	18.8a	13.7c-j	14.2c-i	14.2c-i
75:90	12.1f-k	13.5c-j	4.7l	8.5k
75:120	15.2b-g	16.2a-e	11.3ijk	12.5e-k
90:120	4.6l	5.1l	5.6l	5.0l
SE±		0.82		

Means followed with the same letter in the table are not significantly different using Sidak at a 5% level of probability.

Table 6. Soil Physical and Chemical Properties of the Experimental Site during the Study Period

Physical Properties (g kg^{-1})	
Sand	886.0
Silt	53.2
Clay	71.4
Textural Class	Loamy Sand
Chemical Properties	
pH (H_2O) 5.68	
Electrical Conductivity (EC)	0.04ds/m
Organic Carbon	1.00g/kg
Nitrogen	2.50g/kg
Phosphorous	13.08mg/kg
Calcium	2.22Cmol/kg
Magnesium	1.82Cmol/kg
Potassium	0.11Cmol/kg
Cation Exchange Capacity {CEC)	5.14Cmol/kg

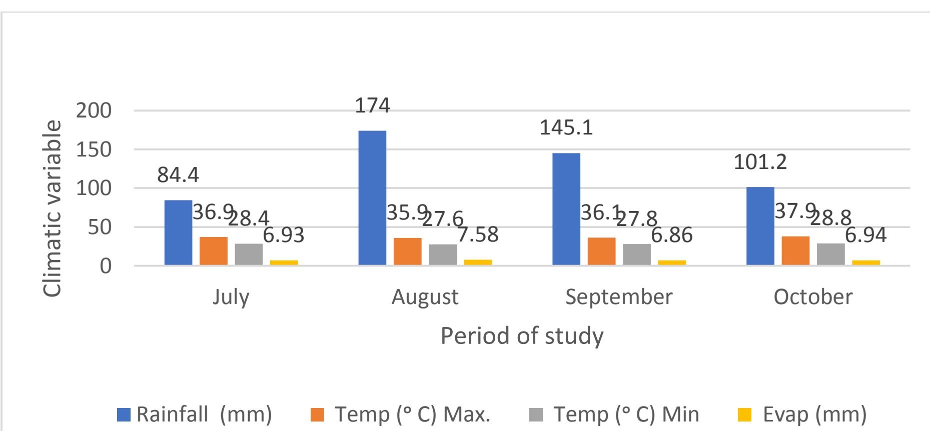

Fig 1. Climatic variables of the experimental site during the period of the study. Source: UBRDA weather report 2023

PERFORMANCE OF COWPEA VARIETIES (*Vigna unguiculata* (L.) WALP) TO TIME OF PHOSPHORUS APPLICATION AT SAMARU.

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ABSTRACT

The experiment was conducted in 2021 wet season at the Teaching and Research Farms of Samaru College of Agriculture, Ahmadu Bello University, (ABU) Zaria, Kaduna State located in the northern Guinea Savanna agro ecological zone of Nigeria. To evaluate the performance of cowpea varieties to time of phosphorus application in Samaru. The experiment consisted of two varieties of cowpea (SAMPEA-10 and SAMPEA-12) and four levels of phosphorus fertilizer (1 week before sowing, at sowing, 1 week after sowing and control). The treatments were factorially combined and laid down in a randomized complete block design (RCBD) with three replications given a total number of twenty four plots. The data was analyzed using general lineal model GLM of statistical analysis system package (SAS) and the treatment means separated using Duncan multiple range test using critical difference at 5% probability level. The results obtained indicated that SAMPEA-10 exhibit variation in some growth characters like; number of branches, number of leaves and yield character like; Haulm yield over SAMPEA-12. Also SAMPEA-12 exhibited superiority in terms of growth characters like; hill count and yield characters like; seed weight. The application of phosphorus at sowing significantly produced higher values for growth and yield characters of cowpea like; hill count, number of leaves, number of branches, seed weight and haulm over time of phosphorus application at 1 week before sowing, 1 week after sowing and the control in this trial. Based on the results, it can be concluded that the use of SAMPEA-12 and P application at sowing gave the best growth characters and highest seed yield.

KEYWORDS: Cowpea, Varieties, Time of phosphorus application, Growth and Yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) belongs to the family *Fabaceae* and its a major grain legume grown in semi-arid regions of Sub-Saharan Africa. It is a major source of protein and a cheap source of quality protein for both rural and urban dwellers in Africa (Ajeigbe *et al.*, 2012; Dube and Fanadzo, 2013). Cowpea leaves and green pods are consumed as vegetable and the dried grain is used in many different food preparations.

More than 7.4 million tons of dried cowpeas are produced worldwide (2017) with Africa producing nearly 7.1 million. Nigeria, the largest producer and consumer, accounts for 48% of production in Africa and 46% worldwide, Africa exports and imports negligible amounts. Most cowpeas are grown on the African continent, particularly in Nigeria and Niger, which account for 66 % of world cowpea production (Hall, 2012).

Despite all these positive developments with regards to cowpea improvement and dissemination, there is limited empirical evidence on the extent and impacts of adoption of improved cowpea varieties in Nigeria. Several studies in Africa that have shown that adoption of improved agricultural technologies plays a vital role in increasing productivity and net returns (Abdulai and Huffman, 2014; Khonje *et al.*, 2015; Manda *et al.*, 2017) focused on other crops, rather than improved cowpea varieties (ICV). The use of improved varieties for a particular ecology is essential in groundnut production. Farmers using improved varieties have derived significant yield gains 31% over local varieties in Nigeria (Anon, 2011).

Generally, the timing of fertilizer application is one of the principles guiding efficient crop yield. Proper timing of fertilizer application increases yields; nutrient use efficiency and prevents damage to the environment (Guy, 2017). Phosphorus plays many essential plant processes, including reproduction, photosynthesis, cell division, root development and energy storage, thus aid good crop growth and high yields. Phosphorus is noted especially for its role in capturing and converting the solar energy into useful plant compounds (Cockfield *et al*., 1988). Ayodele and Oso (2014) reported that applied P at the early stage of cowpea growth stimulated root elongation and proliferation, nodule formation and development of vegetative structures as well as uptake of other plant nutrients; since phosphorus plays vital roles in the reactions involving energy transfer, leguminous crop which depends on fixed N for growth would require large amount of phosphorus at the right time. According to Nkaa *et al*. (2014) phosphorus fertilizer application shortens the time from sowing of cowpea to harvesting of green pods and hastened maturity. But unfortunately, these sources are scarce in Nigeria, especially at the beginning of the cropping season and so farmers are unable to sow seeds timely, are compelled to establish cowpea farms without applying fertilizer or do so late (FAO,2005). Based on the foregoing, the objective(s) of this study therefore were to determine the growth and yield performance of cowpea varieties at Samaru and to determine the most appropriate time of phosphorus application for optimum growth and yield of cowpea at Samaru.

MATERIALS AND METHODS

An experiment was conduct in 2021 at student demonstration field in Samaru College of Agriculture, Division of Agricultural College Ahmadu Bello University, Zaria (11^0 $11^,$ N and longitude 07^0 $38^,$ E 686 M above sea level) in the Northern Guinea Savannah, Agro ecological

Zone of Nigeria. The experiment consisted of two varieties of cowpea (SAMPEA-10 and SAMPEA-12) and four levels of phosphorus fertilizer (1 week before sowing, at sowing, 1 week after sowing and control). The treatments were factorially combined and laid down in a randomized complete block design (RCBD) with three replications given a total number of twenty four plots.

The land was harrowed twice to a fine tilt hand ridged 75 cm between rows and then marked out into 24 plots with 1.0m spacing between blocks and 0.5 m spacing between plots. The gross and net plot size were 9.0 m^2 (3m x 3m) and 4.5m^2 (3m x 1.5 m), respectively. However, there were four ridges in each gross plot and two ridges in net plot. The alley way between plots and replicates were 0.5 m and 1.5 m respectively. The cowpea was sown at 20 cm spacing with 2 seed per hole. Phosphorous fertilizer as single super phosphate (18% P_2O_5) at the rate of 40 kg ha^{-1} was applied according treatment using drilling method. Five plants were randomly tagged from the net plot for periodic observation. Data on the following characters were collected:

Hill count

Hill was determined by counting the individual seedling from the net plot of each plot at 2 WAS and the values were recorded

Number of leaves

The number of leaves were counted from the five (5) tagged plants in the net plot at 9 WAS and the values were computed and recorded.

Number of branches

The number of branches per plant was determined by counting the branches of the tagged plant at 9 WAS and the values were computed and recorded.

Seed weight plant^{-1}

Seed weight was counted from each of the harvested net plots, weighed and the values obtained were recorded in grams (g).

Haulm Yield

The haulm yield per net-plot weighed was extrapolated to kg.

The data collected was subjected to Analysis of Variance (ANOVA) using general linear model GLM of the Statistical Analysis System package (SAS, 2003) and the means was separated using Duncan's Multiple Range Test (5% probability level) (Duncan, 1955).

RESULTS

The performance of cowpea varieties to time of phosphorus application on hill count, number of leaves at 9 WAS and number of branches at 9WAS of cowpea during 2021 wet season at Samaru are indicated in Table 1. Plots sown to SAMPEA-12 cowpea variety significantly produced the higher hill count than SAMPEA-10. Also plot sown to SAMPEA-10 cowpea variety significantly recorded higher values for number of leaves and branches at 9 WAS than SAMPEA-12.

Likewise, applying phosphorus (P) at sowing recorded the higher values for the aforementioned growth characters than the rest of time of P application used. Though statistically at *par* with time of P application 1 week before sowing only on number of leaves.

Table 2 shows the performance of cowpea varieties to time of phosphorus application on seed weight and haulm yield of cowpea during 2021 wet season at Samaru. Plot sown to SAMPEA-10 recorded higher seed weight than of SAMPEA-12. Also SAMPEA-12 recorded higher haulm yield than SAMPEA-10.

Application of P at sowing significantly recorded higher values for both seed weight and haulm yield of cowpea than the rest of time of P application while the control recorded the least value for haulms yield only.

DISCUSSION

Performance of Variety on Growth and Yield of Cowpea

According to Jibrin (2022) crop varieties are known to exhibit variation in their growth and yield parameters due to difference in their genetic makeup and gene interaction with the environment (moisture, sunshine hours and significantly) as well as good agronomic maneuverer. This is no difference from the current results obtained from this research work in that SAMPEA-10 exhibit variation in some growth characters like; number of branches, number of leaves and yield character like; Haulm yield over SAMPEA-12. Also SAMPEA-12 exhibited superiority in terms of characters like; hill count and seed weight.

The reason for the variation exhibited by the two varieties of cowpea (SAMPEA-10 and SAMPEA-12) used could be due to their genetic makeup in that SAMPEA-10 produced vegetation more than SAMPEA-12 probably that could be the reason why its produced more haulm at harvest. This is line with the findings of Jibrin (2022) who reported that the reason for this variation and inconsistencies that manifested the tested groundnut varieties in terms of growth and yield characters could be as a result of differences in genetic makeup of the three varieties in response to environment.

Effect of Time of Phosphorus Application on Growth and Yield of Cowpea

Phosphorus is the second essential nutrient element for the crop growth and good quality yield. Navnikumar *et al.* (2012) reported that P is an important nutrient for all crop in general, and legumes in particularly

The significant differences observed due to time of phosphorus application at sowing on growth and yield characters of cowpea like; hill count, number of leaves, number of branches, seed weight and haulm over time of phosphorus application at 1 week before sowing, 1 week after sowing and the control could be as a result of early emergence and the larger population count of the cowpea plant in plots applied with phosphorus at sowing aided in prevention of leaching way of the phosphorus as opposed to plot supplied with phosphorus at varying period of time. Ayodele and Oso (2014) reported that when phosphorus was applied at planting, it enhanced early vegetative growth in terms of plant height, number of leaves and leaf area per plant, while the control treatment gave the least values of growth parameters which did not differ significantly from withholding phosphorus fertilizer until 3 and 5 WAS.

CONCLUSION

Based on the results obtained it can be concluded the use of SAMPEA-12 and P application at sowing gave the best growth characters and highest seed yield.

REFERENCES

Abudulai, M., Seini, S. S., Haruna, M., Mohammed, A. M., and Asante, S. K. (2016). Farmer participatory pest management evaluations and variety selection in diagnostic farmer field Fora in cowpea in Ghana. *Afr. J. Agric. Res. 11, 1765–1771.*

Ajeigbe, H. A., Saidou, A. K., Singh, B. B., Hide, O., and Satoshi, T. (2012). “Potentials for cowpea (*Vignaunguiculata*) for dry season grain and fodder production in the Sudan and Sahel zones of West Africa,” in *Innovative Research Along the Cowpea Value Chain*, eds O. Boukar, O. Coulibaly, C. A. Fatokun, K. Lopez, and M. Tamo [Ibadan: International Institute of Tropical Agriculture (IITA*)], 189–202.*

Anon. (2011). ICRISAT (International Crops Research Institute for Semi -And Topic) CRISAT Annual Report 2011. *Patancheru. Andrapradesh, India* lCRISAT *52pp.*

Ayodele, O.J and Oso, AA. (2014). Effect of phosphorus fertilizer sources and application time of grain yield and nutrient composition of Cowpea (*Vigna unguiculata* L. Walp). *American Journal of Experimental Agriculture* 4(12): l517- 1524.

Cockfield, S.. Drammeh, S. and Drammeh. K. (1988). *Annual Report, Department of Agriculture* The Gambia Importance of groundnut production in the Gambia.

Duncan, D. B. (1955) Multiple Range and Multiple F-test. *Biometrics II: 1-2.*

FAO. (2005) Use of phosphate rocks for sustainable agriculture. In: Zepata F, Roy RN. (eds) Fertilizer and Plant Nutrition Bulletin 13.FAO Land and Water Development Division and International Atomic Energy BAgency, Vienna Austria; 2005.

Guy, S. (2017).Timing and frequency of fertilizer application. htp/lwww.smani (accessed on 12/06/2017).

Hall, A.E. (2003), "Development of cowpea cultivars and germplasm by the bean/cowpea CRSP", *Field Crops Research*, Vol. 82, No. 2-3, May, *pp. 103-134.*

Jibrin, D.M. (2022). Response of groundnut (*Arachis hypogaea* L.) varieties to weed management strategies and time of phosphorus fertilizer application in Northern Guinea and in Sudan savanna of Nigeria.Unpublished PhD. Dissertation Submitted to Department of Agronomy, Ahmadu Bello University, Zaria. *pp 180.*

Khonje, M., Manda, J., Alene, A. D. and Kassie, M. 'Analysis of adoption and impacts of value chain in Nigeria, Ghana, and Mali', *Agribusiness*, Vol. 25, (2009) pp. 16–35.

Manda, J., Khonje, M. G., Alene, A. D. and Gondwe, T. 'Yield components of nodulated cowpea (*Vigna unguiculata*) plants grown with exogenous phosphorus in different cropping systems. *Aust. J. Exp. Agric., 47: 583-589.*

Nkaa, F.A., O.W. Nwokeocha and O. Ihuoma, 2014.Effect of phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*). *IOSR J. Pharm. Biol. Sci., 9: 74-82.*

Navnitkumar, K., Dhamsaniya, Patel, N. C., Dabhi, M. N. (2012). Selection of groundut variety for making a good quality peanut butter. *Journal of Food Science Technology (J). 2012; 49 (1): 115 – 8.*

SAS. (2003) Statistical Analysis Software Data wach.com.

Table 1: Performance of cowpea varieties to time of phosphorus application on hill count, number of leaves and number of branches of cowpea at Samaru during 2021 wet season

Treatments	Hill count	No. of leaves at 9 WAS	No. of branches at 9WAS
Variety (V)			
SAMPEA-10	7.67b	202.65a	7.52a
SAMPEA-12	10.42a	172.43b	6.33b
SE±	0.624	5.037	0.292
Time of Phosphorus application (T)			
Control	7.60b	164.13b	4.70b
1week before sowing	6.96b	203.63a	4.58b
At sowing	14.10a	226.77a	14.00a
1week after sowing	7.53b	155.67b	4.43b
SE±	0.883	7.124	0.414

Means followed the same letter (s) within treatment group are not significantly different using D.M.R.T at 5% level of probability.

Table 2: Performance of cowpea varieties to time of phosphorus application on seed weight and haulm yield of cowpea at Samaru during 2021 wet season

Treatments	Seed weight (g plot^{-1})	Haulm yield (kg plot^{-1})
Variety (V)		
SAMPEA-10	1.14b	2.22a
SAMPEA-12	1.51a	1.75b
SE±	0.068	0.082
Time of Phosphorus application (T)		
Control	1.28b	1.50c
1week before sowing	1.01b	1.75bc
At sowing	2.01a	2.74a
1week after sowing	1.01b	1.95b
SE±	0.096	0.117

STUDIES ON THE HOST RANGE OF TARO LEAF BLIGHT ON SURROUNDING PLANTS WITH SIMILAR SYMPTOMS AROUND THE TARO GROWING FARMS

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ABSTRACT

Cocoyam production is threatened by a lot of diseases, among which is the taro leaf blight (TLB), caused by a fungus, *Phytophthora colocasiae.* The disease spread like wild fire to many parts of the country where *Colocasia esculenta* are cultivated. The aim of this study was to identify the host range of taro leaf blight on surrounding plants with similar symptoms around the taro growing farms. The experiment involved the identification of alternate host and host range of taro leaf blight in the field. The experiment was laid out in split-split plot, arranged in a randomized complete block design (RCBD) with three replications. Laboratory studies were laid out in a completely randomized design (CRD). Data collected were subjected to laboratory assesments. Five plants were sampled for study which include leaves of trifoliate yam, *Gongronema latifolium* (utazi), Xanthosoma *spp*, *Mucuna flagellipes (Agbara* leaves) and *Manihot esculenta* leaves for host range of *P. colocasiae*. and the following organisms were found *Aspergillus niger, Peniccillum chrysogonum, Rhizopus, Botryodprodia theobromae, Fusarium oxysporum, Aspergillus flavus* and *Geotrichum.* The results from the study confirmed that *P. colocasiae* does not hibernate on surrounding plants. *P. colocasiae* organism does not hibernate in any plant rather the ones susceptible to it. It is recommended that the plants assessed can be planted around taro farms.

INTRODUCTION

Cocoyam (*Colocasia esculenta* (L) Schott) is a herbal crop belonging to the family Araceae, commonly referred to as taro (Ugwuoke *et al*., 2008). It is an important edible stem tuber cultivated in the humid forest regions of Nigeria (Okigbo *et al*., 2017). It is one of the most important tuber crops after yam and cassava in Nigeria (Echebiri., 2004) with various forms of utilization in human food, animal feed and industrial raw materials. Cocoyam is one of the staple food crops and a source of diet to the people in developing countries (FAO, 2012). It has also been reported to be the most important staple root tuber crop after yam and cassava in Nigeria, second to cassava in Cameroun and first in Ghana (Echebiri, 2004). The cultivation of cocoyam in most African countries is essentially by small scale resource poor farmers with minimal input. When compared to other root crops like potato, cassava and yam, relatively little research attention has been devoted to cocoyam (Onyeka, 2011). According to Amadi, *et al*., (2012), there are three cultivars of

Xanthosoma and 10 cultivars of *Colocasia* mostly land races grown in Nigeria. They also associated the limited number of accessions and the resulting narrow genetic base to be partly responsible for the yield stagnation being experienced in recent years.

This research work is specifically reporting on *Colocasia esculenta* and the term taro is being used interchangeably to represent *C. esculenta* throughout the text. Over the years, the problem of taro leaf blight (TLB) has posed some challenges to researchers. The decrease in the production of taro due to devastating effect of leaf blight disease has been a big blow to farmers. Taro leaf blight is so destructive that its effect on a farm can lead to little or no yield. It reduces harvest to the barest minimum and its control is not fully ascertained. Brooks, (2005) reported that *P. colocasiae* sporangia detach and spread by rain splash and wind-blown rain, they germinate on leaves, petioles or washed into the soil where they can infect taro corms. From the available records, researchers have not classified the accessions of *Colocasia* mostly affected by TLB. There is also need to know where disease hibernates when cocoyam is not in the field, that is the alternative host of the pathogen. The sporangia on the infected plant surface is easily disseminated via several means that include windy rains and splashing water from either irrigation or running water. Abdulai *et al*., (2020) stated that although taro leaf surfaces are covered with trichrome, some small accumulation of water droplets can provide conducive environment for the pathogen spore germination. Also, pseudo- fungus can survive for a short while as a mycelium in the dead plant tissues as well as an infected corm and cormel. As a survival mechanism under dry stress conditions, the pathogen can thrive well in the soil as an encysted zoospore with thick cover layers or as chlamydospores which can survive in the soil in the absence of the host for several months. This pathogen that limits taro production in many regions of the world has been reported to relatively be short-lived on the infected plant parts and that, this could be attributed to its poor competitive saprophytic ability (Abdulai *et al*., 2020). It was found that as the dry period began to set in, and the amount of humidity also decreased due to seasonal limitation of water, a large number of infected leaves were hardly standing out farmers were found to intercrop *Colocasia esculenta* (taro plant) with *Xanthosoma sagittifolia* (elephant ear). Though these two plants belong to the same family (Araceae), it was observed that, the disease usually occurred only in the taro plant and not the latter, this could be attributed to the suggested resistance of *X. sagittifolia* to this pathogen that causes blight disease in taro plants. This result is in accordance with the findings of Mbong *et al*.,

(2013) who reported that, *X. saggittifolia* is immune to this disease. Ocimati *et al*., (2018) stated that alternative host plants are important in the survival and perpetuation of several crop pathogens and have been suspected to play a role in the survival of *Xanthomonas campestris* pv. *musacearum* (Xcm) and perpetuation of *Xanthomonas* wilt (XW) disease of banana .

Romo *et al*., (2012) recommended the removal of weeds that are alternative hosts. Nakato *et al*., (2014) reported potential inoculum sources of Xcm to include infected plants, infected planting materials, infected plant residues, traded banana products (fruits and leaves) and contaminated soils and water.

MATERIALS AND METHODS

Samples of plants with similar symptoms were collected and taken to the Pathology laboratory of National Root Crop Research Institute, Umudike to isolate and identify the casual organism. Five plants were collected for this study which include leaves of trifoliate yam, *Gongronema latifolium* (utazi), Xanthosoma *spp, Mucuna flagellipes (Agbara* leaves) and *Manihot esculenta* leaves

The infected samples (2 mm pieces) were collected from suspected plants and cut with sterile surgical blade at the junction between healthy and infected portion. The cut pieces were surface sterilized with 90% ethanol for 1 minute and then rinsed in sterile distilled water for three times. The leaf pieces were placed on sterile paper towels in a laminar air flow hood chamber for 10 minutes to dry and then placed onto a solidified corn meal Agar. The corn meal Agar plates were incubated at 25^{0} C for four days and then examined daily for the growth of mycelia. After four days, the growth mycelia were transferred with the aid of inoculating needle into solidified potato Agar plates and were incubated at 25^{0} C for five days. The culture was later sub cultured for purification.

All the purified cultures were identified through macroscopic examination which was done by physical characteristics of the mycelia (colour) and structure of the mycelia. Microscopic characteristics were also done by using compound microscope in viewing the morphology structures of the fungi. A wet count method was done before viewing the pure isolates under X40 compound microscope. Laboratory studies were laid out in a completely randomized design (CRD). Data collected were analysed using percentage of occurence.

RESULTS

A total of seven fungi were isolated from five plants surrounding the taro field with symptoms that were similar to that of taro leaf blight (Table 1). They were *Aspergillus niger, Peniccillium chrysogenum, Rhizopus stolonifer, Botryodiprodia theobromare, Fusarium oxysporum, Aspergillus flavus and Geotrichum candidum.*

Aspergillus niger is a filamentious fungus, forming filamented hyphae that makes them appear like small plants. Microscopic observation reveals that their growth was initially white but changed to black after few days of producing conidial spore. *Peniccillium chrysogenum* reproduces by forming dry chains of spores (or conidia) from brush-shaped conidiophores. The conidia are typically carried by air to new colonization site. In *P. chrysogenum,* conidia are blue to blue-green and the mold sometimes exudes yellow pigment. Though it cannot be identified by colour alone, observations of morphology and microscopic features are needed to confirm its identity and DNA sequencing is essential to distinguish it from closely related species (Bohm *et al.*, 2013).

Botryodiprodia theobromae has fluffy or depressed, uniform to irregular and cottony white turning to black. *Fusarium oxysporum* has initial colour white which later turns to purple with discrete orange sporadachia (mass of hyphae) present in some strains. *Aspergillus flavus* has hyphae growth which usually occurs by thread-like branching and produces mycelia. Hyphae strands are not seen by unaided eye, rather conidia producing thick mycelial mats are often seen and *Geotrichum* has yeast-like and mold-like strains (Gente *et al.*, 2002). *Botryodiprodia theobromae* and *Geotrichum* had the highest percentage of occurrence (23.08%) respectively while *Peniccilium chrysogonum, Rhizopus* and *Fusarium oxysporum* had the least percentage of occurrence (7.69%) respectively.

DISCUSSION

The results from the study confirmed that *P. colocasiae* does not hibernate on surrounding plants. The organisms found (*Aspergillus niger, Peniccillium chrysogenum, Rhizopus stolonifer, Botryodiprodia theobromare, Fusarium oxysporum, Aspergillus flavus and Geotrichum candidum*) were not *P. colocasiae* during the assessment. The host range of the organism is yet to be ascertained though it may be attributed to plants previously planted on the plot. Host range study shows that though *Colocasiae esculenta* is susceptible to *P. colocasiae,* the assessed surrounding plants were not. Ocimati *et al*., (2018) stated that alternative host plants are important in the survival and perpetuation of several crop pathogens and have been suspected to play a role in the survival of *Xanthomonas campestris* pv. *musacearum* (Xcm) and perpetuation of

Xanthomonas wilt (XW) disease of banana. Ocimati *et al*., (2018) also stated that understanding the interactions of a crop pathogen with other plants is thus important when diversifying agroecosystems.

Romo *et al*. (2012) recommended the removal of weeds that are alternative hosts, which means that weed control is necessary because they serve as alternate host to so many diseases and also compete with cultivated crops. Nakato *et al*. (2014) reported potential inoculum sources of *Xanthomonas campestris* pv. *musacearum* to include infected plants, infected planting materials, infected plant residues, traded banana products (fruits and leaves) and contaminated soils and water. This disagreed with the finding of this study which confirmed that surrounding plants were not susceptible to the pathogen *P. colocasiae*. This may be attributed to the plant previously planted on the plot.

CONCLUSIONS AND RECOMMENDATIONS

Plants with similar symptoms with *P. colocasiae* around the farm assessed were not host to *P. colocasiae* and this shows that the surrounding plants tested were not susceptible to the pathogen. Therefore, *P. colocasiae* organism does not hibernate in any plant rather the ones susceptible to it. It is recommended that the plants assessed can be planted around taro farms.

REFERENCES

Abdulai, M., Norshie, P. M., and Santo, K. G. (2020). Incidence and severity of taro (*Colocasia esculenta* L.) blight disease caused by *Phytophthora colocasiae* in the Bono Region of Ghana. *SSRG International Journal of Agriculture and Environmental Science*, *7*(2):52-63.

Amadi, C.O., Mbanaso, E.N.A. and Chukwu, G.O. (2012). A review of cocoyam breeding in Nigeria: Achievements, challenges and prospects. *African journals online (AJOL)*. 16, 72-80.

Brooks, F.E. (2005). Taro leaf blight. Plant Health Instr. 2005, doi: 10.1094/PHI-I-2005 0531-01.

FAO, 2012. *SIDS-FOCUSED Green Economy: An Analysis of Challenges and Opportunities www. unep. org/greeneconomy and www. unep. org/regionalseas*.

Echebiri, R.N. (2004). Socioeconomic factors and resource allocation in cocoyam production in Abia State, Nigeria: A case study. *Journal of sustainable tropical agricultural research* 9: 69-73.

Gente, S., Desmasures, N., Panoff, J.M (2002). Genetic diversity among *Geotricum candidum* strains from various substrates studied using RAM and RAPD-PCR. *Journal of Applied microbiology* 92:491-501.

Mbong, G. A., Fokunang, C. N., Fontem, L. A., Bambot, M.B and Tembe, E.A, (2013). "*An overview of Phytophthora colocasiae of cocoyams: A potential economic disease of food security in Cameroon*", *Discourse Journal of Agriculture and Food Sciences*, 1,140-145.

Nakato, G. V., Ocimati, W., Blomme, G., Fiaboe, K. K. M., and Beed, F. (2014). Comparative importance of infection routes for banana *Xanthomonas* wilt and implications on disease epidemiology and management. *Journal of Plant Pathology*. 36, 418–427. doi: 10.1080/07060661.2014.959059

Ocimati, W., Were, E., Groot, J.C.J., Tittonell, P., Nakato, V. and Blomme, G. (2018). Risks Posed by Intercrops and Weeds as Alternative Hosts to *Xanthomonas campestris* pv. *musacearum* in Banana Fields. *Frontiers Plant Science*. https://doi.org/10.3389/fpls.2018.01471

Okigbo, R. N., and Nnadiri, P. C. (2017). Effect of Three Tropical African Plants on some Fungal Rot of Stored Cocoyam (*Colocasia esculenta* L.). *Journal of Agricultural Technology*, *13*, 183- 203.

Onyeka, T.J. (2011). Understanding Taro leaf blight: A new challenge to cocoyam (*colocasia esculenta*) production in Nigeria. In: Amadi, C.O.; Ekwe; K.C.; Chukwu, G.O.; Olojede, A.O. and Egesi, C.N. (Eds), Root and Tuber Crops Research for Food Security and Empowerment. *National Root Crops Research Institute* (NRCRI), Nigeria. Pp 301-311.

Romo, J. P., Morales Osorio, J. G., and Yepes, M. S. (2012). Identification of new hosts for *Ralstonia solanacearum* (Smith) race 2 from Colombia. *Revista de Proteccion Vegetal*. 27, 151–161.

Ugwuoke KI, Onyeke CC and Tsopmbeng NGR (2008). The efficacy of botanical protectants in the storage of cocoyam (*Colocasia esculenta* (L.) Shott). *Agro-Science Journal of Tropical Agriculture Food Environment Extension*.;7(2):93-98.

Table 1: Assessment of fungal disease causal organism on plant leaf with similar symptoms as *Phytophtora colocasiae* growing around the taro farm and their percentage frequency of occurrence

Name of Plants	**Fungi isolated**	**Occurrence(%)**
Dioscorea dometorum	*Botryodiplodia theobromae*	23.08
	Aspergillus flavus	15.38
Gongronema latifolium(utazi),	*Aspergillus niger*	15.38
	Geotrichum candidum	23.08
Xanthosoma spp.	*Aspergillus niger*	15.38
	Peniccillum chrysogonum	7.69
	Rhizopus stonolifer	7.69
	Fusarium oxysporum	7.69
	Botryodiplodia theobromae	23.08
Mucuna flagellipes (Agbara leaf)	*Aspergillus flavus*	15.38
	Geotrichum candidum	23.08
Manihot esculenta leaf	*Botryodiplodia theobromae*	23.08
	Geotrichum candidum	23.08

MAIZE GRAIN YIELD, HEAVY METAL ACCUMULATION IN SOIL AND GRAINS UNDER DIFFERENT FERTILIZATION REGIMES

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ABSTRACT

Most fertilization programs in agriculture emphasize yield improvement and less emphasis on plant and soil quality. A two-year study was initiated to comparatively assess the crop – use potentials, input of metals in soil, their uptake and ability of translocation from soil to maize grains under different fertilization regimes. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of three levels -10, 50, 100 tha^{-1} boiler ash (BA); 10, 50, 100 tha^{-1} poultry droppings (PD), 75, 150, 300Kg ha^{-1} NPK 20-10-10 fertilize and their combinations. A control (no fertilizer or manure application) was included**.** Maize seeds (Oba Super II) were grown in each plot. Data collected were analyzed using one-way analysis of variance (ANOVA) and significant means separated by F-LSD at 5% level of probability. Results obtained showed that plots amended with BA_{10} + PD_{20} and PD_{20} produced highest maize grain yield of 5.43 tha^{-1} and 2.56 tha^{-1} at the first and second cropping seasons respectively. Plots amended with NPK 20:10:10 at rates >150 kg ha^{-1} significantly ($p<0.05$) induced highest (4.56 $mgkg^{-1}$) increase in soil boron (B). Highest soil Mn (11.6 mg kg^{-1}) and Zn (12.04 mg kg^{-1}) concentrations were recorded in plots amended with BA_{100}. The maize grain boron (14.5 mg kg^{-1}) and Cadmium (4.53 mg kg^{-1}) concentrations were highest in maize grains grown in BA_{100} + NPK_{75} and BA_{50} + PD_{10} plots, respectively. The metal bio - concentration factor was in the order B > Zn > Cd and Cd > Zn > B in first and second cropping seasons, respectively.

Key words: Boiler ash, heavy metal, bio-concentration, NPK fertilize., poultry droppings

INTRODUCTION

Intensive agriculture, coupled with introduction of higher-yielding and more nutrient demanding crop varieties, reduce soil organic matter levels and nutrients through repetitive harvesting of crops (FMANR, 2011). It becomes obvious that to improve soil productivity and obtain crop yields constantly above the low-input levels, the soil must be amended. Application of soil amendments restores soil quality by balancing pH, adding organic matter, increasing water holding capacity, re-establishing microbial communities, and alleviating compaction (USPA, 2007, Ram and Masto, 2014). Similarly, amendments lead to changes in physico-chemical properties of the soil, such as pH, organic matter, etc., which change the solubility of metals and thus availability to the plants (Singh and Agrawal, 2010).

One major apprehension regarding application of these amendments in soil is their potentials to contaminate soil, plants, surface and ground water (Weber et al., 2007, Saraswat and Chaudhary,2014). Studies however, have shown that organic amendments reduced the bioavailability of heavy metals in soil due to the high content of organic matter, P and Fe (Brown et al. 2003) and inorganic amendments by production of binding sites (Puschenreiter et al., 2005) and promotion of normal metabolism of plants or changing forms of metals (Sun et al., 2007). Therefore, the concentration level and mobility of these elements decide their concern and utilization. If the accumulation of elements in soil becomes excessively available, it will lead to their accumulation in plant tissues, may lower plant productivity and consequently impact on health of human beings and animals. Seçer *et al.* (2016) warned that application of all organic wastes to arable land must be regulated with regard to tolerable amounts of nutrients and heavy metals.

Most studies on utilization of soil amendment in Nigeria have largely focused on yield responses of field crops with very little effort to relate such responses with soil heavy metal loading and crop quality. This indiscriminate use of amendments without caring about possible negative effects might become a major concern. McBride (2002) noted that metal behavior in soils and plant uptake is difficult to generalize because it is strongly dependent on the nature of the metal, sludge, soil properties and crop. Efficient utilization of soil amendment requires clarity on potential loading of heavy metals in amended soils and their bioavailability. This will ensure that addition of soil amendment is protective of human health and the environment. This study therefore, aims to assess comparatively, the maize grain yield. bioavailability of metals in the soil, concentration in maize grains and their bioconcentration factor under single and combined treatments of different levels of boiler ash, poultry droppings and NPK fertilizer.

MATERIALS AND METHODS

The study was conducted at the Research Farm of the Department of Soil Science, University of Nigeria, Nsukka, located by Latitude 06^0 25′ N and Longitude 07^0 24′ E. The soil is coarse to medium textured, acid in reaction and low in nutrient status. It is an Ultisol belonging to the Nkpologu series and classified as Typic Kandiustult (Akamigbo and Igwe, 1990).

Bulk soil samples from 0-20 cm depth were collected, ground and passed through 2 mm sieve. It was analyzed for physico-chemical characteristics according to the methods as described by Page *et al.* (1982). Boiler ash generated from burning oil palm mill wastes (palm kernel shells, cakes, sludge etc.) in boilers was collected from the dumping site of Solive Vegetable Oil Mills Ltd, Nsukka. The poultry dropping was collected from Newera Farms Nsukka. The BA and PD were analyzed for various characteristics according to the methods mentioned above. A hybrid maize (*Zea mays* L.) variety (Oba supper II) was used as a test crop. It was chosen based on its sensitivity to a wide range of contaminants (Wong *et al.*, 1991), short maturation, sensitivity to soil nutrient status and common use in the study area.

The experiment was laid out in a randomized complete block design (RCBD) having three replications using plot size 3m x $4m^2$. It consisted of sixteen treatments with designations and application rates as shown in Table 1. The experiments were conducted in two successive cropping seasons.

Two seeds of maize (*Zea mays* L.) Var. Oba super I) were sown per hole using inter-row and intra row spacing of 0.75m by 0.25m on each of the 4m by 3m plots. Plants were later thinned down to one per stand- two weeks after planting, thus giving a plant population of about 53,333 plants per hectare and 64 plants per plot. Supplying was done during thinning where necessary. Weeds were controlled using a pre-emergence herbicide (Primextra).

Five plants were randomly sampled from two rows at the centre of each plot and tagged. The cobs obtained from the five randomly selected and tagged plants were carefully harvested and threshed. The grains were oven-dried to 14 % moisture content and weighed. The grain yield in tons per hectare based on the plant population of 53,333 plants / hectare used in this study was estimated as per the relationship below:

$$GYha = Yp \, x \, Pha$$

where,

$GYha$ = Grain yield per hectare

Yp = Average grain yield per plant

Pha = Plant population per hectare

Post- harvest soil samples were collected at the end of first and second cropping seasons according to the treatments. These were air-dried, passed through 2mm sieve. The heavy metal content of soil and maize grains were determined by using a digestion system with the program: 0.5 g soil or maize dry weight (DW) + 10 ml diacid mixture (HNO_3 + $HClO_4$ in 2:1 ratio). The digested solution was analyzed for heavy metal content using atomic absorption spectrophotometry (Chemito AA203) (for more details, read Arnesen and Singh,1998).

Bio-concentration factor for B, Cd and Zn were calculated in grains as

BCF = Plant tissue concentration (mgkg^{-1}) / Concentration in Soil t (mgkg^{-1})

Higher ratio of BCF implies higher phytoaccumulation capabilities. (Zayed et al., 1998)

Where,

C = concentration of a particular metal in ppm.

The data collected were subjected to analysis of variance (ANOVA) using GENSAT Discovery Version (GENSTAT 2009). Differences between means of treatments were compared using the Fisher's Least Significant Difference (F- LSD).

RESULTS AND DISCUSSION

Physico-chemical characteristics of the experimental soil, boiler ash and poultry droppings

The physico-chemical properties of the soil, BA and PD used for the experiment are shown in Table 2. The soil was sandy clay loam in texture, strongly acidic, low in carbon and nitrogen. The extractible soil micronutrients (Mn, Fe, and Zn) were 0.2, 1.12 and 2.2 mgkg^{-1} respectively. These values are lower than the established critical levels of 5.00, 1.00 and 3.00 mg kg^{-1} respectively (Oluwatosin and Ogunkunle, (1991). The soil boron (0.59 mgkg^{-1}) and cadmium (7.5 mgkg^{-1}) concentrations were also low.

The BA and PD were strongly alkaline as shown by their pH values of 9.2 and 8.3, respectively. The cadmium content of the BA and PD were 16.71 and 29.27 mgkg^{-1} respectively, while, their lead content was below detection. Manganese content of the BA (17.5 mgkg^{-1}) was 22 times higher than that of the PD (0.92 mgkg^{-1}) and 4 times higher in Zn. Poultry droppings have higher potentials to increase the pool of Cd within the soil than the BA, since the BA contained less Cd and high pH, which could increase soil pH thereby reducing Cd availability to plants. However, the high concentration of boron in the ash may be a potential toxicant when applied under high rates (Etiegini *et al.*, 1990).

Impact of amendments on soil boron, cadmium, manganese, zinc and copper content

Determination of the amounts of these metals stored in soil was made only at the upper, tilled horizon, because it is the first horizon involved in transfers. The bioavailable soil B, Cd, Mn and

Zn concentrations were significantly ($p<0.01$) influenced at both cropping seasons in the amended soils (Table 2). Application of NPK 20:10:10 at rates >150 kg ha^{-1} induced highest (4.56 $mgkg^{-1}$) increase in soil B at the end of the first cropping season. However, blending them with low levels of BA obliterated the increase and further reduced them to as low as 1.18mg kg^{-1} B relative to the control (2.37 $mgkg^{-1}$). Poultry dropping amended soils had the least (1.19 $mgkg^{-1}$) B content, which did not differ significantly with increase in application rate. Neither fertilization of soil with BA, PD, NPK nor their combinations caused any significant change in the content of B in the second cropping season. Significantly high levels of B in BA which can be detrimental to crop production were of no concern in this study and this may be due to the source, quality and age of BA used. Application of BA_{50} induced the highest concentration of Cd (0.32 and 0.85 $mgkg^{-1}$) in soil at the first and second cropping seasons; respectively. The concentration increased with increasing application rate of BA up to the peak agronomic rate of 50 tha^{-1} and thereafter declines. Similar trend was observed at the end of the second cropping season. Relative to sole BA application, combined application of BA with PD significantly ($p<0.01$) reduced the soil Cd loading. Generally, soil Cd increased more in the second cropping season.

At the end of the first cropping season, high levels of BA increased Mn content of the soil. The total Mn content in the control soil sample was 6.75mg Kg^{-1}. Lower level of BA (BA_{10}) and all sole PD and NPK fertilizer had significantly ($p<0.01$) lower Mn content relative to the control. Similar trend was observed when BA was combined with either PD or NPK. This result indicates that high rates of BA were responsible for the Mn soil enrichment. The same trend was observed in the second cropping season. Highest concentration of Zn (13.5 $mgkg^{-1}$) and Cu (1.5$mgkg^{-1}$) were found in BA_{100} and NPK_{300} treated soils respectively at the first cropping season's post-harvest soil analysis. Boiler ash enriched the soil with Zn linearly with increase in application rate. The concentration in control soil (2.10 mg kg^{-1}) was higher than all the NPK treated plots although not significantly different. All BA combinations with either PD or NPK significantly ($p<0.05$) enriched the soil with Zn relative to the control. Similar result was obtained at the second cropping season. The treatments did not significantly increase the soil Cu content at the first cropping season. At the end of the second cropping season, BA significantly ($p<0.01$) enriched the soil with Cu at the BA_{100} and BA_{10} rates. Blending the BA_{50} rate with either PD_{10} or NPK_{150} increased the soil available Cu from 0.04 to 1.14 and 1.63mg kg^{-1} respectively.

Generally, the observed increase in soil micronutrients (Mn, Cu, Zn and Cd) in BA amended plots may be attributed to inherent properties of the BA as evidenced from the characteristic properties (Table 2). Several researchers reported similar elevation of the concentration of micronutrients (Mn, Cu, Zn and Cd) in the soil after ash application (Naylor and Schmidth, 1989; Rautarary *et al.*, 2003; Buddhe *et al*., 2014). The increase in B content in soils amended with NPK relative to the control could be attributed to the effect of soil pH. The observed values of B exceeded the FAO (1976) permissible limits of 1.0. Result of this study also revealed an apprehension in BA application considering the accumulation of Cd at the agronomic rate of 50 tha^{-1}. The maximum critical levels of these heavy metals and uptake by crops may however, depend on crop type (Kabata- Pendias and Pendias (1992), metal form and soil type (He *et al.*, 2004) and soil management (Chen and Lee, 1999).

Impact of amendments on maize grain yield (tha^{-1}) at first and second cropping seasons

Maize grain yield (tha^{-1}) was very highly significantly (P<001) as influenced by the type and quantity of amendment applied (Table 3). Boiler ash application did not significantly increase grain yield at both cropping seasons relative to the control. Among the BA treated plots lowest dose (10 tha^{-1}) consistently had the highest grain yield at both cropping seasons. The result agrees with that of Haraldsen *et al.* (2012) who noted that if bottom wood ash is applied without sufficient N supply, the effect on crop growth and yield is minimal and the plants do not take up the potential plant nutrients supplied. The result however contrasts with the findings of several authors (Jamil et al. 2004; Khan and Qasim, 2008; Ram *et al.*, 2011; Ezema *et al.*, 2013) who reported that BA increases crop yield significantly at an agronomic rate between 25 to 60 tons per hectare.

The highest maize grain yield of 5.67 and 2.56 tha^{-1} were obtained in plots amended with 20 tha^{-1} PD at the first and second cropping seasons, respectively. It is worthy to note that the yield was at par with a blend of 50tha^{-1} BA and 10 tha^{-1} PD. The recommended NPK 20:10:10 fertilizer rate for maize (NPK_{300}) had significantly (P<0.01) higher yields than the unfertilized plots at the first cropping season. The residual effect however, revealed non-significant difference relative to the control. The maize grain yield obtained from plots amended with lower rates (NPK_{150}, NPK_{75}) did not significantly differ with that of the control.at both cropping seasons.

A yield advantage was observed due to combined application of BA with low levels of PD and all levels of NPK 20:10:10 in both seasons of experimentation. The integrated fertilization treatments involving BA and PD or NPK 20:10:10 were superior to all levels of NPK 20:10:10 and low level of PD. Similar findings have been reported by Selvakumari *et al. (*1999), Rautaray *et al*. (2003) and Ram *et al.* (2007). They noted that integration of fly ash alone or with other components of the nutrient supply system because of synergistic effects resulted in better nutrient uptake, higher yield and improved maintenance of soil fertility. In this study, synergism occurred only when low doses of BA were blended with low levels of PD or low levels of BA and high doses of NPK-fertilizer. The most synergistic effect of blending BA with either PD or NPK-fertilizer was observed with the lowest rate of BA (BA_{10}). This implies that the inclusion of BA in the amendments at high application rate did not affect the maize grain yield significantly

Impact of amendments on heavy metal concentration in grains at first and second cropping seasons

Table 3 also shows the total boron, cadmium, zinc and cupper concentrations in maize grains grown in the control and amended soils at at both cropping seasons. Boron concentration in maize grain was significantly ($p<0.05$) influenced by the treatments at both cropping seasons as compared to grains harvested from the control soil. In the first cropping season, it was highest (14.35 $mgkg^{-1}$) in grains harvested from the plot treated with integrated fertilization of BA with either PD or NPK (BA_{100} + NPK_{75}, BA_{10} + PD_{20}, BA_{50} + PD_{10}), while the least was obtained from BA_{100} treated plots. During the second cropping season, the highest (3.62 $mgkg^{-1}$) was obtained from grains grown in plots treated with NPK_{150} which was statistically the same with NPK_{300} plots. The least value was obtained from BA_{50} + NPK_{150} treated plots. Among the BA treated plots, B concentration in maize grains obtained from BA_{50} treated plots increased significantly ($p<0.05$) over other sole BA treatments and the control in the first cropping season. In the second cropping season it was the BA_{100} rate. Overall boron concentration decreased drastically from the first to the second cropping season.

Cadmuim concentrations in the grains harvested from all treated plots were higher in the second cropping season than in the first cropping season. At the first cropping season, the highest Cd concentration was obtained in the grains grown on the BA_{50} + NPK_{150} treated plot while the lowest value was recorded in BA_{10}. Samples from both the treated plots and control were below 0.05 $mgkg^{-1}$. Patterson (2001) noted that since they were below the detection limit of 1$mgkg^{-1}$ they did not warrant further statistical comparison among samples.Mean cadmium content of the grains from second seasons harvest was statistically ($p<0.05$) higher in samples obtained from plots amended with BA_{100} + NPK_{75} and lowest in the control. All treatments significantly increased cadimum content of the maize grains relative to the control. Among the sole BA treatments, BA_{50} had significantly higher value than others. It is interesting to note that lower accumulation of cadmium was observed in the soil compared to the maize grain regardless of the source of fertilizations. This result indicates that cadmium accumulation in grains should be of concern.

Zinc content in grains harvested at the first cropping season from plots amended with BA_{100} had the highest value of 13.0 $mgkg^{-1}$. It was statistically the same with BA_{100} + PD_{5}. The least value was observed in NPK_{75}. Similar trend was obtained at the second cropping season. Average Zn concentration across all treatments was 7.47 $mgkg^{-1}$ in the first cropping season and decreased to 3.24 $mgkg^{-1}$,the following year. The observed decrease may be potentially the result of the stabilization of the organic matter in the biosolid fraction of the amendments. Metal uptake by plants in biosolid amended soils is generally highest in the first year following application (Logan and Chaney, 1983, Brown *et al.* 2003). It is important to note that despite the high total plant Zn concentration in all treatments that included BA, they were below levels associated with Zn toxicity (Chaney, 1993).

The presence of trace amounts of elements of environmental concerns in the BA was not of much concern. This may be attributable to the alkaline nature of the ash and associated impact of its application with organic substrates (PD), which help in the controlled carryover of these elements, besides the accompanying dilution of these elements due to enhancement in the yield of crop products. None of the elements demonstrated that their concentration traversed permissible limits at 10 and 50 tha^{-1} of BA addition. Although, cadmium and zinc didn't reach up to phytotoxic level in any rate but phytotoxicity symptoms were noticed at 100tha^{-1} rate addition viz. decline in growth parameters.

Impact of amendments on heavy metal - maize grain concentration factor (BCF) at first and second cropping seasons

Table 4 shows the bio-concentration factor (BCF) of heavy metals from soil to maize grains as influenced by the different amendments. The sequence of bio Concentration factor of heavy metal(s) within the different fertilization regime were in the order B>Zn>Cd at the first cropping season and Cd > Zn >B in the second season. Significantly, higher BCF was achieved in B and

Cd at the first and second cropping seasons respectively, compared to other heavy metals. Bioconcentration factor was highest for B in plants grown in BA_{100} + NPK_{75} treated soil in the first cropping season, for Cd in NPK_{300} -treated soil in the second cropping season and for Zn in non-amended soil (Table 4).

At the first cropping season, BCF of boron in maize grains ranged from 0.222 in BA_{100} to 12.16 in BA_{100} + NPK_{75}. Among the sole BA treatments, the BA_{50} treated plot had the highest BCF of boron. Generally, the sole NPK 20:10:10 treated plots were low in BCF of B compared with that of BA and PD. Blending BA with either PD or NPK increased the BCF of boron remarkably. One year after application (second cropping season) there was a drastic reduction. For instance, in BA_{100} + NPK_{75}, the BCF of boron reduced by about 134%. The BCF of cadmium was low at the first cropping season ranging from 0.009 in the control to 0.274 in the PD treated plots. However, at the second cropping season, the value increased remarkably in all plots ranging from 3.665 in BA_{50} + NPK_{150} to 11.365 in NPK_{300}. The bio concentration factor of zinc was higher at the first cropping season and the least value (0.456) was obtained from the BA_{50} + NPK_{150} plots, while, the highest (5.476) was observed in the control. At the second cropping season, the value reduced remarkably with the highest and lowest values obtained in maize grains harvested from plots treated with NPK_{150} and BA_{100} + PD_5 respectively.

The result revealed large differences in BCF depending on the type of amendment, time of cropping and on the metal in question. The higher BCF achieved in Cd agrees with the findings of Orhue *et al.* (2015) on *Amaranthus cruentus*. Thus, the study agrees with that of Harrison and Chirgawi, (1989) which reported that bioconcentration factor (BCF), which represents the transfer potential of heavy metals from the soil to the plants, depends upon properties of the metals and the soil and time. Higher values of bioconcentration factor for the metals reflect their easier translocation from soil to the plants.

The bioavailability of B and Zn becoming less with time may be because of permanent immobilization by soil or biosolids reducing the chance of delayed "time bomb effect". However, there is concern that at the cessation of application, Cd bound metal would be released to soluble forms thus increasing the chance of delayed "time bomb effect". The ability of the maize grains to accumulate the metals in question may be due to some soil factors such as soil organic carbon and CEC as shown by the correlation coefficient as earlier reported by Ezema (2016). The result indicates that growing maize in soils amended with BA blended with either PD or NPK would represent a higher risk of food contamination than growing maize in sole BA, PD or NPK treated plots. However, amending BA contaminated soils with either NPK or PD and growing maize in it could be used for phyto remediation of lightly BA contaminated soils providing that the crop residues were safely disposed.

It is apparent from the present study that the maize plant absorbs heavy metals in different concentrations with respect to different amendments. Combined application of BA especially with NPK poses a threat to heavy metal accumulation in grains. The finding collaborates the assertion of Carbonell *et al.* (2011) that indiscriminate use of biosolids to improve agricultural yields without caring about any possible negative effects may be a major concern; thus, the management of agricultural soils amendments must also consider plants nutritional needs and metal content for assessing the real potential toxicity and their risk for soils.

CONCLUSION

After two years of field studies, poultry manure was found to be superior to BA and NPK as a source of nutrients to crops. There was no synergistic effect of integrating the amendments on maize grain yield. Soil levels of B, Cd, Mn and Zn were increased, but did not exceed their tolerable levels. In this study, no single factor was identified that would prohibit use of any of the materials as an agricultural soil amendment. It is recognized, however, that the increase in maize grain Cd at the second cropping season may require greater monitoring in order to derive the greatest amount of benefit and minimize potential risks in utilizing these soil amendments.

REFERENCES

Akamigbo FOR. & Igwe CA. Morphology, Geography, genesis and taxonomy of three soils series in Eastern Nigeria. Samaru Jour. Agric. Res. 1990; 7:33─48.

Arnesen AKM & Singh BR. Plant uptake and DTPA extractability of Cd, Cu, Ni and Zn in a Norvegian alum shale soil as affected by previous addition of dairy, pig fertilizers and peat. Can. J. Soil Sci. 1998; 78: 531–539.

Brown SL. Henry CL, Chaney R, Compton H & De Volder PS. Using municipal bio-solids in combination with other residuals to restore metal-contaminated mining areas. Plant and Soil. 2003; 249: 203-215.

Buddhe, ST, Thakre M & Chaudhari PR. Effect of fly ash-based soil conditioner (Biosil) and recommended dose of fertilizer on soil properties, growth and yield of wheat. American J. of Engineer. Res. 2014; 3 (1): 185-199.

Carbonell G, Miralles de imperial R, Torryos M, Delgado M, & Rodriguez JA. Effects of municipal solid waste compost and mineral fertilizer amendments on soil properties and heavy metal distribution in Maize plants (Zea mays L.). Chemosphere, 2011; 85:1614−1623.

Chaney RL. Zinc phytotoxicity. *In* Zinc in Soils and Plants. Eds. A D Robson. Kluwer Academic, Dordrecht, The Netherlands. 1993.

Chen ZS. & Lee TM. The effect of chemical remediation treatment on the extractability of cadmium and lead by wheat growing in contaminated soils. Proceedings of the 2nd Int. conf. on contaminants in the soil environment in the Australia –pacific region. New Delhi, India. 1999..

Etiegini L. Wood ash as an additive and liming agent. PhD dissertation. Forest products Department. Univ. of Idaho Moscow, Idaho. 1990.

Ezema RA, Ibudialo AN, Omeje TE & Chienyinam GI. Evaluation of agronomic performance of Nsukka Yellow pepper (*Capsicum annum L*.) under different rates of b[illegible] application in Iwollo, Enugu State, Nigeria. Proc. 1st Nat. Conf. Crop Sci. Soc. o[illegible]. 2013. pp.29-32.

Ezema RA. Comparison of the physicochemical potential of boiler ash, poultry droppings and inorganic fertilizer and their effects on Ultisol and maize performance in South eastern Nigeria. PhD Thesis submitted to Department of Soil Science and Land Resources, University of Nigeria, Nsukka. 2016,

Federal Ministry of Agriculture and Rural Development. Fertilizer use and management for crops in Nigeria. Edited by V. O. Chude *et al.* Produced FPPD, Federal Ministry of Agriculture, Water Resources and Rural Development, Lagos, Nigeria. 2011. Pp.163.

Food and Agricultural Organziation of the United Nation, World reference base for soil resources. World soil Resources Report 84. 1979. Pp 88.

GENSTAT. Discovery Edition. 3 VSN International Ltd. ,2009.

Haraldsen TK.& Krogstad T. Efficiency of organic NPK fertilizers combining N-rich organic wastes and bottom wood ash. NJF Report 2011; 7(8): 50-53.

Harrison, R.M., Chirgawi, M.B., 1989. The assessment of air and soil as contributors of some trace metals to vegetable plants III-experiment with field-grown plants. Sci. Total Environ. 83, 47–63.

He Z.L. Zhamg MK, Calvert DV., Stopella PJ, Yany XE. & Yu S. Transport of heavy metals in surface run off. from vegetable and citrus fields. Soil Sc. SOC, AM J. 2004; 68 :1662-1669.

Jamil M, Qasim M & Subhan A. Impact of organic waste (Baggasse ash) on the yield of wheat (Triticum aestivum L.) in a calcareous soil. Int. Jour of Agric., and Biology. 2004; 6 (3): 468─470.

Kabata- Pendias A & Pendias, H. Trace elements in soils and plants (zinc ed). CRC ress, Inc., Boca ration Florida USA. 1992.

Khan MJ & Qasim M. Integrated use of boiler ash as organic fertilizer and soil conditioner with NPK in calcareous soil. Songklanakarin Jour. Sci. Tech. 2008; 30(3): 281─289.

Logan TJ & Chaney RL, Utilization of municipal wastewater and sludge on land–metals. *In* Proceedings of the Workshop on Utilization of Municipal Wastewater and Sludge on Land. 1983; 235–326.

Mastro RC. Fly ash for soil amelioration: A review on the influence of ash blending with inorganic and organic amendments, Earth Science Review, 2014 ;128, 52 -7

Mc- Bride MB. Toxic metals in sewage sludge-amended soils: has promotion of beneficial use discounted the risk? Advances in Environmental Research. 2003; 8: 5–19

Naylor LM & Schmidt E. Paper mill and wood ash as a fertilizer and liming material: Field Trials. Tappi J. 1989; 72:199 - 206.

Oluwatosin GA & Ogunkunle AO. Suitability rating of some soils of the savanna zone of southwestern Nigeria for maize production. Nigerian Journal of Soil Science. 1991; 10: 1-24.

Orhue ER & Izunwanne CL. Heavy metals status of soil and their uptake by fluted pumpkin (Telferia occidentals Hook F) cultivated along Ikpoba river bank. Benin City. Nigeria Jour. of Soil Sci. 2013; 23(1): 102- 109.

Page AI, Miller RH. & Keeney DR *Methods of Soil Analysis*. Part–2. 2nd Ed. 1982; Agron. 9, Madison, Wisconsin, USA

Patterson S. The agronomic benefit of pulp mill boiler wood ash. An M. SC. Thesis submitted to the School of Graduate Studies Council of the University of Lethbridge, Lethbridge, Alberta, Canada. 2001.

Puschenreiter, M., Horak, O., Friesl, W., Hartl, W. Low cost agricultural measures to reduce heavy metal transfer into the food chain – a review. Plant Soil Environ. 2005; 51 (1): 1–11.

Ram LC, Orhue, ER, Edosa IV& Iyagbaye L. Heavy metal status in soils and Amaranthus cruentus from farmland on the bank of Orogodo river, Agbor, Delta state, Nigeria. NJSS 2015,25, 2015, 38-44.

Ram LC, Srivastava NK, Jha K, Sinha AK, Masto RE & Selvi VA.. "Management of lignite fly ash through its bulk use via biological amendments for improving the fertility and crop productivity of soil." Environmental Management, 2007; 40:438–452.

Rautaray SK, Gosh BC& Mittra BN. Effect of fly ash organic waste and chemical fertilizer on yield, nutrient uptake, heavy metal content and residual fertility in a rice-mustard cropping sequence under lateritic soils. Bioresour. Technol. 2003; 90:275-83.

Rautaray SK, Gosh BC, Mittra BN. Effect of fly ash organic waste and chemical fertilizer on yield, nutrient uptake, heavy metal content and residual fertility in a rice-mustard cropping sequence under lateritic soils. Bioresour. Technol. 2003; 90:275-83.

Saraswat PK. & Chaudhary K. Effect of Fly Ash (FA) to improving soil quality and increase the efficiency of crop productivity. European Journal of Biotechnology and Bioscience 2014; 2 (6): 72-78.

Seçer M, Elmaci OL& Fafak C. The Effects of Organic Wastes on Soil and Cotton Quality with respect to the Risk of Boron and Heavy Metal Pollution. International Journal of Agronomy. 2016. pp. 1-7

Selvakumari G, Bhaskar M, Jayanthi D & Mathan KK. Effect of integration of fly ash and fertilizers and organic manure on nutrient availability, yield and nutrient uptake of rice on Alfisols Jour of the Indian Soc. of Soil Sci. 2000; 48: 268-278.

Singh, RP. & Agrawal, M. Effect of different sewage sludge applications on growth and yield of Vigna radiata L. field crop: metal uptake by plant. Ecol. Eng. 2010; 36: 969–972.

Sun, L., Niu, Z., Sun, T. Effects of amendments of N, P, Fe on phytoextraction of Cd, Pb, Cu, and Zn in soil of Zhangshi by mustard, cabbage, and sugar beet. Environ. Toxicol. 2007; 22 (6): 565–571

United State Environmental Protection Agency. The use of soil amendment for remediation, revitalization and reuse. Super fund Remediation and Emergency Response. EPA, 2007: 542-R-07-013.

Weber JA, Karczewska J, Drozd M, Licznar S, Licznar J & Kocowicz A. Agricultural and ecological aspects of a sandy soil as affected by the application of municipal solid waste composts. Soil Biology and Biochemistry.2007; 39:1294-1302. \

Wong W, Gorsuch JW & Lower WR. Plants for toxicity assessment. 1991; ASTM STP 1091, ASTM Philedelphia.

Zayed, A., Gowthaman, S &Terry, N. Phyto-accumulation of Trace Elements by Wetland Plants:1. Duckweed. Jour. of Environmental Quality. 1998; 27(3):715 – 721.

Table 1: Physico-chemical characteristics of the experimental soil and the boiler ash

Properties	Soil	Boiler ash	Poultry droppings
pH ($H_2$0)	4.8	9.2	8.3
Coarse sand (gkg^{-1})	380		
Fine sand (gkg^{-1})	290	182	
Silt (gkg^{-1})	110	347	
Clay (gkg^{-1})	220	354	
Textural class	Sandy clay loam		
Bulk density (Mgm^{-3})	1.98	0.37	
Organic carbon (%)	1.29	12.4	43.1
Total nitrogen (%)	0.24	0.2	4.2
C:N	5.4	62	8.8
Available P	7.5	293.8	8.32
Mn (mg kg^{-1})	0.2	17.5	0.92
B (mg kg^{-1})	0.59	31.5	0.38
Zn (mg kg^{-1})	2.2	19.4	5.57
Pd (mg kg^{-1})	n.d	Trace	Trace
Cd (mg kg^{-1})	7.5	2.6	29.8

n.d.= not detectable, Mn = Manganese, Zn = Zinc, B =Boron, Pd = Lead, Cd = Cadmium

Table 2: Treatments applied their designation and application rate

S/N	Treatments	Designation	Rate (kg/plot)	Rate (t/ha)
T1	Boiler ash	BA_{100}	120	100
T2	Boiler ash	BA_{50}	60	50
T3	Boiler ash	BA_{10}	12	10
T4	Poultry droppings	PD_{20}	24	20
T5	Poultry droppings	PD_{10}	12	10
T6	Poultry droppings	PD_{5}	6	5
T7	N.P.K 20: 10: 10	NPK_{300}	0.36	0.3
T8	N.P.K 20: 10: 10	NPK_{150}	0.18	0.15
T9	N.P.K 20: 10: 10	NPK_{75}	0.09	0.075
T10	Boiler ash + poultry droppings	BA_{100} + PD_{5}	120 + 6=126	100 + 5=105
T11	Boiler ash + poultry droppings	BA_{50} + PD_{10}	60 + 12=72	50 +10= 60
T12	Boiler ash + poultry droppings	BA_{10} + PD_{20}	12 + 24=36	10 + 20=30
T13	Boiler ash + NPK 20: 10: 10	BA_{100} + NPK_{75}	120+0.09=120.09	100+0.075=100.075
T14	Boiler ash + NPK 20: 10:10	BA_{5O} + NPK_{150}	60 + 0.18=60.18	50 +0.15=50.15
T15	Boiler ash + NPK 20: 10: 10	BA_{10} + NPK_{300}	12 + 0.36= 12.36	10 +0.3 =10.3
T16	Control	Control	No amendment	No amendment

Table 3 Impact of different rates of boiler ash, poultry droppings, NPK 20:10:10 and their combinations on soil heavy metal content

	B		Cd		Mn		Zn		Cu	
	………………………… mgkg^{-1} ……………………………									
Treatment	**1st C.S**	**2nd CS**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**
BA_{100}	3.45	4	0.295	0.637	11.55	12.04	13.5	14.5	1.21	1.84
BA_{50}	1.21	7	0.324	0.846	9.60	10.14	11.0	9.4	1.41	0.04
BA_{10}	2.35	2	0.309	0.595	3.05	3.37	4.0	6.5	1.08	1.48
PD_{20}	1.19	9	0.295	0.596	3.50	3.85	4.0	4.3	1.01	1.05
PD_{10}	1.19	5	0.320	0.503	5.35	6.46	2.9	11.7	0.97	1.04
PD_{5}	1.19	7	0.124	0.616	1.85	2.04	1.8	11.3	0.79	2.43
NPK_{300}	4.56	5	0.281	0.381	3.20	3.57	1.9	10.5	1.59	2.07
NPK_{150}	4.56	10	0.283	0.415	5.85	6.31	1.7	14.7	1.35	1.54
NPK_{75}	3.45	7	0.267	0.476	3.30	3.48	1.95	5.1	1.07	3.00
BA_{100} + PD_{5}	3.44	11	0.255	0.549	10.35	10.81	13.3	5.9	1.18	1.66
BA_{50} +PD_{10}	1.18	11	0.259	0.565	7.15	7.77	9.2	6.7	0.83	1.14
BA_{10} + PD_{20}	1.18	11	0.263	0.475	4.90	5.62	4.85	7.1	1.47	2.39
BA_{100} + NPK_{75}	1.18	12	0.295	0.681	9.40	9.71	10.85	9.7	1.02	1.46
BA_{50} + NPK_{150}	1.19	5	0.279	0.584	10.75	11.33	11.85	5.4	1.37	2.26
BA_{10} + NPK_{300}	2.37	10	0.230	0.775	2.50	2.92	2.60	5.5	1.10	1.63
No amendment	2.37	7	0.226	0.373	6.75	7.09	2.10	12.7	1.71	1.04
$F\text{-}LSD_{(0.05)}$	0.218	n.s	0.008	0.014	0.610	0.269	1.225	0.418	n.s	0.059

1st C.S= First cropping season. 2nd C.S= Second cropping season, n.s= non-significant at 5% level, $F\text{-}LSD_{0.05}$= Fishers least significant difference at 5% level of probability

Table 4: Effect of different rates of boiler ash, poultry droppings, NPK 20:10:10 and their combinations on maize grain yield and heavy metal concentration during the first and second cropping season

	Maize Grain yield (t/ha)		Cd		B		Zn		Cu	
			………………………… mgkg^{-1} ………………………							
Treatment	**1st C.S**	**2ndC S**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**	**1st C.S**	**2nd C.S**
BA_{100}	0.58	.077	0.034	3.12	0.77	2.42	13.0	5.3	1.21	1.84
BA_{50}	1.39	0.64	0.039	3.32	9.55	1.13	7.5	3.1	1.41	0.04
BA_{10}	1.50	0.95	0.043	3.24	4.77	1.17	7.0	2.7	1.08	1.48
PD_{20}	5.67	2.56	0.045	3.24	11.58	1.10	5.5	2.3	1.01	1.05
PD_{10}	4.01	1.91	0.023	4.7	5.95	1.1	10.5	4.7	0.97	1.04
PD_5	1.90	1.87	0.034	4.29	9.45	1.20	5.6	2.1	0.79	2.43
NPK_{300}	2.52	1.22	0.037	4.33	7.33	3.56	5.4	4.6	1.59	2.07
NPK_{150}	1.36	1.48	0.037	2.47	10.44	3.62	6.6	2.7	1.35	1.54
NPK_{75}	1.36	1.37	0.036	3.74	8.34	2.55	4.6	2.1	1.07	3.00
BA_{100} + PD_5	2.41	0.88	0.042	3.82	11.85	2.39	12.0	4.7	1.18	1.66
BA_{50} +PD_{10}	4.37	1.35	0.049	2.72	13.06	1.08	6.1	2.7	0.83	1.14
BA_{10} + PD_{20}	5.43	2.38	0.039	3.93	13.11	1.06	6.7	2.7	1.47	2.39
BA_{100} + NPK_{75}	1.19	0.34	0.044	4.53	14.35	1.10	6.2	2.5	1.02	1.46
BA_{50} + NPK_{150}	1.06	0.77	0.039	2.84	11.83	0.94	5.4	2.2	1.37	2.26
BA_{10} + NPK_{300}	2.62	0.93	0.041	2.84	11.63	1.21	6.1	2.7	1.10	1.63
No amendment	0.86	1.12	0.002	2.18	8.34	1.20	11.5	4.7	1.71	1.04
F-LSD$_{(0.05)}$	1.446	0.927	0.035	0.078	0.189	0.149	1.184	0.281	n.s	0.059

1st C.S= First cropping season. 2nd C.S= Second cropping season, n.s= non-significant at 5% level, F-LSD$_{0.05}$= Fishers least significant difference at 5% level of probability

Table 5: Bio-concentration factor (BCF) of heavy metals in maize grains as affected by different rates of boiler ash, poultry droppings, NPK 20:10:10 and their combinations.

	Boron		Cadmium		Zinc	
Treatment	**1st C. S**	**2nd C. S**	**1st C. S**	**2nd C.S**	**1st C.S**	**2nd C.S**
BA_{100}	0.223	0.605	0.124	4.898	0.963	0.366
BA_{50}	7.893	0.161	0.120	3.924	0.664	0.330
BA_{10}	2.03	0.585	0.139	5.445	1.750	0.415
PD_{20}	9.731	0.122	0.153	5.436	1.375	0.535
PD_{10}	5.0	0.226	0.072	6.282	3.621	0.402
PD_5	7.941	0.171	0.274	6.964	3.111	0.186
NPK_{300}	1.607	0.712	0.132	11.365	2.842	0.438
NPK_{150}	2.289	0.362	0.131	5.952	3.882	0.184
NPK_{75}	2.417	0.364	0.135	7.857	2.359	0.412
BA_{100} + PD_5	3.445	0.217	0.165	6.958	0.902	0.797
BA_{50} +PD^{10}	11.068	0.098	0.189	4.814	0.663	0.403
BA_{10} + PD_{20}	11.11	0.096	0.148	8.274	1.381	0.365
BA_{100} + NPK_{75}	12.161	0.092	0.149	6.603	0.571	0.258
BA_{50} + NPK_{150}	9.941	0.188	0.140	4.863	0.456	0.407
BA_{10} + NPK_{300}	4.907	0.121	0.178	3.665	2.346	0.491
No amendment	3.519	0.171	0.009	5.845	5.476	0.370
Sd	3.970	0.200	0.0551	1.887	1.450	0.143

1st C.S= first cropping season , 2nd C.S= second cropping season, Sd=Standard deviation

SEASONAL VARIATION, MANURE TYPES, AND RATES: IMPACT ON FRESH LEAF YIELD AND FUSARIUM ROT DISEASE PREVALENCE IN KALE (*Brassica oleracea* VAR. ACEPHALA)

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ABSTRACT

Kale (*Brassica oleracea* var. *acephala*) is a popular leafy vegetable grown worldwide. Understanding the influence of seasonal variation, manure types, and application rates on kale production is crucial for sustainable agriculture. This study investigates how different factors affect fresh leaf yield and disease prevalence, specifically focusing on Fusarium rot disease. Seasonal variation did not influence the leaf yield, disease incidence, and severity significantly (($p \geq 0.05$) at 8 and 10 weeks after transplanting but manure type and rates significantly (($p \leq 0.05$) influenced the leaf yield of kale at harvest. Application of poultry manure gave the optimum leaf yield (29, 992.00 kg/ha) while the pig slurry recorded 16, 474.00 kg/ha. Furthermore, the application of 30 tons of gave a better leaf yield when compared to other rates studied but the manure type and rates did not affect the incidences and severity of fusarium rot. Manure type and rates play an important role in the fresh leaf weight of kale thereby increasing the farmers' income whereas season, manure types, and rate have no impact on the fusarium rot disease of kale.

Keywords: Poultry, Pig slurry, Fusarium rot, Season, Kale

INTRODUCTION

Kale (*Brassica oleracea* var *acephala*) belongs to the family Brassicaceae. This variety is among the most popular cruciferous vegetable crops cultivated and is valued for its succulent leaves as edible parts. Other crucifers include Cabbage, Cauliflower, Brussels sprouts, Collards, Kohlrabi, Mustard, and Broccoli which are different. Crucifers have been ranked by the Food and Agriculture Organization among the top twenty vegetable crops grown worldwide, establishing it as an important food source globally (Singh, 1993). They are grown all through the year for their tender vegetables but thrive best in a cool, moist climate and do not withstand extreme temperatures (Din *et al*., 2007). They are native to coastal Southern and Western Europe and were, however, domesticated from one ancestral species, the wild cabbage, *Brassica oleraceae* (Maggioni *et al.* 2020).

They are highly nutritious and are excellent sources of vitamins, folate, and dietary fiber (Manchali *et al*., 2012). In addition to fiber-related components kale contain different minerals, sugars, carbohydrates, and proteins that increase its nutritional value (Rop *et al*., 2009). On the other hand, Satheesh *et al.,* (2020) described kale as a good source of fiber and minerals (potassium) with higher calcium bioavailability than that of milk. They also possess different health benefits such as playing a protective role in coronary artery disease, anti-inflammatory activity, gastro-protective activity, inhibition of the carcinogenic compounds' formation, positive to gut microbes, and antimicrobial against specific microorganisms (Favela- González *et al.*, 2020).

Organic manure is known to promote soil improvements and agricultural productivity. Poultry and pig slurry are good sources of N, P, K, and S which are responsible for the higher yield of some crucifers such as cauliflower (Ishieze *et al*, 2024).

In Southeastern Nigeria, kale production is impaired by the occurrence of destructive diseases, in particular foliar diseases which affect the economic part of the plants. Fusarium wilt, leaf spot disease, grey mold, and anthracnose are among the destructive diseases of brassicas worldwide (Meah *et al*., 2002). In this study, we explore the effects of seasonal variation, manure types, and application rates on fresh leaf yield and Fusarium wilt disease prevalence in kale. By understanding these factors, we aim to improve kale production and disease management.

MATERIALS AND METHODS

The field experiment was conducted six weeks after sowing. Seedlings from the nursery were transplanted to an already made bed measuring 1m x1m, 0.5m between beds, and 1m between blocks. This study was laid out as a 2 x 4 factorial experiment in a randomized complete block design (RCBD) replicated three times. Factor A is the manure type while the manure rates (0 tonnes, 10 tonnes, 20 tonnes, and 30 tonnes per hectare) are Factor B. Beds were prepared 2 weeks before transplanting, and well-cured manure was applied on the already made bed. Seedlings were transplanted with a spacing of 25cm in between plants and 9 plants per bed. This experiment was performed in rainy and dry seasons (May to August (2019) and November (2019) to February (2020). It was repeated in (May to August (2020) and November (2020) to February (2021).

For the disease incidence and severity estimation, sterile topsoil was filled in a 25kg bag (40 in number) and manure was also applied at the above four different rates before transplanting. Before manure application, the microbial load of the poultry and pig manure was evaluated and certified safe for use in this experiment. This experiment was a 2x4 factorial in CRD replicated 5 times. From the 40 bags, 2 plants were planted in each, and data were taken from the 4 placed in the Centre where the other six samples for each rate were not sampled because of the border effect. 200µl of Fusarium isolated previously from Kale farm in the Department of Crop science, were inoculated in each bag of soil at 4 weeks after transplanting. The following parameters were collected

a. Disease incidence and severity at 2, 4, 6, 8, and 10 weeks after transplanting
b. Total leaf weight per plant in kg
c. Total curd weight per plot in kg
d. Total curd weight per hectare kg

Disease incidence was calculated using the formula elucidated by Aba *et al*., (2018) whereas severity was calculated and rated using the formula elucidated by the author above.

Data collected were subjected to analysis of variance (ANOVA) using GenStat 12th edition release statistical software. Mean separation was done using Fishers' least significance test at 5% probability level as described by Obi (2002).

RESULT AND DISCUSSION

Effect of season, manure type, and rates on the fresh leaf weight of kale:

The season did not significantly ($p > 0.05$) influence the fresh leaf weight of kale at 10WAT (Table 1 and Table 2) in both 2019 and 2020.

Manure type significantly ($p \leq 0.05$) influenced the fresh leaf weight at 10 WAT (Table 1). Poultry manure (30 .00 t/h) was higher than pig manure (16.50t/h) in leaf weight in 2019. It followed the same trend in 2020 where poultry manure recorded higher weights (25.00t/h) while pig manure had a smaller weight (18.00t/h) at 10 WAT as represented in Table 2.

Manure rates significantly ($p \leq 0.05$) influenced the leaf weight at 10WAT (Table 1). Manure rates; 0, 10, 20, and 30t ha^{-1} produced 13.69, 23.76, 26.87 and 28.60 t/h respectively in 2019. It followed the same trend in 2020 where 0, 10, 20, and 30t ha^{-1} produced 15.20, 21.40, 21.40, and 27.90 t/h respectively at 10 WAT.

Effect of season, manure type, and rates on the Fusarium wilt disease and Severity on kale

Season, Manure type and manure rates did not significantly ($p > 0.05$) influence the incidence of *F. oxysporum* on kale (Table 3 and 4) in both 2019 and 2020 respectively. Also, Season, manure type and manure rate did not significantly ($p > 0.05$) influence the severity of *F. oxysporum* (Tables 3-4 and Figures 1-6) in both 2019 and 2020.

The result showed that disease incidences and severity though not significant were more pronounced during the rainy season. This may be attributed to the high relative humidity in the area during the rainy season as well as the parasitic nature of these fungal organism. This high Relative Humidity favors fungal diseases incidence and severity. This is in tandem with the findings of Nwufo *et al*. (2008); Yanez-Lopez *et al*. (2012) and Ishieze *et al*., (2015). The study also revealed that variability existed among the two organic manures utilized on this study on yield of kale but was not significant on the fusarium wilt incidence and severity. It is evident that leaf yield was highest with poultry manure. These results may be attributed to the release of nutrients from early decomposition of poultry-based manure whereas pig based organic manure tend to release nutrients slower than poultry. The variability observed may also be attributed to increased organic matter component in poultry manure as opined by Ovsthus *et al*., (2015) and Hameed *et al*., (2019). The Physicochemical properties of the field, poultry and pig manure utilized during this study, showed that their organic matter content is 47.98% and 32.69% respectively. Total N, available K and P, exchangeable Ca and Mg also varied. Poultry manure contains high N, P and K. Organic matter content is high in poultry-based manure when compared with the pig slurry. Organic matter as opined by Akanni *et al.*, (2011) is the major determinant of soil fertility in most tropical soils which accounts for its use to raise seedlings in tropical area. Higher fertilization rates are common in crucifer production. From the results of this study, different rates of manure (0, 10, 20 and 30 t ha^{-1}) had variation in leaf weight, but did not affect the disease incidence and severity. The 30t ha^{-1} gave the highest plant height, number of leaves and yield kale and cauliflower. The higher value of morphological and yield attributes of these crucifers with the application of different rates of manure suggests that they are highly responsive to manure application. Jigme *et al*., (2015) studied effects of rate of organic fertilizers on broccoli and found that the use of different rates of poultry manure increases vegetative development and yield. The observations were also in tandem with the findings of Agbede, (2010); Ojeniyi, (2008), Farhad *et al.*, (2009), Adeleye *et al.*, (2010) and Yaldiz *et al.*, (2019).

CONCLUSION

From the studies conducted, the following conclusions were made: It was evident that season did not play any significant role in the yield, Fusarium wilt disease incidence and severity. Application of poultry manure and pig slurry improved leaf yield of kale. Four rates of poultry and pig manure (0, 10, 20 and 30 t ha^{-}) were used but 30 t ha^{-} of poultry and pig manure enhanced leaf yield and this could be recommended in the study area.

REFERENCES

Aba, S. C., Baiyeri, P. K. and Tenkouano, A. (2011). Impact of poultry manure on growth behaviour, black sigatoka disease response and yield attributes of two plantain (Musa spp. AAB) genotypes.

Adeleye, E. O., Ayeni, L. S.and Ojeniyi, S. O. (2010). Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam (Dioscorea rotundata) on alfisol in southwestern Nigeria. *Journal of American science*, *6*(10), 871-878.

Agbede, T. M. (2010). Tillage and fertilizer effects on some soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria. *Soil and Tillage Research*, *110*(1), 25-32.

Akanni, D. I., Ojeniyi, S. O. and Awodun, M. A. (2011). Soil properties, growth yield and nutrient content of Maize, Pepper and Amaranthus as influenced by organic and organomineral fertilizer. *Journal of Agricultural Science and Technology*, *1*, 1074-1078.

Din, M., Qasim, M., & Jan, N. E. (2007). Response of different sowing dates on the growth and yield of cauliflower. *Sarhad Journal of Agriculture (Pakistan)*.

Farhad, W., Saleem, M. F., Cheema, M. A. and Hammad, H. M. (2009). Effect of poultry manure levels on the productivity of spring maize (Zea mays L.). *Journal of Animal and Plant Science*, *19*(3), 122-125.

Favela- González, K. M., Hernández- Almanza, A. Y. and De la Fuente- Salcido, N. M. (2020). The value of bioactive compounds of cruciferous vegetables (Brassica) as antimicrobials and antioxidants: A review. *Journal of Food Biochemistry*, *44*(10), e13414.

Hameed, F., Xu, J., Rahim, S. F., Wei, Q., Khalil, R. and Liao, Q. (2019). Optimizing nitrogen options for improving nitrogen use efficiency of rice under different water regimes. *Agronomy*, *9*(1), 39

Ishieze, P. U., Amuji, C. F., Ugwuoke, K. I., Baiyeri, P. K., & Eze, M. O. (2023). Comparative Efficacy of Systemic and Combination Fungicides for the Control of Alternaria Leaf Spot of Cabbage. *Applied Microbiology*, *3*(3), 906-914.

Jigme; N. Jayamangkala; P. Sutigoolabud; J. Inthasan and S. Sakhonwasee (2015).The effect of organic fertilizers on growth and yield of broccoli (*Brassica oleracea* L. var. italic Plenck cv. Top Green). Journal of Organic Systems., 10(1): 9–14.

Maggioni, L., von Bothmer, R., Poulsen, G. and Härnström Aloisi, K. (2020). Survey and genetic diversity of wild Brassica oleracea L. germplasm on the Atlantic coast of France. *Genetic Resources and Crop Evolution*, *67*(7), 1853-1866.

Manchali, S., Murthy, K. N. C. and Patil, B. S. (2012). Crucial facts about health benefits of popular cruciferous vegetables. *Journal of functional foods*, *4*(1), 94-106.

Meah, M. B., Hau, B. and Siddiqua, M. K. (2002). Relationships between disease parameters of Alternaria blight (Alternaria brassicae) and yield of mustard/Beziehungen zwischen Krankheitsparametern der Rapsschwärze (Alternaria brassicae) und dem Ertrag von Rübsen. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz/Journal of Plant Diseases and Protection*, 243-251.

Nwufo, M. I. and Ihejirika, G. O. (2008). Influence of inter-cropping and removal of diseased leaves on incidence and severity of leaf spot disease of Telfairia occidentalis Hook f. caused by *Phoma sorghina*. *Life Science Journal*, *5*(2), 81-83.

Obi, I. U. (2002). Statistical methods in detecting differences between treatment means and Research methodology issues in laboratory and field experiment. Second edition p. 41.

Ojeniyi, S. O. (2008). Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. *African Journal of Agricultural Research*, *3*(9), 612-616.

Øvsthus, I., Breland, T. A., Hagen, S. F., Brandt, K., Wold, A. B., Bengtsson, G. B. and Seljasen, R. (2015). Effects of organic and waste-derived fertilizers on yield, nitrogen and glucosinolate contents, and sensory quality of broccoli (Brassica oleracea L. var. italica). *Journal of agricultural and food chemistry*, *63*(50), 10757-10767.

Rop, O., Jurikova, T., Mlcek, J., Kramarova, D. and Sengee, Z. (2009). Antioxidant activity and selected nutritional values of plums (Prunus domestica L.) typical of the White Carpathian Mountains. *Scientia Horticulturae*, *122*(4), 545-549.

Satheesh, N. and Workneh Fanta, S. (2020). Kale: Review on nutritional composition, bio-active compounds, anti-nutritional factors, health beneficial properties and value-added products. *Cogent Food & Agriculture*, *6*(1), 1811048.

Singh, B. (1993). Brief report on the Brassica Sub-network. In *Oil crops: Brassica Subnetwork; proceedings of the Third Workshop, Quality Training, and Chinese Project Reports*, *held in Shanghai, People's Republic of China, 21-24 Apr. 1990*. IDRC, Ottawa, ON, CA.

Yaldız, G., Çamlıca, M., Özen, F. and Eratalar, S. A. (2019). Effect of poultry manure on yield and nutrient composition of sweet basil (Ocimum basilicum L.). *Communications in soil science and plant analysis*, *50*(7), 838-852.

Yáñez-López, R., Torres-Pacheco, I., Guevara-González, R. G., Hernández-Zul, M. I., Quijano-Carranza, J. A. and Rico-García, E. (2012). The effect of climate change on plant diseases. *African Journal of Biotechnology*, *11*(10), 2417-2428.

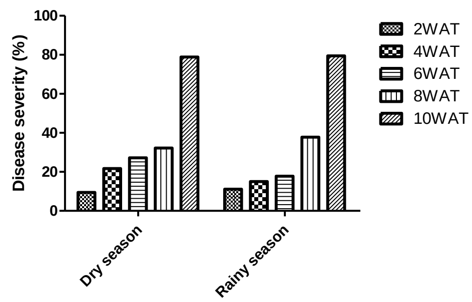

Figure 1: Effect of Season on Fusarium wilt disease severity in 2019

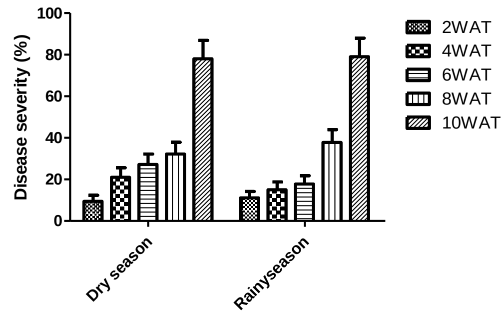

Figure 2: Effect of Season on Fusarium wilt disease severity in 2020

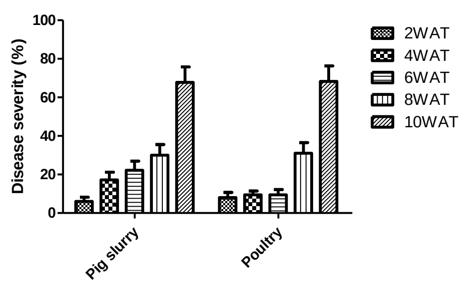

Figure 3: Effect of Manure type on Fusarium wilt disease severity in 2019

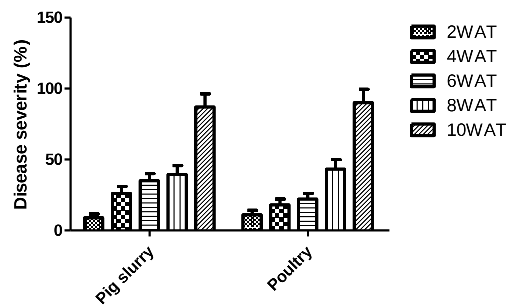

Figure 4: Effect of Manure type on Fusarium wilt disease severity in 2020

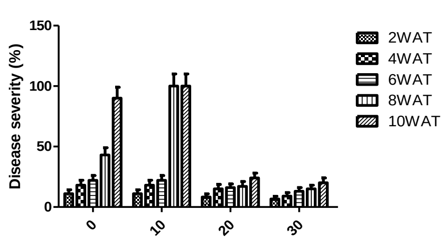

Figure 6: Effect of Manure rates on FUSARIUM wilt disease severity in 2020 (t/ha)

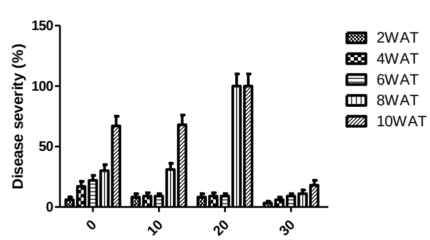

Figure 5: Effect of Manure rates on Fusarium wilt disease severity in 2019(t/ha)

Table 1: Main effect of season, manure type, and manure rates on fresh leaf weight of kale in 2019

Leaf fresh weight in kg (2019)					
Season	8WAT	10WAT	per plant	per plot	per ha
Dry	0.249	0.0310	0.280	2.52	25189.0
Rainy	0.204	0.0324	0.236	2.13	21278.0
F-LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
Manure type					
Piggery	0.164	0.0190	0.183	1.65	16474.0
Poultry	0.289	0.0445	0.333	3.00	29992.0
F-LSD (0.05)	**0.036**	**0.018**	**0.054**	**0.484**	**4836.1**
Manure rate (tonnes)					
0	0.134	0.0177	0.152	1.37	13695.0
10	0.232	0.0315	0.264	2.38	23760.0
20	0.266	0.0329	0.299	2.69	26872.0
30	0.273	0.0447	0.318	2.86	28605.0
F-LSD (0.05)	**0.059**	**0.015**	**0.072**	**0.647**	**6474.4**

Table 2: Main effect of season, manure type, and manure rates on fresh leaf weight of kale in 2020

Leaf fresh weight in kg (2020)					
Season	8WAT	10WAT	per plant	per plot	per ha
Dry	0.199	0.124	0.223	2.01	20059.0
Rainy	0.338	0.172	0.255	2.29	22922.0
F-LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
Manure type					
Piggery	0.226	0.086	0.200	1.80	17979.0
Poultry	0.310	0.110	0.278	2.50	25003.0
F-LSD (0.05)	**0.0426**	**0.0170**	**0.0515**	**0.464**	**4639.2**
Manure rate (tonnes)					
0	0.073	0.187	0.169	1.52	15218.0
10	0.135	0.350	0.238	2.14	21449.0
20	0.095	0.268	0.238	2.14	21449.0
30	0.088	0.268	0.304	2.74	27368.0
F-LSD (0.05)	**0.054**	**0.047**	**0.063**	**0.532**	**5321.0**

TABLE 3: Main effect of season, manure type, and manure rates on the disease incidence on leaves of kale

Disease incidence for weeks after transplanting (WAT) 2019										
Season	2		4		6		8		10	
Dry	11.11	(3.10)	15.00	(3.78)	17.78	(4.20)	37.78	(6.16)	79.44	(8.92)
Rainy	11.11	(3.10)	15.00	(3.78)	17.78	(4.20)	37.78	(6.16)	79.44	(8.92)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**
Manure type										
Piggery	6.11	(2.18)	17.22	(4.13)	22.22	(4.71)	30.56	(5.53)	67.78	(8.16)
Poultry	8.33	(2.74)	9.44	(2.80)	9.44	(2.80)	31.11	(5.58)	68.33	(8.21)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**
Manure rates (tonnes)										
0	6.11	(2.18)	17.22	(4.13)	22.22	(4.71)	30.56	(5.53)	67.78	(8.16)
10	8.33	(2.74)	9.44	(2.80)	9.44	(2.80)	31.11	(5.58)	68.33	(8.21)
20	8.33	(2.74)	9.44	(2.80)	9.44	(2.80)	100.00	(10.02)	100.00	(10.02)
30	3.33	(1.48)	6.67	(2.18)	9.44	(2.89)	11.11	(3.31)	18.89	(4.36)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**

Values in parenthesis are square root transformed values to which LSD is applicable. WAT = Weeks after transplanting.

TABLE 4: Main effect of season, manure type, and manure rates on the disease incidence on leaves of kale

Disease incidence for weeks after transplanting (WAT) 2020										
Season	2		4		6		8		10	
Dry	9.44	(2.96)	21.67	(4.62)	27.22	(5.22)	32.22	(5.67)	78.89	(8.89)
Rainy	11.11	(3.10)	15.00	(3.78)	17.78	(4.20)	37.78	(6.16)	79.44	(8.92)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**
Manure type										
Piggery	8.89	(2.82)	26.67	(5.11)	35.00	(5.88)	39.44	(6.28)	87.78	(9.36)
Poultry	11.11	(3.24)	18.89	(4.14)	22.22	(4.62)	43.33	(6.59)	90.56	(9.52)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**
Manure rates (tonnes)										
0	11.11	(3.24)	18.89	(4.14)	22.22	(4.62)	43.33	(6.59)	90.56	(9.52)
10	11.11	(3.24)	18.89	(4.14)	22.22	(4.62)	100.00	(10.02)	100.00	(10.02)
20	8.33	(2.61)	15.00	(3.74)	16.67	(3.94)	17.78	(4.15)	24.44	(4.95)
30	6.67	(2.32)	9.44	(2.96)	13.89	(3.54)	15.00	(3.75)	20.00	(4.39)
F-LSD (0.05)		**NS**		**NS**		**NS**		**NS**		**NS**

Values in parenthesis are square root transformed values to which LSD is applicable. WAT = Weeks after transplanting.

EFFECT OF NITROGEN APPLICATION ON THE GROWTH AND YIELD OF MAIZE (*Zea mays* L.) IN DADIN-KOWA, NORTH EAST NIGERIA

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ABSTRACT

This field trial was conducted in the 2023 growing season at the Teaching and Research Farm of the Federal College of Horticulture, Dadin-Kowa, Gombe State in the Sudan Savanna belt of Nigeria to determine the effect of nitrogen application on the growth and yield of maize (Zea mays L.) in Dadin-kowa, Gombe State. Four nitrogen levels and two maize varieties (SAMAZ-15 and SAMAZ-18) were used as factors, hence a two-factors Split-plot-experiment laid in a Randomized Complete Block Design (RCBD) with three replications. The Nitrogen (N) was applied at a varied rate of 0kg, 50kg, 100kg and 150kgha^{-1} in two split dozes, first doze at two weeks after sowing and second dose at the sight of first tassel, while Phosphorus (P) and Potassium (K) were applied once at two weeks after sowing at a constant rate of 50kg ha^{-1} respectively. The findings revealed that Nitrogen affected positively the performance of maize. The 50kgN, 100kgN and 150kgNha^{-1} all perform better than 0kg NPK (control). The plant height, number of leaf, stem girth, leaf area and grain yield gave higher performance values at 150kg N ha^{-1} than 100kg N ha^{-1}, but without any significant difference. The interaction between varieties and the fertilizer showed significant effect. The two maize varieties tested did not show any significant difference between them. Base on the findings of this study, therefore, it could be recommended that Nitrogen should be applied at the rate of 100kgha^{-1}.
Keywords: Nitrogen, Maize, Growth, Yield, Fertilizer

INTRODUCTION

Maize (Zea mays L.) is one of the most important cereal crops globally, providing food, feed, and industrial raw materials (FAO, 2022). It is a staple food for millions of people, especially in developing countries, and a crucial source of calories, proteins, vitamins, and minerals (Shiferaw et al., 2011). Maize provide over 20% of total calories to human diets in 21 countries and over 30% in 12 countries that are home to a total of more than 310 million's people (Shiferaw *et al* 2011), but forecast indicate that by the year 2050, the demand for maize in developing countries will double owing to the rapid growth in poultry industries, the biggest driver of growth in maize production. (Rosegrant *et al.*, 2009; Prasanna, 2014). In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018).

Yield decrease in the tropical areas, relative to the yield in the temperate area, is largely due to low nutrient status of tropical soils especially nitrogen, phosphorus and potassium as a result of wrong agricultural practices including slash and burn farming system associated with bush fallow in addition to excessive leaching of the soil nutrients occasioned by high rainfall (Adediran and Banjoko, 2003). It was generally observed that maize fail to produce good grain in plots without adequate nutrients (Adediran and Banjoko, 2003). Inorganic fertilizers exert strong influence on plant growth, development and yield (Stefano *et al*., 2004). The availability of sufficient growth nutrients from inorganic fertilizers lead to improved cell activities, enhanced cells multiplication and enlargement and luxuriant growth (Fashina *et al*., 2002).

The majority of savanna soils have been so depleted that growing most crops without fertilizer is nearly impossible (Kamara *et al.*, 2020). Decline in soil fertility in savanna regions, attributed to population pressure and low fertilizer use has rendered the soil unable to adequately support maize yields without proper fertilization (Kamara *et al.,* 2020). Soils deficient in both macronutrients, such as N, P, and K, as well as other key micronutrients such as copper and zinc cannot support maize yields adequately without proper fertilization (Kamara *et al.*, 2020). Nitrogen application rate of 100kgha^{-1} is required for maize in the Northern part of Nigeria (Kamara *et al.*, 2020). Maize yields below 1tonha^{-1} can occur without fertilizer use on poorly fertile soil (Kamara *et al.*, 2020). This study, therefore, seeks to determine the effect of nitrogen application on the growth and yield of maize and also to identify the optimal application rate that promotes resource efficiency to guide farmers in applying the right amount for maximum yield. Identifying this effective nitrogen rate will not only boosts agricultural productivity but also minimizes resource wastage, fostering sustainable farming practices.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa, located at latitude 11^{0}3' N, longitude 10^{0}2' E and altitude of 240m above sea level. Average annual rainfall in the study area is 1021.80mm, mostly distributed between the months of May and October, while the mean daily temperature ranges from 22^{0}C to 35^{0}C (UBRBDA, 2015). Two maize varieties were used for the experiment, SAMMAZ-15 and SAMMAZ-18 and were sourced from the Institute for Agricultural Research (IAR) Zara, Kaduna

State. The treatments used were four levels of nitrogen: T_1: 0kg N ha^{-1} N (control), T_2: 50 kg N ha^{-1}, T_3: 100 kg N ha^{-1} and T_4: 150 kg N ha^{-1} with 50 kg ha^{-1} P and 50 kg ha^{-1} K.

The experiment was a two-factor Split-plot laid in a Randomized Complete Block Design (RCBD). The field was divided into three Blocks each of which was divided into two Main plots. Each Main plot was further divided into four subplots. Each treatment was replicated three times, giving a total of twenty-four (24) experimental units/ plots. Each plot contained 48 stands of 1 plant per stand. The entire experimental field had a plant population of 1152 plants. The field was kept pest free throughout the trial period. The treatments (fertilizer) were applied in two split applications. The first dose - 50kg N ha^{-1}: 50kg P ha^{-1}: 50kg K ha^{-1} (sourced from NPK 15.15.15 fertilizer) was applied at two weeks after sowing. The second doses - 50kg N ha^{-1} and 100kg N ha^{-1} for T_3 and T_4 respectively (sourced from urea fertilizer) was applied at when the first tassel appeared. The application was by dollop method 5 cm away from the plant and at the depth of 5 cm. All application was done when the soil was moist.

Observations were made on bi-weekly basis on the growth parameters including: plant height, leaf number, stem gird and leaf area, and as well on yield parameters including: number of days to tasselling, number of days to fifty percent (50%) tasselling, number of cobs per plot, fresh cob yield, grain yield and thousand grain yield. All data collected were subjected to analysis of variance (ANOVA) using Genstat Release 10.3 Discovery Edition 4.0 software (GENSTAT, 2011). Treatment means were separated using Fishers' Least Significant Difference at 5% level of probability.

RESULTS AND DISCUSSION

The effect of nitrogen levels and varieties on maize plant height and number of leaves at 4, 6 and 8WAS is presented in Table 1. The results obtained showed that there was significant effect of the nitrogen on the maize plant height and number of leaves. All the three (3) rates of the nitrogen gave a significant effect across the observation periods (4, 6 and 8WAS) respectively as compared to control (0kg N ha^{-1}). At 8WAS, 150 kg N ha^{-1} produced the highest mean scores (233.30 cm) of plant height, while 100 kg N ha^{-1} produced a higher mean score (16.458) of number of leaves, but with no significant difference, statistically, between them. However, they both significantly performed better than 50 kg N ha^{-1}. SAMAZ-18 plots treated with 150 kg N ha^{-1} gave the highest scores. Moreover, the two tested varieties (SAMAZ-15 and SAMAZ-18) showed no significant difference between them. The result is in agreement with the reports from Stefano *et al.*, (2004) who stated that inorganic fertilizers exert strong influence on plant growth, development and yield. They also found that fertilizer application resulted in luxuriant growth with excessive leaves and higher number of leaves which contribute to a better canopy cover that result in weeds suppression. Fashina *et al.*, (2002 and Saeed *et al.*, (2001) reported that height of plant is an important growth character directly linked with the productive potential of plants in terms of grains; noting that the availability of sufficient growth nutrients from inorganic fertilizers lead to improved cell activities, enhanced cells multiplication and enlargement and luxuriant growth.

The effect of nitrogen levels and varieties on maize stem girth and leaf area at 4, 6 and 8 WAS is presented in Table 2. The results revealed that there was significant effect of nitrogen on the maize stem diameter and leaf area growth performance compared to the control (0kg N ha^{-1}). At 8 WAS, 150 kg N ha^{-1} showed no significant difference from 100 kg N ha^{-1}. The highest mean diameter scores were recorded at 6 WAS as there was decline in the mean stem diameter at 8 WAS, suggesting the transition from the growth phase to the reproductive phase, thus transferring greater part of the energy to the grain formation and development. The two varieties recorded no significant difference between them, but SAMAZ-18 plots treated with 150 kg N ha^{-1} gave a higher stem diameter and leaf area than SAMAZ-15. The results supported the claim from (Stefano *et al.*, 2004) who earlier from their findings reported that fertilizer application resulted in luxuriant growth with excessive leaves and higher number of leaves which contribute to a better canopy cover that result in weeds suppression.

The effect of nitrogen levels and varieties on maize yield parameters are presented in Table 3. The results showed a significant yield improvement as recorded (Table 3). The yield increased with increased rate of fertilizer. Fresh cob yield of 10.81 tons ha^{-1} and 11.86 tons ha^{-1} were recorded for 100 kg N ha^{-1} and 150 kg N ha^{-1}, respectively (Table 3). This is in consistent with the report by Adediran and Banjoko (2003) who earlier reported that the use of inorganic fertilizers on crops increased yield. They also observed in their experiment that there was substantial depletion of nutrients with the yields where no nitrogen was applied (Table 3). They also noted that maize fail to produce good grain in plots without adequate nutrients (as observed in Table 3). This position was equally reported by Uyovbisere *et al.*, (2000) who reported that there was substantial depletion of nutrients when no NPK fertilizer was applied and nitrates and available phosphorus were substantially reduced with cropping in humid zone of Southwestern Nigeria. Kolawole and Joyce (2009) reported that NPK 15-15-15 fertilizer increased significantly fresh cob yield and have a profound effect on the overall performance of maize. According to the findings of Babatola (2006), they reported that increasing level of fertilizer application increased growth and yield of crops. According to Kamara *et al.* (2020), opined that 100 kg N ha^{-1} is required for maize in the Northern part of Nigeria. Their report was confirmed by the finding of this study which revealed that there was no significant difference between 100 kg N ha^{-1} and 150 kg N ha^{-1}, even though 150 kg N ha^{-1} gave more grain yield (5.29 tons ha^{-1}) than 100 kg N ha^{-1} (4.91 tons ha^{-1}) (Table 3).

CONCLUSION

The study showed that maize yield was positively influenced by the application of Nitrogen, which increased with the increasing rates of the nitrogen up to the optimum level. Nitrogen application at the rate of $100kgha^{-1}$ is the optimum application rate that promotes resource efficiency and maximum yield in the study area.

REFERENCES

Adediran, J. A. and Banjoko V. A. (2003). Comparative effectiveness of some compost fertilizer formulations for maize in Nigeria. Nig. J. Soil Sci., 13:42-48.

Babatola, I. A. (2006). Effects of NPK 15:15:15 fertilizer on the performance and storage life of okra (*Abelmuschus esculentus*). Proceedings of the Horticultural Society of Nigeria Conference, pp. 125-128.

FAO. (2022). FAOSTAT. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/faostat/en/#data/QC

FAOSTAT, FAOSTAT statistics database, (2018). https://search.library.wisc.edu/catalog/999882363002121.

Fashina, A. S., Olatunji K. A. and K. O. Alasiri K.O. (2002). Effects of different plant population and poultry manure on yield of Ugu (Telfairia occidentalis) in Lagos State, Nigeria in Proceedings of the annual Conference of Horticultural Society of Nigeria (HORTON), pp. 123-127.

Kamara, A. Y, Kamai, N, Omoigui, L.O, Togola, A and Onyibe, J.E. (2020). Guide to Maize Production in Northern Nigeria: lbadan, Nigeria. Revised edition 2020. Publisher: International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria, 18 pp.

Kolawole, E. L and Joyce, E. L., (2009). The Performance of *Zea mays* as Influenced by NPK Fertilizer Application. Not Sci Biol 1, (1): 59-62.

Prasanna, B.M. (2014). Maize Research-for-Development Scenario: Challenges and Opportunities for Asia. Plenary Lectures, 12th Asian Maize Conference, Bangkok, Thailand, pp. 2-11.

Rosegrant M. R., Ringlerc-Sulser T. B., Ewing M. and Palazzo A, Z. (2009). Agriculture and food security under global change: prospect for 2025/2050 IFPRI, Washington DCS. Annu. Rev. Environ. Resource, 2009:34:205-222. arjournals.annualreviews.org

Saeed, I. M., Abbasi R. and Kazim M. (2001). Response of maize (Zea mays) to nitrogen and phosphorus fertilization under agro-climatic condition of Rawalokol, Azad Jammu and Kaslim and Kashmir, Pak. J. Biological Sci., 4: 949-952.

Shiferaw B, Prasanna B.M, Hellin J and Banziger M, (2011). Crops that feed the world.6 past successes and future challenge to the role played by maize in global food security. Food sec 3:307-327.

Stefano, P., Dris, R. and Rapparini, F. (2004). Influence of growing conditions and yield and quality of cherry. II. Fruit. J. Agric. And Env., 2:307-309.

UBRBDA (2015). Upper Benue River Basin Development Authority Dadinkowa, Annual Reports.

Uyovbisere, E. O., Chude V.O. and Bationo, O. (2000). Promising nutrient ratios in the fertilizer formulations for optimal performance of maize in Nigerian savanna. The need for a review of current recommendations. Nig. Soil Res., 1:29-34.

Table 1: Effect of Nitrogen and Varieties on Plant Height and Number of Leaves at 4, 6 and 8 WAS

Treatments	**Plant Height (cm)**			**Number of Leaves**		
Varieties	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
SAMAZ-15	75.08	159.30	220.30	6.812	7.833	16.042
SAMAZ-18	77.08	158.90	220.10	6.771	7.604	16.042
L.S.D. (<0.05)	5.320	11.95	18.74	0.766	1.186	1.763
NKP 15-15-15						
0kg NPK	63.08	142.90	204.20	6.083	6.833	15.357
50kg NPK	76.93	157.60	213.30	6.625	7.625	15.917
100kgN:50kgP & K	80.29	163.90	229.90	7.042	8.165	16.458
150kgN:50kgP & K	84.03	171.90	233.30	7.417	8.250	16.417
L.S.D. (<0.05)	6.019	13.19	9.68	0.543	0.562	0.446
Interaction (Variety X Fertilizer)						
L.S.D. (<0.05)	7.730	16.99	15.68	0.766	0.960	1.379

Key: WAS = Weeks After Sowing; LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; * = significant.

Table 2: Effect of Nitrogen and Varieties on Stem Diameter and Leaf Area at 4, 6 and 8 WAS

Treatments	Stem Diameter (cm)			Leaf Area (cm^2)		
Varieties	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
SAMAZ-15	22.81	24.30	22.96	531.70	802.80	847.80
SAMAZ-18	23.63	25.13	23.61	558.10	833.40	885.20
L.S.D. (<0.05)	3.162	2.904	2.471	183.01	57.02	82.52
NKP 15-15-15						
0kg NPK	19.94	22.05	20.96	459.10	728.80	772.70
50kg NPK	23.77	24.55	22.71	538.00	804.70	848.10
100kg N: 50kg P and K	24.15	25.28	24.69	562.70	836.40	906.60
150kg N:50kg P and K	25.01	26.97	24.79	619.70	902.50	938.80
L.S.D. (<0.05)	1.689	1.233	1.407	57.57	55.15	53.50
Interaction (Variety X Fertilizer)						
L.S.D. (<0.05)	2.685	2.280	2.164	139.85	72.31	77.77

Key: WAS = Weeks After Sowing; LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; * = significant.

Table 3: Effect of Nitrogen and Varieties on Number of Days to Tasseling, 50% Tasseling, Number of Cobs Plot^{-1}, Fresh Cob Yield, Grain Yield and Thousand Grain Yield of Maize.

Treatments	NDT	NDT 50%	Number of Cobs Plot^{-1}	FCY (tons/Ha)	Grain Yield (ton/Ha)	TGY (ton/Ha)
Varieties						
SAMAZ-15	44.67	49.17	25.58	9.05	4.05	0.442
SAMAZ-18	45.50	49.33	26.92	9.95	4.05	0.426
L.S.D. (< **0.05**)	3.187	0.949	4.041	1.237	0.767	0.075
NKP 15-15-15						
0kg NPK	46.50	49.67	23.33	6.98	3.07	0.406
50kg NPK	45.00	49.17	25.33	8.36	3.83	0.420
100kg N and 50kg P and K	44.67	49.00	27.67	10.81	4.91	0.450
150kg N and 50kg P and K	44.17	49.17	28.67	11.86	5.29	0.460
L.S.D. (< **0.05**)	1.519	0.593	2.730	1.066	0.687	0.014
INTERACTION (Variety X Fertilizer)						
L.S.D. (< 0.05)	2.586	0.875	3.909	1.427	0.913	0.062

Key: LS = Level of Significance; LSD = Least Significant Difference; NS = Not Significant; NDT = Number of Days to Tasseling; NDT 50% = Number of Days to 50% Tasseling; FCY = Fresh Cob Yield; TGY = Thousand Grain Yield; * = significant.

STUDIES ON PHYTOTOXICITY OF *TRIGODERMA*-BIOFORTIFIED COMPOST EXTRACTS AND THEIR FUNGICIDAL EFFECTS AGAINST *Fusarium oxysporum* f. sp. *lycopersici* CAUSING FUSARIUM WILT OF TOMATO

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ABSTRACT

In-vitro experiment was carried out in Crop Pathology laboratory of the Department of Crop Protection, Bayero University, Kano to evaluate the fungitoxic and phytotoxicity effect of three compost extracts COM A (20% poultry droppings and 80% cow dung), COM B (13% poultry droppings and 87% cow dung) and COM C (7% poultry droppings and 93% cow dung) using percentage inhibition and seed germination test as a tool for evaluating the fungitoxic effect and phytotoxicity in compost extracts used respectively. The experiment was laid in a complete randomized design. All the data collected from the experiment were subjected to analysis of variance using Genstat 17th edition and means were separated using LSD at 5% level of significance ($P \leq 0.05$). The physicochemical properties of the compost used in the experiments was determined, and found to be rich in organic matter, organic carbon and nutrients that influence beneficial microbial populations and activity. The result of the fungitoxic effect of the compost extracts showed; least radial growth of the pathogen (4.8) and highest percentage inhibition 27.0 was obtained on plates treated with COM A compared to the other compost extracts. For the phytotoxicity effect, the number of germinated seed were counted in each compost extracts and the root length of the seedling were measured. Germination index, Seed Germination Percentage and Root Germination Percentage were computed. All the compost extracts had germination index greater than 100 and indicates a beneficial effect on seed growth and proved matured compost
Keywords: Compost extracts, seed germination, phytotoxicity, germination index, percent-inhibition

INTRODUCTION

Tomato is one of the most important and economic horticultural crop cultivated worldwide (Baysal *et al.* 2015). The crop is considered as “poor man’s Orange” due to its attractive appearance and nutritive value. Moreover, tomato is one of the most widely cultivated vegetable, with high economic value (Waheed *et al.*, 2015). Despite the economic and nutritional values of the crop its production is threatened by several pests and diseases, among which is Fusarium wilt endemic in the study area (Haruna *et al*., 2011).

Fusarium wilt of tomato is caused by soil borne plant pathogen *Fusarium oxysporum* in the class Hyphomycetes. It is among the most significant diseases of tomato in both field and control environment (Abdel-Monaim, 2012, Amino *et. al.*, 2017). Most of the chemical’s farmers are using against fungal pathogens are not readily biodegradable, and tend to persist over years in the environment leading to the development of new physiological races of the pathogens (Dwivedi and Neetu, 2012). The current trend to near zero-market tolerance for pesticide residues in fresh leafy vegetables provides an additional motivation to search for non-chemical means to control pests and diseases (Reuveni *et al.,* 2002). This led to urgent need for development of sustainable control measure, using organic compost which is mostly economically feasible and eco-friendly than conventional fungicides and at the same time adding more fertility to the soil to improve the growth and yield of tomato plants and it tends to reduce parasites and suppresses soil borne plant pathogens (Larney and Hao 2007; Mehta *et al*., 2014).

Phytotoxicity in compost is a delay in germination of seed and inhibition of plant growth or presence of phytotoxins and inadequate growth conditions (Baumagarten and Spiegel, 2004). It is one of the most vital criteria in assessing compost quality and sustainability for agricultural purposes and it assess the stage of the composting process that has been achieved and was introduced by Zucconi *et al.* (1985). Germination index (GI) is the combination of the relative measures of seed germination (SG) and root elongation (RE) and it has been used to test the phytotoxicity of compost (Wong *et al*., 2001). The objective of this research is to evaluate the phytotoxicity effects of the composts used on tomato seeds and the suppressiveness and effectiveness of the extracts on the pathogen causing Fusarium wilt.

MATERIALS AND METHODS

Experimental Sites: The experiment was carried out in Pathology Laboratory of the Department of Crop protection, Bayero University Kano.

Preparation of composts and compost extracts

Three composts were made from cow dung and poultry manure, namely; Compost A (80% cow dung: 20% poultry droppings), Compost B (87% cow dung: 13% poultry droppings), Compost C (93% cow dung: 7% poultry droppings). The three composts were separately produced in three different compost pits. Animal manures in the three pits were watered to saturation, covered with sack to rise the temperature and subjected to decomposition for sixty (60) days, the compost were turned every two (2) weeks for the materials to be mixed evenly. Compost extracts were prepared following the procedures described by Gurama *et al*. (2011) and Haruna *et al.* (2012). One kilogram (1kg) of compost was mixed with 5 liters (5L) of water in a container, the mixture were stirred and left undisturbed for 7 days at 15-25 ºC. Finally, the mixture was filtered to obtain the extracts.

Determination of Physico-chemical Properties of the Composts

Two hundred and fifty grams (250 g) from each of the three composts were collected and air-dried and subjected to analyses. The pH and Electrical conductivity of the composts were determined as described by Chandrabose *et al.* (1988). Samples (30 g) were air-dried and were passed through a 2mm sieve and were transferred to 100 mL beaker to which 60 mL of distilled water was added and contents vigorously stirred for one minutes. The electrode was immersed into the meter and readings were recorded. Electrical conductivity was measured and expressed in millisimens/cm (mS/cm). Fifty milliliters of distilled water was added to 5g of the composts and stirred for 30 minutes. After stirring, the suspension was allowed to settle for eight hours and readings were recorded.

Total N was determined using Kjeldahl method (Bremner and Mulvaney, 1982), while organic matter was estimated by Walkley and Black method (Nelson and Sommers, 1982). Exchangeable cations (Ca, Mg, and K) were measured with the atomic absorption spectrophotometer (Wright and Stuczynski, 1996). Ammonium nitrogen and nitrate nitrogen was also determined. Five grams (5g) of air-dried bio-enriched vermicomposts was mixed with 50 mL each of KCl and water, vigorously shaken for 45 minutes and then filtered. The concentration of ammonium-nitrogen and nitrate-nitrogen in the filtrates was measured by the indol-phenol method according to Mulvancy (1996).

Fungitoxic Test

To test the fungitoxic effect of the composts, the experiment was laid in a completely randomized block design (CRD), consisting of 5 treatments; 3 compost extracts (COM A, COM B and COM C), Ridomil gold as check and distilled water as control (DW). The treatments were replicated 4 times. Seven days old mycelia of *Fusarium oxysporum* f. sp. *lycopersici* was used, where a 6mm plug of the culture was removed and placed on molten potato dextrose agar amended with chloramphenicol (antibiotic) at 0.5mg concentration per liter of molten Potato Dextrose (PDA) to suppress bacterial growth. A total of 20 petri dishes were used in this experiment (4 dishes each for the 5 treatments). Three drops of each compost extract were added to a petri dish after inoculation respectively and three drops of distilled water was added as control. The dishes were covered and sealed to prevent contamination (Haruna *et al*., 2011) and was incubated at room temperature (28 ±2 ºC) for eight (8) days. The mycelia growth of the pathogen was measured at 2, 4, 6 and 8 days to evaluate the pathogen progressive growth. Percentage growth inhibition was calculated using a formula by (Rini and Sulochana; 2007).

$$PI= \frac{C-T}{C} \times 100$$

Where: - PI = Percent inhibition

C = Mycelia growth of pathogen in control plates (cm)

Phytotoxicity Test

In the phytotoxic test conducted, the treatments consisted of the three (3) compost extracts and water as control as which was laid in a Completely Randomized Design (CRD) and were replicated three times. The Phytotoxicity test of the compost extracts was carried out using seed germination test. Ten (10) mL of each compost extract was applied to a filter paper in separate petri-dishes and twenty (20) tomato seeds were placed on the filter paper for 7 days. The petri dishes were sealed to minimize water loss while allowing air penetration and was incubated at room temperature (28 ±2 ºC) for 7days. Seed germination percentage and root length of the seedlings and germination index (GI) were computed using the following formulas (Tiquia *et al*., 1996).

$$\text{Seed Germination percentage (SGP)} = \frac{\text{number of seed germinated in compost extracts}}{\text{number of seed germinated in control}} \times 100$$

$$\text{Root elongation percentage (REP)} = \frac{\text{root length in compost extracts}}{\text{root length in control}} \times 100$$

$$\text{Germination index (G.I)} = \frac{SGP \times REP}{100}$$

Data analysis

Data collected from the study were subjected to analysis of variance (ANOVA) using Genstat17th edition and means were separated using Students' Newmans Keul (SNK) at 5% level of significance ($P \leq 0.05$).

RESULTS

Table 1 indicates the result of the physicochemical analysis of the compost carried out and it showed the presence of high amount of ammonium, nitrate, organic carbon, phosphorous, potassium C: N, and some beneficial compounds. The pH of all the compost is slightly alkaline ranging from 8.2 (COM C), 8.5 (COM B) and 8.6 (COM A).

Table 2 results shows the effect on the compost extracts on mycelia growth of *Fusarium oxysporum f. sp lycopersici*. All the compost extracts tested significantly ($P\leq0.05$) inhibits the mycelia growth of the pathogen compared with the control (6.8cm). All the compost reduced the mycelia growth similarly with no significant difference amidst them.

Significant difference ($P\leq 0.05$) in the phytotoxicity test conducted with the compost extracts on seed germination, root elongation and germination index was observed (Table 3). All the compost extracts used significantly had higher germination percentage than control (62.1%). Higher germination percentage (127.1%) was recorded in COM A followed by COM C, although it doesn't varied significantly with COM B on root elongation percentage (REP) and germination index (GI) and Seed germination percentage (SGP).

DISCUSSION

The result of physicochemical properties of the three compost used as (C:N, NH_4, NO_3, pH, EC, total organic carbon, phosphorous, potassium and total nitrogen). The C:N ratio of the compost ranges from 16.3:1- 16.5:1; the highest ratio 16.5 is found in COM A and the lowest 16.3 is that of COM C this coincided with the result reported earlier by (Rosen *et al*., 1993) that a matured and ready to use compost's C:N ratio ranges from 15:1-20:1. The three compost were rich in a readily available form of NH_4 and NO_3 for plant up take hence will enhance plant growth and increases the resistance of the plants, Hoffland *et al.*, (2000) also reported that high NO_3^-decreases Fusarium wilt severity. The compost had high organic matter, organic carbon and nutrients that influence beneficial microbial populations and activity as reported by Butler *et al.*, (2001) and Wu and Ma (2001) that most compost relatively contain high organic matter and organic carbon and nutrients that support microbial populations and activity.

The result of the *in-vitro* experiment showed positive fungitoxic effects of all the compost extracts as they inhibited the mycelia growth of *Fusarium oxysporum* than control. This is in agreement with a report by Kerkeni *et al*., (2008) that there is an important decrease in the mycelial growth of *Fusarium oxysporum* f. sp. *radisis-lycopersici* using animal manure compost. Similar research disclosed the reduction in *Phythium amphanidermatum's* mycelia growth on tomato by compost extract made from animal manure (Bernal *et al*., 2009). COM A had the highest percentage inhibition this can be due to the presence of other antagonistic fungi as Suare-Estrella *et al.*, (2007) reported the isolation of fungal strains with antagonistic effects on *Fusarium oxysporum* f.sp *melonis* and can also be the presence of some chemicals that might inhibit the growth of the pathogen. In another finding, Ros *et al*., (2005) reported that two mechanisms can be attributed to pathogen suppressiveness by compost which is either mycoparasitism or production of microbial antibiotic.

The result of the compost phytotoxicity test as showed in table 3 indicated all the compost extracts had germination index greater than 100% which is in line with (Doncean *et al.*, 2013) that a germination index value greater than 100% indicate beneficial effect on seed growth and proved a mature compost. It is in accordance with Zucconi *et al.*, (1985) and Emino and Warman (2004) that Germination index (GI) values lower than 50% indicate high phytotoxicity; values from 50% to 80% indicate moderate toxicity; and values greater than 80% indicate the absence of phytotoxicity. Wong *et al*. (2001), suggests that phytotoxicity elimination has been widely used for compost maturity, also Zucconi *et al.*, (1981) reported that a GI values greater than 80% described phytotoxic-free and mature compost. When GI exceeds 100%, the compost can be considered a phytonutrient or phytostimulant.

CONCLUSION

From the result of this experiment it was concluded that compost extracts are rich in primary and secondary minerals needed for plant growth, exhibit fungitoxic effect on *Fusarium oxysporum* f. sp. *lycopersici* with COM A (20% poultry droppings and 80% cow dung) having the highest percent inhibition of 27%. The experiment also highlighted the negative phytotoxicity effects on tomato seeds.

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REFERENCES

Baumagarten, A. and Spiegel, H. (2004). Phytotoxicity (plant tolerance), Horizontal 8, http://www.ecn.nl/docs/society/horizontal/hor8_phytotoxicity.pdf.

Baysal, O., Karaaslan, C., Siragusa, M., Alessandro, R., Carimi, F., De-Pasquale, F., and Teixera-da, S. J.A (2013). Molecular markers reflect differentiation of *Fusarium oxysporum* f. sp. on tomato and eggplants. *Biochemical Systematic and Ecology*, 47: 139-147

Bernal, M. P., Alburquerque, J. A., Moral, R. (2009). Composting of animal manures and Chemical criteria for compost maturity assessment. *Annual Rev. Bioresource Technology,* 100: 5444-5453.

Bremner, J. M. And Mulvancy, C. S. (1982). Nitrogen Total. ***In***: Page, A. L., Miller, R. H., Keeny, D. R. (Eds.), **Methods of Soil Analysis Part 2**. Chemical and Microbial Properties. Pp 592 – 641.

Butler, T.A., Sikora, L.J., Steinhilber, P.M., Douglas, L.W. (2001). Compost age and sample Storage effects on maturity indicators of biosolids compost. *Journal of Environmental Quality*, 30:2141-2148.

Chandrabose, M.S., Natarajan, S. and Selvakumari, G., (1988). **Methods of soil analysis**. Book World Publications, pp. 1-102.

Doncean, A., Sumalan, R., Beisan, C., Sumalan, R. (2013). Seed germination and seedling growth of as tomato affected by different types of compost water extracts. *Journal ofHorticulture, Forestry and Biotechnology*, 17(1): 155-160

Dwivedu, S. K. and Neetu, D. (2012) antifungal activity of some plant extract against guava wilt pathogen. *International Journal of Environmental Sciences,* 3(1):412-417

Emino, E. R and Warman, P. R (2004). Biological Assay for Compost Quality. Compost Science and Utilization, 12: 342-348.

Foolad, M. R. (2007). Genome mapping and molecular breeding of tomato. *International Journal of Plant Genomics*. https://doi.org/10.1155/2007/64358

Gurama, A. U., Haruna, S. G. and Adebitan, S. A. (2012). Field evaluation of compost extractsfor the suppression of *Fusarium* wilt of tomato of tomato caused by *fusariumoxysporum*. *International Journal of Agronomy and Agricultural Research* (IJAAR), 2 (4):7-17.

Haruna , S. G., Adebitan, S. A., Gurama, A. U., Abubakar, B. and Dawakiji, A. Y. (2011). *In vivo* efficacy of compost extracts at different concentrations on *Fusarium* wilt of tomato. *Journal of Phytopathology and Plant health*, 1: 32-39.

Hoffland, E., Jerger M. J., van Beusichem M. L. (2000). Effect of nitrogen supply rate on disease Resistance in tomato depends on pathogen. *Journal of Plant and Soil*, 218: 239-247

Kerkeni, A., Daami-Remadi, M., Tarchoun, N., Mohammed, B. K. (2008). Effects of bacterial isolates obtained from animal manures compost extracts on the development of *Fusarium oxysporum*F.sp. *radisi-lycopersici*. *Asian Journal of Plant Pathology,* 2(1): 15-23

Larney, F. J., Canada, A., Hao, X., & Canada, A. (2007). A review of composting as a management alternative for beef cattle feedlot manure in southern Alberta , Canada. *Journal of Biotechnology*3–7.https://doi.org/10.1016/j.biortech.2006.07.005.

Mehta, C. M., Palni, U., Franke-Whittle, I. H. and Sharma, A. K. (2014). Compost: Its role mechanism and impact on reducing soil-borne plant diseases. *Waste Management*, *34*(3), 607–622. https://doi.org/10.1016/j.wasman.2013.11.012

Nelson, D. W. And Sommers, L. S. (1982). Total carbon, organic carbon and organic matter ***In***:Page, A. L., Miller, R. H., Keeny, D. R. (Eds.), **Methods of Soil Analysis Part 2**. Chemical and Microbial Properties. Pp 539 – 579.

Reuveni, R., Raviv, M., Krasnovsky, A. Freiman, L., Medina, S., Bar, A. and Orion, D. (2002). Compost induces protection against *Fusarium oxysporum* in sweet basil. *Journal of Crop protection*, 21: 583-587.

Ros, M.; Hernandez, T.; Garcia C., Bernal, A. and Pascual, J.A. 2005. Biopesticide effect of green compost against fusarium wilt on melon plants. *Journal for Applied Microbiology*, 98:845- 854.

Singh, V. K., Singh, A. K., and Kumar, A. (2017). Disease management of tomato through PGPB: current trends and future perspective. *Journal of Biotechnology*, *7*(4). https://doi.org/10.1007/s13205-017-0896-1.

Suarez-Estrella, F., Vargas-Garcya, C., Lopeza,M. J, Capelb, C., Morenoa, J. (2007). Antagonistic activity of bacteria and fungi from horticultural compost against *Fusarium* *oxysporum* f.sp. *melonis*. *Crop protection*, 26: 46-53

Tiquia, S.M., Tam N.F.Y., Hodgkiss, I.J. (1996). Microbial activities during composting of spent Pig-manure sawdust litter at different moisture contents. *Journal of Bio-resource technology* 55:201-206. https://doi.org/10.106/0960-8524(95)-6

Waheed, A., Hamid, F. S., Ahmad, H., Abbassi, F. M., Aslam, S., Shah, A. H., Ahmad, N., Naheed, Z., Ali, H., and Khan, N. (2015). Effect of Indole Butyric Acid (IBA) on early Root formation (Tomato "Sahil" hybrid) cuttings. *Journal of Materials and Environmental Science*, *6*(1), 272–279.

Wong, J. W. C., Mak, K. F., Chan, N. W., Lam, A., Fang, M. and Zhou, L. X (2001). Co-Composting of soybeans residues and leaves in Hong Kong. *Bioresource Technology*, 76: 99-106.

Wright, R. J. and Struczynski, T. (1996). Atomic Absorption and Flame Emission Spectrometry. Pages 65 – 90 ***In***: D. C. Sparks (Ed) **Methods of Soil Analysis,** Soil Science of America, Inc. Madison, W. J.

Wu, L. and L.Q Ma. 2002. Relationship between compost stability and extractable organic carbon. *Journal of Environmental Quality*, 30: 222-228.

Zucconi, F., Monaco, A., Forte, M., De Bertoldi, M. (1985). Phytotoxins during the stabilization of organic matter. In: Composting of Agricultural and other wastes, pp. 78-85. Gasser J.K.R. (ed.). Elsevier, London.

Table 1: Physicochemical properties of the compost used in the experiments

Parameters	**Soil**	**COM A**	**COM B**	**COM C**
PH	7.10	8.60	8.50	8.20
EC (ds m^{-1})	23.20	4.90	5.00	5.20
Ca^+(meql^{-1})	82.50	17.50	17.30	17.10
Mg^+(meql^{-1})	51.70	13.70	13.20	13.0
Na^+(meql^{-1})	90.50	22.30	21.70	21.40
K^+(meql^{-1})	1.50	3.30	3.10	3.00
OC (g kg^{-1})	25.60	58.40	58.20	57.5
TN (g kg^{-1})	2.70	3.55	3.53	3.52
P (%)	0.50	1.57	1.54	1.51
NH_4^+(mg kg^{-1})	0.91	29.50	29.30	29.10
NO_3^+(mg kg^{-1})	73.40	129.30	127.50	127.0
C/N	9.48	16.50	16.40	16.30

Table 2: Fungitoxic effects of compost extract on mycelia growth and percent inhibition of *Fusarium oxysporum* at 2, 4, 6 and 8 days after inoculation

Treatment	2DAI		4DAI		6DAI		8DAI	
	MG (cm)	P.I (%)	MG (cm)	P.I (%)	MG (cm)	P.I (%)	MG (cm)	P.I (%)
COM A	2.9^b	26.6^b	4.5^b	21.6^b	4.7^b	24.9^b	4.8^b	27.0^b
COM B	3.3^b	16.0^b	4.6^b	16.3^b	5.0^b	22.8^b	5.5^b	18.9^b
COM C	3.4^b	23.5^b	4.6^b	18.0^b	4.8^b	24.8^b	5.3^b	20.9^b
Ridomil	2.2^c	42.7^a	2.3^c	58.0^a	2.5^c	59.9^a	2.7^c	59.9^a
CONTL	4.0^a	0.0^c	5.6^a	0.0^c	6.4^a	0.0^c	6.8^a	0.0^c
SE±	0.17	3.46	0.16	2.92	0.27	4.04	0.25	3.35

Means with a superscript of same letters within a column are statistically similar at 5% level of significant ($P\leq 0.05$) using Student Newman-Keuls (SNK) test. COM A= (20% poultry manure + 80% cow dung), COM B= (13% poultry manure + 87% cow dung), COM3= (7% poultry manure + 93% cow dung), CONTL= Control. Ridomil Gold® = (80% Mancozeb WP) MG =mycelial growth, PI= percentage inhibition, DAI= days after inoculation**,** NS= No Significant difference

Table 3: Phytotoxicity effect of compost extracts on seed germination percentage, root elongation percentage and germination index

Treatment	SGP1	SGP 2	SGP 3	REP1	REP 2	REP 3	GI 1	GI 2	GI 3
COM A	113.0[a]	118.7[a]	127.1[a]	186.8[a]	181.2[a]	188.2a	189.9[a]	196.8[a]	199.1[a]
COM B	96.7[b]	103.6[b]	108.0[b]	132.8[b]	145.0[b]	156.3b	166.2[b]	152.2[b]	162.8[b]
COM C	85.4[b]	88.8[b]	96.2[b]	119.0[b]	125.6[bc]	134.6bc	148.7[bc]	155.3[b]	165.6[b]
CONTL	47.5[c]	55.9[c]	62.1[c]	64.1[c]	74.1[d]	81.0d	85.6[e]	88.2[c]	91.7[c]
SE±	4.25	3.73	3.86	8.16	7.46	8.20	5.67	8.18	7.21

Means with a superscript of same letters within a column are statistically similar at 5% level of significant ($P \leq 0.05$) using Student Newman-Keuls (SNK) test.COM A= (20% poultry manure + /80% cow dung), COM B= (13% poultry manure + 87% cow dung), COM3= (7% poultry manure + 93% cow dung), CONTL= Control. SGP=Seed germination percentage, REP = Root elongation percentage, GI = Germination index.

EFFECT OF PRIMARY NUTRIENTS APPLICATION ON THE GROWTH AND YIELD PARAMETERS OF WHITE MUSTARD (*Sinapis alba* L.) PLANT IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

The experiment was conducted in the screen house of the Center for Dryland Agriculture, Bayero University, Kano (Latitude 11.9765^{0}N and ^{L}ongitude 8.42483^{0}E) to study aimed to investigate the effects of different levels of NPK fertilizer on the growth and yield of white mustard plant. The parameters examined included plant height, leaf development, and yield parameters. The results revealed that the impact of NPK fertilizer on plant height varied over time, with the highest rates of 80.0 kg ha^{-1} and 40.0 kg ha^{-1} resulting in significantly taller plants compared to the control group. However, no significant differences were observed in leaf development among the fertilizer rates. In terms of yield parameters, higher rates of NPK fertilizer led to increased root number, fresh weight, and dry weight, while other parameters such as the number of branches, chlorophyll content, and root length did not differ significantly. These findings suggest that higher levels of NPK fertilizer can positively influence plant height, root development, and overall biomass production of white mustard plant. The results contribute to the existing knowledge on the role of NPK fertilizer in crop production and provide valuable insights for farmers and agricultural practitioners aiming to optimize the growth and yield of white mustard plant. It is recommended to utilize NPK fertilizer, particularly at higher levels, to enhance the growth and yield of white mustard seeds, considering multiple factors for a comprehensive approach to cultivation.
Keyword:

INTRODUCTION

White mustard (*Sinapis alba* L.) is an annual herb that is native to the Mediterranean region but now widely cultivated throughout the world (Ma, 2013). The seeds are a rich source of oil and protein (Kumar & Gupta, 2015) and contain high levels of sinapine, a compound that gives mustard its characteristic pungency (Wang & Wang, 2017). The seeds are also a good source of minerals such as potassium, calcium, and iron (Kumar & Gupta, 2015). The seeds are traditionally used for medicinal purposes to treat various ailments including rheumatism, respiratory disorders, and skin diseases (Tiwari and Sharma, 2011). Another study by Kaur et al (2013) found that the methanolic extract of white mustard seed has antioxidant properties, and it can scavenge free radicals and reduce the risk of cancer. The study also reported that the extract has antibacterial activity against various bacterial strains such as E. coli, S. aureus, and P. aeruginosa. Nitrogen is a crucial component of amino acids and proteins, which are essential for plant growth and structure. It promotes leaf and stem development, resulting in healthier and more robust plants (Carvalho *et al.,* 2020). Similarly, the white mustard plant require an adequate supply of phosphorus for optimal root system establishment. Phosphorus supports root growth by stimulating cell division and elongation, enabling the plant to efficiently absorb water and nutrients from the soil (Khan *et al.*, 2019). Research by Hussain *et al.* (2018) demonstrated that phosphorus fertilization positively influenced the growth and yield of white mustard seeds. The application of phosphorus fertilizer resulted in increased plant height, number of branches, flower production, and seed yield. White mustard seeds require an adequate supply of potassium for maintaining water balance within the plant. Potassium regulates the opening and closing of stomata, which helps in controlling water loss through transpiration. This osmoregulatory function ensures that white mustard plants can efficiently manage water uptake and utilization (Zhu *et al.*, 2020). Furthermore, potassium is involved in enzyme activation and metabolic processes within the plant. It plays a critical role in the activation of various enzymes required for photosynthesis, protein synthesis, and carbohydrate metabolism. Potassium is also involved in the translocation of sugars and other nutrients from source to sink, promoting efficient seed filling and maturation (Hafsi *et al.*, 2017).

The application of NPK fertilizers has been reported to improve the quality of plants. Kim *et al.* (2021) found that the application of NPK fertilizers increased the sugar content and vitamin C levels in strawberry fruits. Additionally, NPK fertilizers can help to improve the nutritional value of crops, such as increasing the protein content of cereal grains (Li et al., 2020). Ahmed *et al.* (2015) reported that the application of NPK fertilizers improved growth, yield, and oil content of white mustard. Pandey *et al*. (2019) found that the application of NPK fertilizers improved the growth, yield and oil content of white mustard. This study aims to explore the impact of NPK fertilizers on the growth and yield parameters of white mustard plant, as well as assess its adaptability to the savannah regions of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the screen house of Center for Dryland Agriculture (CDA) Annex Bayero University Kano (latitude 11.97650N, longitude 8.424830E) in the Sudan savannah region during the dry season of 2021/2022. The experimental design used was completely randomized design (CRD) with five treatments and five replications, giving a total of 25 pots arranged in random position within the screenhouse. The pots were filled with sandy loam top soil, that was crushed and sieved into fine particles, weighing 5.45kg per pot. Each pot was thoroughly watered to field capacity before planting. All preparations and maintenance operations regarding the conduct of the experiment were uniform. The white mustard seeds were sown first in nursery using drilling method and then transplanted after two weeks into the 25 pots with a single stand of plant per pot. The pots were irrigated at an interval of three days using watering can and manually kept relatively weed free through hand pulling as they emerge throughout the growing period. Data were collected at an interval of two weeks for two months on parameters like plant height (cm), number of branches, number leaves, chlorophyll content, days to 50% flowering, number of roots, length of roots (cm), fresh weight (g), and dry weight (g). The plant height was measured using ruler from the base of the main stem to the highest tip of the plant at two weeks interval and recorded in cm. The chlorophyll content of the plant was recorded using SPAD meter, while the number of branches of the plant were counted manually and recorded. The plant fresh weight(g) was taken using sensitive weighing scale immediately after harvesting, while the dry weight(g) was taken after oven drying for 48 hours (2 days). The data collected were subjected to analysis of variance (ANOVA) using GENSTAT version 16. Significant means were separated using Student Newman Keuls' (SNK) test.

RESULTS AND DISCUSSION

Plant Height (cm)

The effect of NPK on the plant height of white mustard was found not to be significant between the application rates of 20,40,60 and 80 kgha^{-1}, but all of these applied rates vary significantly with the control (Table 1). However, even though significant difference was not observed at two, six and eight weeks after sowing an unusual trend was observed with the applied treatment of 40kgha^{-1} having the highest plant height (80.4 cm) and control having the lowest (39.6 cm).

Generally, there was a linear response portrayed by Table 1 with respect to plant height with increased primary nutrients application. These findings are consistent with previous research studies that have reported a positive effect of NPK fertilizer on plant height in various plant species (Smith *et al.*, 2018; Johnson *et al.*, 2020). Primary nutrients are reported to be essential for root, leaf, and stem growth and development by their improvement of photosynthetic efficiency, water-use efficiency, metabolic activity, and increased minerals content.

Number of Leaves

The result obtained from all weeks of data collection indicates no significant difference throughout the table (with p-value greater than 0.05). Implying that number of leaves were not affected by the levels of treatments applied (Table 2). The number of leaves did not show any significant differences among the different NPK fertilizer rates, implying that the primary nutrients did not portray a significant impact on leaf development in white mustard with varying application levels. These results are in line with a study conducted by Brown and Jones (2019), which found no significant effect of NPK fertilizer on leaf number in a similar plant species.

Number of Branches

The highest mean number of branches (3.40) recorded at a fertilizer rate of 40.0 $kgha^{-1}$ is not statistically significant among the tested NPK fertilizer rates for the white mustard plant (Table 3). This suggests that NPK fertilizer rates did not have a significant effect on the number of branches of white mustard plants in this study.

Number of Roots

Table 3 presents the effect of NPK fertilizer rates on the number of roots of white mustard plant. The highest number of roots (8.00) was recorded at the 80.0 kg ha^{-1} fertilizer rate, while the lowest number of roots (4.40) was observed in the control group with no fertilizer application. There is a significant difference in the number of roots of white mustard plants among the tested NPK fertilizer rates. Sufficiency of the primary nutrients, especially phosphorus plays a crucial role in promoting root growth and elongation. The phosphorus is reported to be essential for the formation of new roots and for the development of a well-branched root system (Lynch, 2011). It is also involved in energy transfer and storage within plants.

Root Length

The result obtained indicates no significant difference ($p > 0.05$), implying the root length remains statistically the same irrespective of treatments (Table 3).

Fresh Weight

Table 3 displays the fresh weight observed for the different primary nutrients rates. The highest fresh weight (51.7) was observed with a treatment application rate of 80.0 kg ha^{-1}, while the lowest fresh weight (21.6) was observed in the control. Significant difference was observed between the control and the treatment applications in the fresh weight of the white mustard plants, indicating that the fertilizer rates had a significant impact on the growth and development of white mustard plants in terms of fresh weight.

Dry Weight (g)

There is a significant difference in the dry weight of white mustard plants among the tested primary nutrients rates. The highest dry weight (10.52) was observed at the 80.0 $kgha^{-1}$ fertilizer rate, while the lowest dry weight (2.42) was observed in the control group with no fertilizer application (Table 3). The data suggests that the application of NPK fertilizer had a significant effect on the dry weight. The highest dry weight was observed at the 80.0 kg/ha fertilizer rate. The observed differences in dry weight are statistically significant at the given significance level, indicating that the fertilizer rates had a significant impact on the growth and development of white mustard plants in terms of dry weight. The positive impact the primary nutrients have on the growth and yield components of the mustard seed plant could be attributed to their ability in improving photosynthetic efficiency, root growth and metabolism, development of root hairs, uptake of nutrients (Marschner, 2012), cell division (Lynch, 2011), maintaining hormonal balance (Shabala, 2017), and promoting leaf and stem development (Carvalho *et al.*, 2020).

CONCLUSION

The research findings indicates that primary nutrients have significant impact on most growth parameters of white mustard, such as plant height, number of roots, fresh weight, and dry weight. The findings contribute to the existing body of knowledge on the role of primary nutrients in crop production and can be useful for farmers and agricultural practitioners seeking to optimize the growth and yield of white mustard seeds.

REFERENCES

Ahmed, S., et al. (2015). Effect of NPK fertilizers and irrigation on growth, yield, and oil content of white mustard (*Sinapis alba* L.). *International Journal of Agronomy*, 2015, 1-6.

Carvalho, S. I. C., Pereira, I. J. M., Ribeiro, A. C., de Oliveira, I. S., Chaves, T. V., Soares, A. A., de Sousa, V. A., Costa, F. M. M., Souto, L. S., & Costa, T. G. (2020). Nitrogen l evels in white mustard cultivation. Semina: Ciências Agrárias, 41(3), 1131-1140.

Hafsi, C., Romero-Aranda, R., & Míguez-Soto, B. (2017). Potassium in plants: A review. *The Scientific World Journal*, 2017, 1-27.

Hussain, S., Shahid, M., Rizwan, M., Imran, M., Pervaiz, Z. H., Ashraf, F., & Rinklebe, J. (2018). Phosphorus nutrition of crop plants: Achievements and challenges. In Phosphorus in Agriculture: 100 % Zero (pp. 159-191). Springer.

Kaur, G., et al. (2013). In vitro antioxidant and antibacterial activities of methanolic extract of Sinapis alba seeds. *Asian Journal of Pharmaceutical and Clinical Research*, 6(3), 74-78.

Khan, R., Khan, M. Z., Saleem, M. F., Raza, A., Iqbal, M., Riaz, M., & Shahid, M. (2019). Phosphorus bioavailability, uptake, and utilization by plants: Mechanisms and future prospects. In Soil Remediation and Plants (pp. 105-125). Elsevier.

Kim, S., et al. (2021). Effects of NPK fertilizers on sugar content and vitamin C levels in strawberry fruits. HortScience, 56(4), 506-512.

Kumar, V., & Gupta, S. K. (2015). White mustard (*Sinapis alba* L.) - A potential oilseed crop for economic sustainability. *International Journal of Chemical Studies*, 3(2), 26-32.

Lynch, J. P. (2011). Root phenes for enhanced soil exploration and phosphorus acquisition: Tools for future crops. *Plant Physiology*, 156(3), 1041-1049.

Ma, L. (2013). White Mustard (*Sinapis alba* L.) Crop Fact Sheet. Washington State University Extension.

Marschner, P. (2012). Marschner's mineral nutrition of higher plants. Academic Press

Pandey, N., et al. (2019). Effect of NPK fertilizers on growth, yield, and oil content of white mustard (*Sinapis alba* L.). *Journal of Pharmacognosy and Phytochemistry*, 8(6), 1283-1287.

Shabala, S. (2017). Signaling by potassium: Another second messenger to add to the list? *Journal of Experimental Botany*, 68(15), 4003-4007.

Smith, R. D., et al. (2019). Effects of NPK fertilizer on growth and yield of tomato plants. *International Journal of Agricultural Sciences*, 9(3), 944-952.

Tiwari, A., & Sharma, V. (2011). Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India. *Journal of Ethnopharmacology*, 138(3), 643-649.

Wang, X., & Wang, H. (2017). Mustard. In: Ma, Y., Prasad, M.N.V. (eds.) Sustainable Agriculture Reviews. Springer.

Zhu, X., Song, F., & Xu, H. (2020). Potassium (K) in plant growth and development. In Plant Macronutrient Use Efficiency (pp. 131-144). Academic Press.

Table 1: Effect of different rates of NPK on plant height of white mustard

Treatment	Plant height (cm)			
	Weeks after sowing (WAS)			
Fertilizer rates (Kg ha^{-1})	2	4	6	8
0.00	8.00	12.64 b	16.4	39.6
20.0	8.94	14.48 ab	38.3	75.2
40.0	10.34	16.92 a	52.2	80.4

60.0	8.88	15.46 ab	36.9	78.6
80.0	9.58	17.34 a	39.4	71.1
LSD0.05	2.541	2.547	32.98	46.57
P value	>0.05	<0.01	>0.05	>0.05
SE	0.84	0.84	11.0	15.53

Means followed by same letter(s) are not significantly different at 5% level of probability using (Student Neuman Keuls' Test).

Table 2: Effect of different levels of NPK on number of leaves of white mustard

Treatment	Number of Leaves			
	Weeks after sowing (WAS)			
Fertilizer rates (Kg/ha)	2	4	6	8
0.00	4.80	6.60	8.60	10.80
20.0	5.20	8.20	9.20	10.40
40.0	5.20	8.20	11.20	9.40
60.0	4.80	7.80	10.80	7.00
80.0	5.00	8.40	10.40	10.40
$LSD_{0.05}$	1.254	1.855	2.084	3.675
P value	>0.05	>0.05	>0.05	>0.05
SE	0.41	0.61	0.69	1.22

Means followed by same letter(s) are not significantly different at 5% level of probability using (Student Neuman Keuls' Test).

Table 3: Effect of NPK on number of branches Number of Roots, Root length of white mustard plant

Treatments	Number of Branches (#)	Number of Roots	Root length (cm)	Fresh weight (g)	Dry weight (g)
Fertilizer rates (Kg/ha)					
0.00	1.00	4.40^{b}	10.80	21.6^{b}	2.42^{b}
20.0	2.20	5.80^{b}	10.80	30.6^{ab}	4.04^{b}
40.0	3.40	5.80^{ab}	9.60	40.8^{ab}	7.06^{ab}
60.0	2.80	5.80^{ab}	7.00	34.7^{ab}	6.24^{ab}
80.0	3.20	8.00^{a}	10.40	51.7^{a}	10.52^{a}
$LSD_{0.05}$	2.156	2.168	4.205	18.84	3.736
P value	>0.05	<0.05	>0.05	<0.05	<0.01
SE	1.07	0.72	1.40	8.89	1.24

Means followed by same letter(s) are not significantly different at 5% level of probability using (Student Neuman Keuls' Test).

EFFECT OF SOWING METHOD AND WEEDING INTERVAL ON THE PERFORMANCE OF SOYBEAN (*Glycine max* L.) IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

The research was conducted on the effect of sowing method and weeding interval on the performance of soybean (*Glycine max* L.) in the Sudan Savanna of Nigeria during 2021 rainy season at the research farm of Aliko Dangote University of Science and Technology Gaya and Federal College of Education (Technical) Bichi research farm. The treatments consisted of three sowing methods (broadcasting, dibbling or drilling) and six weeding frequency (weeding at 2,4, 6, 8 weeks after sowing, weed free until harvest or weed infested until harvest). These were factorially combined and laid out in randomized complete block design and replicated three times. Data were collected on growth and yield characters of soybean. The results indicated that dibbling methods kept free of weeds up to six weeks recorded significantly highest number of branches (18.0), leaf area (58.4), 100- hundred grain weight (10.0 g), grain yield per hectare (2131.0 kg/ha) and Stover yield per ha (3.51). Based on the findings dibbling method and weeding interval at six weeks after sowing is recommended for soybean farmers in the study areas.

Key words: Sowing methods, Weeding intervals, soybean, growth, yield

INTRODUCTION

Soybean (*Glycine max* L.) is a legume that grows in tropical, subtropical, and temperate climates. Soybean was domesticated in the 11th century around Northeast of China. It is believed that it might have been introduced to Africa in the 19th century by Chinese traders along the East Coast of Africa. (Balasubramaniyan and Palaniyappan, 2010). China was the world's largest Soybean producer and exporter during the first half of the 20th century. The cultivated area of soybean in

China in 2007 was 8.90 million hectare with total production of 13.80 million tons. It was introduced to USA in the early 19th century and it expanded drastically thereafter. USA has 60% of the world hectares under soybean cultivation accounting for about 75% of world population. Other countries that produce the crop are Brazil, Argentina, India, Japan and Nigeria. (Chadha, 2007). The objectives of the studies were to determine the effects of sowing methods on the growth and yield of soybeans and to determine the effects of weeding interval on the growth and yield of soybeans.

MATERIALS AND METHODS

The research was conducted in 2020/2021 rainy season at the research farm of Aliko Dangote University of Science and Technology Wudil, situated at Gaya latitude (11°48'33.6''N) and longitude (8°50'39''E) with an elevation of 419 m above sea level. The mean annual rainfall is 779 mm. The experiment consisted of 18 (eighteen) treatment combinations by the use of three sowing methods i.e. V broadcasting, dibbling and drilling factorially combined with 6 (six) weeding intervals (weeding at 2, 4, 6, 8 WAS and WF (weed free up to harvest) and WI (weed infested up to harvest) per plot to serve as control. The experiment was laid out in randomized complete block design (RCBD) and was replicated 3 times. Weeds were identified for each location and grouped into sedges and broad leaves and grasses. Crop data were taken on crop height, number of leaves, number of branches, number of pods per plant and pod yield per hectare.

RESULTS AND DISCUSSION

Weed species composition

There were twelve (12) species of weeds identified at Gaya location. Out of these four were grasses, six broad leaves and only two were sedges (Table 1). Also at Bichi location a total of twelve species of weeds were also identified. These comprised of seven grass species, three broad leaves and two sedges (Table 1).

Canopy height

Effect of sowing method and weeding interval on canopy height at 6 WAS in Gaya and Bichi during the 2021/2022 season is presented in Table 2. No significant difference ($P \leq 0.05$) was observed on sowing methods at both locations, however, significant difference was observed on weeding interval among the treatments where weed free at 6 WAS recorded the significantly higher canopy height at Gaya but this was at par with the rest of the treatments except weed free at harvest and weed infested at harvest that recorded the lowest height. The highest canopy height at Bichi was recorded by weed free at 4 WAS while the shortest canopy was observed in the weed infested at harvest. The results is supported by Yadava and Kumar (2012), who reported that fertility of the soil in legume crop leads to increase in the canopy height.

Number of leaves per plant

Effect of sowing method and weeding interval on number of leaves per plant at 6 WAS in Gaya and Bichi during the 2021/2022 season is presented in Table 2. Effect of sowing method on number of leaves per plant was not significantly different at both locations. However significant difference was recorded on weeding interval where the weed free at 8 WAS had the highest number of leaves at the two locations and the lowest number was observed at weed infested at harvest at Gaya location and by Weed free at Harvest at Bichi location, respectively. The results is supported by Weiss, Collins and Anderson (2018), who reported that weed control in legumes led to increased numbers of branches per plant compared to non- weeded plants. How? It is not about supported by another author but what is the physiological or biochemical explanation?

Number of pods per plant

The effect of sowing method and weeding interval on number of pods at harvest in Gaya and Bichi during the 2021/2022 season is presented in Table 3. significant difference ($P \leq 0.05$) was observed on sowing methods at both locations, however, significant difference was observed on weeding interval among the treatments where weed free at 4 WAS recorded the significantly highest number of pods at both Gaya and Bichi locations but this was at par with the rest of the treatments except weed free @ harvest and weed infested at harvest that recorded the lowest number at Gaya while at Bichi the least number of pods was recorded only by weed infested at harvest.

Stand count at harvest

The effect of sowing method and weeding interval on stand count at harvest in Gaya and Bichi during the 2021/2022 season is presented in Table 3. No significant difference ($P \leq 0.05$) was observed on both sowing methods and weeding interval across the locations.

Stover Yield (Kg/ha)

The effect of sowing method and weeding interval on stover yield in Gaya and Bichi during the 2021/2022 season is presented in Table 4. No significant difference ($P \leq 0.05$) was observed on sowing methods at both locations. Stover yield at Gaya did not record significant difference from weeding interval. However, at Bichi location a statistical difference was observed among the treatments, where weed free at 4 WAS recorded the significantly higher stover weight though at par with other treatments except weed infested at harvest that recorded the lowest stover weight.

A significant difference was recorded on stover yield per hectare on the sowing method, where dibbling and weeding interval at 6WAS recorded the highest stover yield in both two stations though at par with all other sowing methods except weed infested up to harvest which recorded statistically the least stover yield weight per ha. This result also conformed to KNARDA (2012) results that significant difference can be determined on the specific weight of soya beans stover yield with appropriate cultural practices.

Grain yield (kg ha^{-1})

The effect of sowing method and weeding interval on grain yield in Gaya and Bichi during the 2021/2022 season is presented in Table 4. No significant difference ($P \leq 0.05$) was observed on sowing methods at both locations. Grain yield was significantly different at both locations where weed free @ 4 WAS scored the highest yield and the weed infested @ harvest on the other hand had the least yield across the locations. The result was also in conformity with the work done by Donald (2010) that uncontrolled weeds could reduce yield of some crops by 68-78%.

CONCLUSION

Based on the results obtained in this field research on the two locations, dibbling method supported the maximum growth performance and yield of soybean and weeding at 6 weeks interval had a positive effect on all the characters.

REFERENCES

Abdelhamid, M.T., Horiuchi T. and Oba S. (2014). Composting of rice straw with oilseed Ripe cake and poultry manure and its effects on Soybean (*Glycine max* L.) growth and soil properties. *Biorsour Journal of Technology,* 93, 183-189.

Adeniyan, O.N. and Ayoola O.T. (2016). Growth and yield performance of some improve Soybean varieties as influenced by intercropping with maize and cassava in two contrasting location in south West Nigeria. *African Journal of Biotechnology,* 5(200-1886-1889

Agric. News (2014), Kano State Ministry of Agriculture & Natural Resources, a quarterly Publication, April-august, 2014.

Akobundu, I.O and Agyakwa C.W. (1998), **A hand book of West African Weeds**, Second Edition, Revised and Expanded. INTEL printers, Ibadan.

Amujoyegbe, B. and Elemo K. (2013). Growth performance of maize/cowpea in intercrop as influenced by time of introducing cowpea and nitrogen fertilizer, *International Research Journal of Plant Science, 4(1): 111.*

Anthony, Y, Ezedinma F.O.C, and Onazi O.C. (1999). **Introduction to Tropical Agriculture** (15th impression Longman Publishers, P. 125).

Table 1: Weed species composition at the experiment sites

WEEDS	GAYA	BICHI
GRASSES		
Chenchrus biflorus	*	*
Commelina benghalensis L.	-	*
Eragrostis tremula Hochst	*	*
Pennisetum pedicellatum	-	*
Panicum maximum	*	*
Echinochloa obtusiflsora	*	*
Eragrostis tenella	-	*
BROADLEAVES		
Eichichloa crassipe	*	-
Phyllanthus amarus	*	-
Senna occidentalis	-	*
Ipomoea aquatica	*	*
Ipomea asarifolia	*	-
Vosiacuspidata grift		*
SEDGES		
Fimbristylis littoralis	*	-
Kylinga pumila	*	-

Key: * presence of weed, - absentce of weed

Table 2: Response of soybeans to sowing method and weeding internal on canopy height and number of leaves per plant at 6 WAS in Gaya and Bichi during the 2021/2022 season

Treatment	Canopy height (cm)		Number of leaves per plant	
	Gaya	Bichi	Gaya	Bichi
Sowing Method				
Broadcasting	29.85	46.28	13.28	15.06
Drilling	29.59	46.00	13.39	13.89
Dibbling	29.27	46.44	13.27	15.06
SE±	5.702	3.932	4.657	11.05
Weeding Interval				
Weed free @ Harvest	25.92b	33.78b	8.89d	9.33b
Weed free @ 2 WAS	32.29a	53.00a	15.11c	15.78a
Weed free @ 4 WAS	32.56a	53.56a	15.67bc	17.11a
Weed free @ 6 WAS	33.66a	52.44a	16.00b	17.56a
Weed free @ 8 WAS	33.11a	53.11a	17.56a	18.00a
Weed infested @ Harvest	19.89c	31.56c	6.67e	9.67b
SE±	1.686	1.818	0.620	2.338

Means with the same letter are not significantly different $P \geq 0.005$

Table 3: Response of soybeans to sowing methods and weeding interval on number of pods per plot and stand count at harvest at Gaya and Bichi during the 2021/2022 season

Treatment	Number of pod per plot		Stand count at harvest	
	Gaya	Bichi	Gaya	Bichi
Sowing Method				
Broadcasting	35.17	39.50	58.33	57.77
Drilling	35.89	39.55	56.67	57.22
Dibbling	38.89	39.66	57.22	57.77
SE±	14.095	5.532	8.371	8.408
Weeding Frequency				
Weed free @ Harvest	16.44b	16.77c	58.89	57.78
Weed free @ 2 WAS	47.56a	51.11b	54.44	56.67
Weed free @ 4 WAS	48.11a	53.33a	58.89	58.89
Weed free @ 6 WAS	47.67a	50.78b	58.89	56.67
Weed free @ 8 WAS	45.67a	50.44b	56.67	57.78
Weed infested @ Harvest	14.44b	15.00d	56.67	57.78
SE±	5.165	1.793	4.805	4.839

Means with the same letter are not significantly different P ≥ 0.005

Table 4: Response of soybeans to sowing method and weeding interval on stover and grain yield in kilogram per hectare at Gaya and Bichi during the 2021/2022 season

Treatment	Stover yield per hectare (Kg/ha)		Grain yield (Kg/ha)	
	Gaya	Bichi	Gaya	Bichi
Sowing Method				
Broadcasting	2077.0	2069	2130.89	2141.60
Drilling	2098.0	2069	2127.86	2142.44
Dibbling	4019.2	2089	2122.25	2140.65
SE±	865.84	190.52	150.208	170.753
Weeding Frequency				
Weed free @ Harvest	4037	2001b	269.83c	284.37d
Weed free @ 2 WAS	3029	3031a	2161.00ab	2177.33b
Weed free @ 4 WAS	4010	3036a	2177.51a	2203.95a
Weed free @ 6 WAS	3009	3000a	2154.22b	2141.83c
Weed free @ 8 WAS	3019	2093a	2147.09b	2171.28b
Weed infested @ Harvest	1089	1093b	252.35c	270.64d
SE±	2008.68	538.91	190.315	250.132

Means with the same letter are not significantly different P ≥ 0.005

INCIDENCE, SYMPTOM SEVERITY OF PEPPER VEINAL MOTTLE VIRUS (PVMV) AND APHID POPULATION INFECTING PEPPERS (*Capsicum annum* L.) IN ALIERO LOCAL GOVERNMENT AREA, KEBBI STATE, NIGERIA

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ABSTRACT

Field research was carried out in Aliero Local Government area of Kebbi State to assess the incidence, symptom and severity of *Pepper Veinal Mottle Virus Disease* (*PVMVD*) and Aphid population on Peppers (*Capsicum* spp.) in selected Peppers growing villages of Aliero L.G.A. of Kebbi State. Thirty (30) Asymptomatic and Symptomatic pepper plants were randomly assessed for the disease symptoms and severity while aphids were counted in epical terminal leaflets of each plant to assess *Pepper Veinal Mottle Virus Disease* (*PVMVD*). Mean of disease and aphid population were analysed using Excel Version (2007). The result shows that, there were incidence and severity of *Pepper Veinal Mottle Virus* (*PVMV*) and high aphid population in Aliero L.G.A. However, the villages recorded with the highest disease incidence were Gumbulu with (43.34 %), followed by Jiga Birni (28.33%), Aliero Town (21.67%) and kali village with (20.5%). Kali and Gumbulu had the high disease Severity (2%) followed by Aliero Town (1.75%), Jiga Birni recorded the lowest (1.55%). Aphid population was highest in Gumbulu, Kali, Jiga Birni, Aliero Town with (10.45%), (8.29%), (4.64%), and (4.17%) respectively.

Keywords: Pepper, solanaceae, aphids, incidence, severity.

INTRODUCTION

Peppers (*Capsicum* annum L.) are members of Solanaceae family, characterized by their diverse flavor and pungency. A range of varieties are grown for both fresh market and processing. These include varieties that are mild in flavor and those that have varying levels of pungency (Baramidze *et al*., 2015). Pepper is a high value crop that is grown for cash by farmers all over the world. Peppers whether fresh, dried or processed, are an important iteming our daily diet and can be found in all local markets in Africa. Production of peppers in Africa is estimated to be 4.88 million ton cultivated on 463,937 ha of land (FAO, 2018); in West Africa, the total production is 864,260 ton cultivated on 158,452 ha (FAO, 2018). Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production (FAO, 2018). In recent years, interest and demand for peppers has increased dramatically worldwide and peppers have achieved major economic significance in the global market (Mohammed *et al*., 2015). Apart of potentials of this commodity to generate foreign exchange for Nigeria, their common use in confectionary, medicinal and culinary purpose is on the increase. Peppers are used both as pungent or condiment for culinary purposes for domestic catering and food processing industry. The moderate pungency of the Nigerian chilli allows its use for the production of spice blends and red pepper. Industrial users also require the moderately pungent chilies (Nigerian type) for use in the pharmaceutical industries (Mohammed *et al*., 2015).

Aphids are the most important group of virus vectors in the tropical and temperate regions, as they can transmit a large number of different viruses (Dijkstra and de Jager, 1998). Aphid transmission may be non-persistent, semi-persistent or persistent. Potty viruses of which *Pepper veinal mottle virus* (PVMV) is a member are the largest group of plant infecting RNA viruses that cause significant losses in a wide range of crops across the globe (Gadhave *et al*., 2020). The majorities of the viruses in the genus Potty virus are transmitted by aphids in a non-persistent, non-circulative manner and extensively studied vis-à-vis their structures, taxonomy, evolution, diagnosis, transmission and molecular interactions with host (Gadhave *et al*., 2020).

Pepper veinal mottle virus is one of the serious viral diseases of peppers in Nigeria and cause significant yield loss. Peppers farmers have been using various insecticides in the management of the vector (aphids) which in turn increase the cost of production and cause environmental pollution. *Pepper veinal mottle virus* is difficult to manage with insecticides because it is non-persistently transmitted by its aphid vectors which may transmit the virus into healthy peppers before insecticides act on them. Insecticide application and removal of infected plants are usually inadequate in reducing the virus spread (Fajinmi and Odebode, 2010).Various cultural management methods have been practiced in growers' fields for the management of virus infection on cultivated peppers, especially with viruses transmitted by aphids in a non-persistent manner, with varying degrees of success (Fajinmi and Odebode, 2010).Whether intercropping peppers with barrier crops (non-hosts of the virus) can reduce the incidence of *Pepper veinal mottle virus* (a non-persistent pepper virus) and the population of aphid vectors is not known.

Pepper veinal mottle virus (*PVMV*) disease had been reported to be a major constraint to pepper production in almost all parts of Nigeria where pepper has been cultivated, contributing to its low yield and reduced fruit quality and leading to great economic loss for the farmers and country at large (Fajinmi 2006).There have been reports of 100% losses of marketable pepper fruit due to infection with *PVMV,* causing whole fields to be abandoned prior to harvest and in some areas making the cultivation of pepper uneconomical in northern and some parts of south western Nigeria (Fajinmi, 2006). Many cultural methods have been practiced in growers' fields for the management of virus infection on cultivated pepper, especially with viruses transmitted by aphids in a non-persistent manner, with varying degrees of success. Therefore, a research that will evaluate the effect of intercropping peppers as one of the cultural management practices in farmers' fields on incidence and symptom severity as well as management of *PVMV* and its vector is of paramount important. The outcome of this research will be of great benefit to pepper farmers, extension workers, agronomists, entomologists, plant virologists and other researchers.

MATERIAL AND METHODS

Study Area

The research was conducted in Aliero local government area of Kebbi state, Nigeria. Aliero is one of the twenty-one (21) Local Government Areas of Kebbi State, Nigeria. The town is located on latitude 12^{o}61 to 42'N and on longitude 4"7'to 6" E of the equator (Illo *et al.*, 2016). The climate of the town is of tropical in nature and characterized by dry and rainy seasons, with the onset of rainy season in May/June and ends in October and the heaviest rainfall occurring in July and August (Illo *et al.*, 2016). The area is characterized by extreme cold harmattan period which is usually accompanied by dusty winds and fog with alarming intensity; prevails in November through January (Illo *et al.*, 2016). The annual temperature of the area varies considerably but usually ranges between 26^{o} and 37^{o}C while average annual rainfall is about 500 mm (Illo *et al.*, 2016). The town is located in the South East of the state, and bordered in the North-East by Gwandu Local government area, in the South-West by Jega Local Government, and in the North-West by Birnin Kebbi Local Government area (Illo *et al.*, 2016).

Fields survey was conducted in Aliero town, Gumbulu, Kali, and Jiga Birni areas of Aliero local government, Kebbi State, Nigeria in January, 2021 dry season. In each area selected two (2) pepper farms were randomly selected and surveyed based on the following crop mixtures: sole pepper, pepper/maize, pepper/onion and pepper/any other crop not in the same family with pepper. In each field, 30 pepper plants were randomly sampled along two diagonals in form of an 'X' and examined for symptoms of *Pepper veinal mottle virus* (PVMV), disease incidence, symptom severity, and aphid abundance (Sseruwagi *et al.*, 2004). Five symptomatic and asymptomatic leaf samples were sampled from each field. Information on cropping type, pepper type, age of the crop, cropping system, crops grown on neighboring field, field, and weather condition during the time of the survey (Temperature and Relative humidity) and other relevant *PVMV* information were all recorded in a survey data sheet (Table 1). Geographical Positioning System (GPS) co-ordinates were also recorded from each field. Materials used for this study were mainly survey materials such as field survey data sheet for collecting relevant information for the research, Global Positioning System (GPS) receptor for taking coordinates of the locations (longitude and latitude); pencil and eraser were also used as writing materials; thermometer/hygrometer for taking temperature and humidity.

Disease incidence

Disease incidence of each field were calculated as the percentage (%) of visually diseased plants over the total plants assessed in the two diagonal method using the following formula as suggested by Sseruwagi *et al.* (2004) and the percentage of disease incidence of each field were used to calculate percentage disease incidence of Aliero Local Government Area.

$$\text{Disease incidence (\%)} = \frac{number\ of\ diseased\ plants}{total\ number\ of\ plants\ examined} \times 100$$

Symptom severity

Symptom severity of each field were scored by the arbitrary score: 1-5 (Sseruwagi *et al.*, 2004) indicating the degree of symptom development of each sampled plant in the field. Mean symptom severity of each field were calculated.

Where:

1= Symptomless (no symptom development)

2= Mild (symptoms but no pronounced development)

3= Moderate (pronounced symptom on about one thirds of the leaves)

4= Severe (symptoms on about two thirds of the leaves)

5= Very severe (symptoms on almost all the leaves)

Estimation of aphid abundance

Evaluation of aphid population in a field were directly counted from adults on 5 youngest apical leaves of the shoots of each 30 plants sampled because the adults feed preferentially on the youngest immature leaves and the total number of aphids were taken to represent the estimate of the number of aphids per plant (Ndunguru *et al.*, 2009).

Data analysis

Data collected on incidence and symptom severity of PVMV and aphids population in Aliero Local government area of Kebbi state Nigeria were analyzed using Microsoft Excel (2016) and GenStat software (17th Edition).

RESULTS AND DISCUSSION

Incidence of Pepper veinal mottle virus in Aliero Local Government Area of Kebbi State during the 2021 dry season

The results revealed that, there is high incidence in Gumbulu village with value of (43.34%), Jiga birni ranked second with (28.33%) while Kali and Aliero town recorded the lower values with (20.5%) and (21.67%) (Fig 1).

Symptom Severity of Pepper veinal mottle virus in Aliero Local Government Area of Kebbi State during the 2021 dry season

The symptom severity varied significantly among the villages. However, Kali and Gumbulu villages showed the higher symptom severity with (2%) each while Jiga birni and Aliero town had the lower symptom severity (1.55%) and (1.75%) (Fig 2).

Aphid population infesting pepper farms in Aliero Local Government Area of Kebbi State during the 2021 dry season.

Aphid population of the current research work revealed that there is high population of aphid in Gumbulu village with (10.45%) when compared with other locations visited, Kali was ranked second in term of aphid population (8.29%), while Jiga birni and Aliero town showed lower population.

DISCUSSION

The current survey work conducted in January, 2020 dry season determined the incidence and symptom severity of *Pepper Veinal Mottle Virus Disease* (PVMVD) and Aphis population in Aliero LGA of Kebbi State. The higher incidence recorded in Gumbulu village could be attributed to the mixed cropping practiced by the farmers in the area which may invites aphis to the crop for transmission of *pepper veinal mottle virus disease.* This is contrary with the findings of (Gerardo *et al.* 2010) who reported that intercropping significantly reduces the occurrence of the virus disease. The results obtained from this study had shown that Gumbulu and Kali had the highest severity of PVMVD. The high symptom severity recorded in Gumbulu and Kali could be attributed to the used of susceptible varieties by the farmers in the study area. During the survey work some of the farms were found weedy and unhygienic this could contribute to the high population of aphid in Gumbulu as reported by (Costopoulos, 2014).

CONCLUSION

The study provides evidence for the possible risk of transboundary movement of the virus through plant materials and insects vectors in PVMV share under pepper. Due to continuous resurgence of aphid vector and indiscriminate use of chemical insecticides, there is a strong need to develop resistant cultivar against the virus dominating in major pepper growing areas of Aliero L.G.A. and carrying out local level publicity campaign to create awareness among farmers' community towards possible risk.

REFERENCES

Baramidze, V., Khetereli, A. and Kushad, M. (2015). Identification and control of major diseases and insect pests of vegetables and melons in Georgia. USAID Agricultural University of Georgia.

Blackman,R.L. and Eastop, V.F.(2000). Aphids on the worlds crops: An identification and information Guide. 2nd ed John Wiley and sons, Chichester, England. Clue,A.D. (1993).Companion planting; Intercropping Certain Vegetables enhance their yield so long as you choose companions on the basis of science ,not garden lore , *Flower Garden Magazine*,1:1-3

Carrizo García C, Barfuss MHJ, Sehr EM, Barboza GE, Samuel R, Moscone EA. (2016) Phylogenetic relationships, diversification and expansion of chili peppers (*Capsicum*, Solanaceae). Ann Bot 118:35–51

Davenport WA (1970) Progress report on the domestication of Capsicum (chili peppers). Proc Assoc Am Geogr 2:46–47

Degri, M.M. and Samaila, A.E. (2014). Impact of Intercropping Tomato and Maize on the Infestation of Tomato Fruit Borer (*Helicoverpa armigera* Hubner). *Journal of Agricultural and Crop Research*, 2(8):160-164

Degri,M.M.(2013).Bio-efficacy of Aqueous plant Extracts and Cyperdicot on insect pests Infestation. Growth and yield of sweet pepper (*Capsicum annum* L.) in the dry savannah of Nigeria. *Scientific Research Journal,* 1(4): 12-16

Fajinmi, A.A. and Fijinmi,O.B.(2006). Evaluation of pepper intercropped with tall-companion crop in the management of *pepper venial mottle* Potyvirus Disease and its vector on cultivated pepper (*Capsicum annum* L.) in Nigeria. *Agricultural Journal*, 5:205-210

Fajinmia, A. A. and Odebode, C. A. (2010). Evaluation of maize/pepper intercropping model in the management of *pepper veinal mottle virus*, genus Potyvirus, family Potyviridae on cultivated pepper (*Capsicum annuum* L.) in Nigeria. *Archives of Phytopathology and Plant Protection* 43(15): 1524–1533

FAOSTAT. (2018). Statistics division of food and agriculture organization of the United Nations. *Karnataka Journal of agricultural Science*,21:162-164.

Hugar,H.Y and Palled, Y.B.(2008). Studies on Maize-Vegetable intercropping systems.

Illo, A., Kaka, Y., Hassan, U., Umar, S., and Bamidele, A. (2016). Marketing of Onion in Aliero Central Market, Aliero Local Government Area of Kebbi State. *Journal of Humanities Social Science, 21*, 42-49.

Hussein, M. and Samad, N.A.(1993). Intercropping Chili with maize or brinjal tosuppress populations of Aphis gossypii Glove and transmission of chilli Viruses. *International Journal of Pest Management* 39:216-222

Marini E, Magi G, Mingoia M, Pugnaloni A, Facinelli B (2015) Antimicrobial and Anti-Virulence activity of Capsaicin against Erythromycin-Resistant, cellinvasivegroupAStreptococci.FrontMicrobiol6:1281

Mohammed, B., Abdulsalam, Z. and Ahmed B. (2015). Profitability in Chilli pepper production in Kaduna state, Nigeria. *British Journal of Applied Science and Technology*, 12(3): 1-9

Mohammed, B., Abdulsalam, Z. and Ahmed B. (2015). Profitability in Chilli pepper production in Kaduna state, Nigeria. *British Journal of Applied Science and Technology*, 12(3): 1-9

Ndunguru, J., Kapinga, R., Sseruwagi, P., Sayi, B., Mwanga, R., Tumwegamire, S., and Rugutu, C. (2009). Assessing the sweetpotato virus disease and its associated vectors in northwestern Tanzania and central Uganda. *African Journal of Agricultural Research*, 4(4), 334-343.

Sseruwagi, P., Sserubombwe, W., Legg, J., Ndunguru, J., and Thresh, J. (2004). Methods of surveying the incidence and severity of cassava mosaic disease and whitefly vector populations on cassava in Africa: a review. *Journal of Virus Research, 100*(1), 129-142.

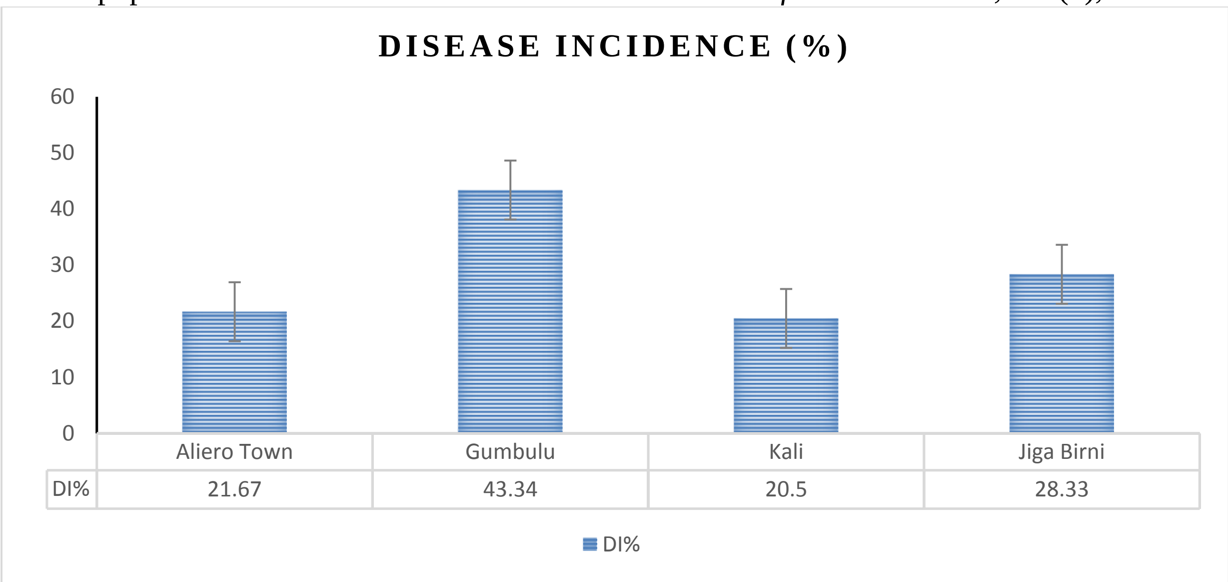

Figure 2: Incidence of Pepper veinal mottle virus in Aliero Local Government Area of Kebbi State during the 2021 dry season. Bars indicate standard error of means at 5 % probability level.

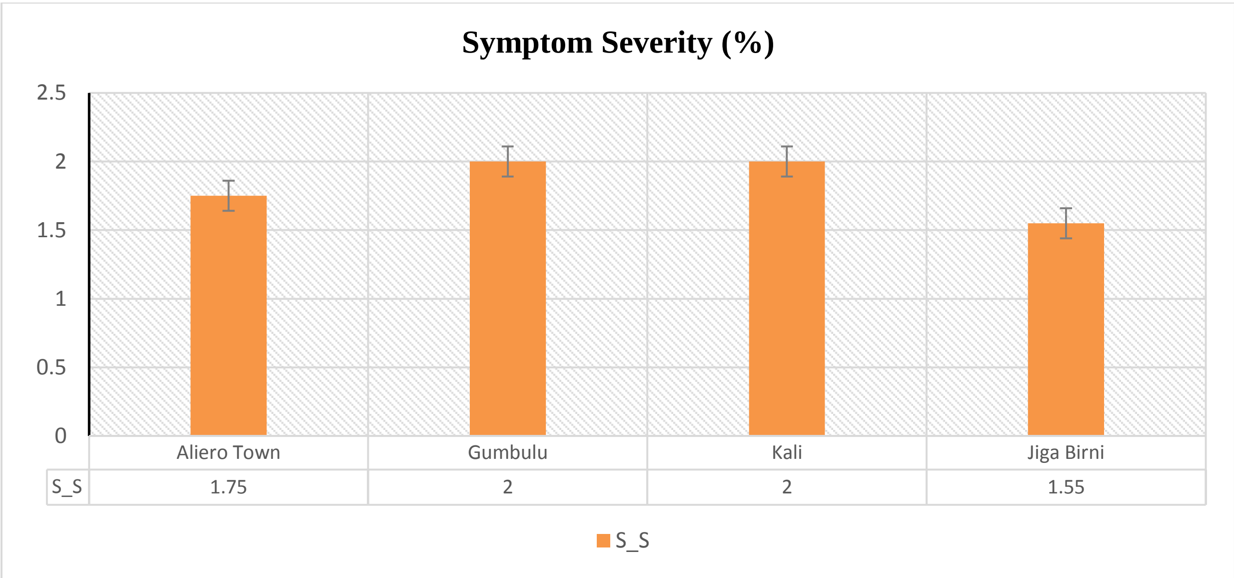

Figure 3: Symptom Severity of Pepper veinal mottle virus in Aliero Local Government Area of Kebbi State during the 2021 dry season. Bars indicate standard error of means at 5 % probability level.

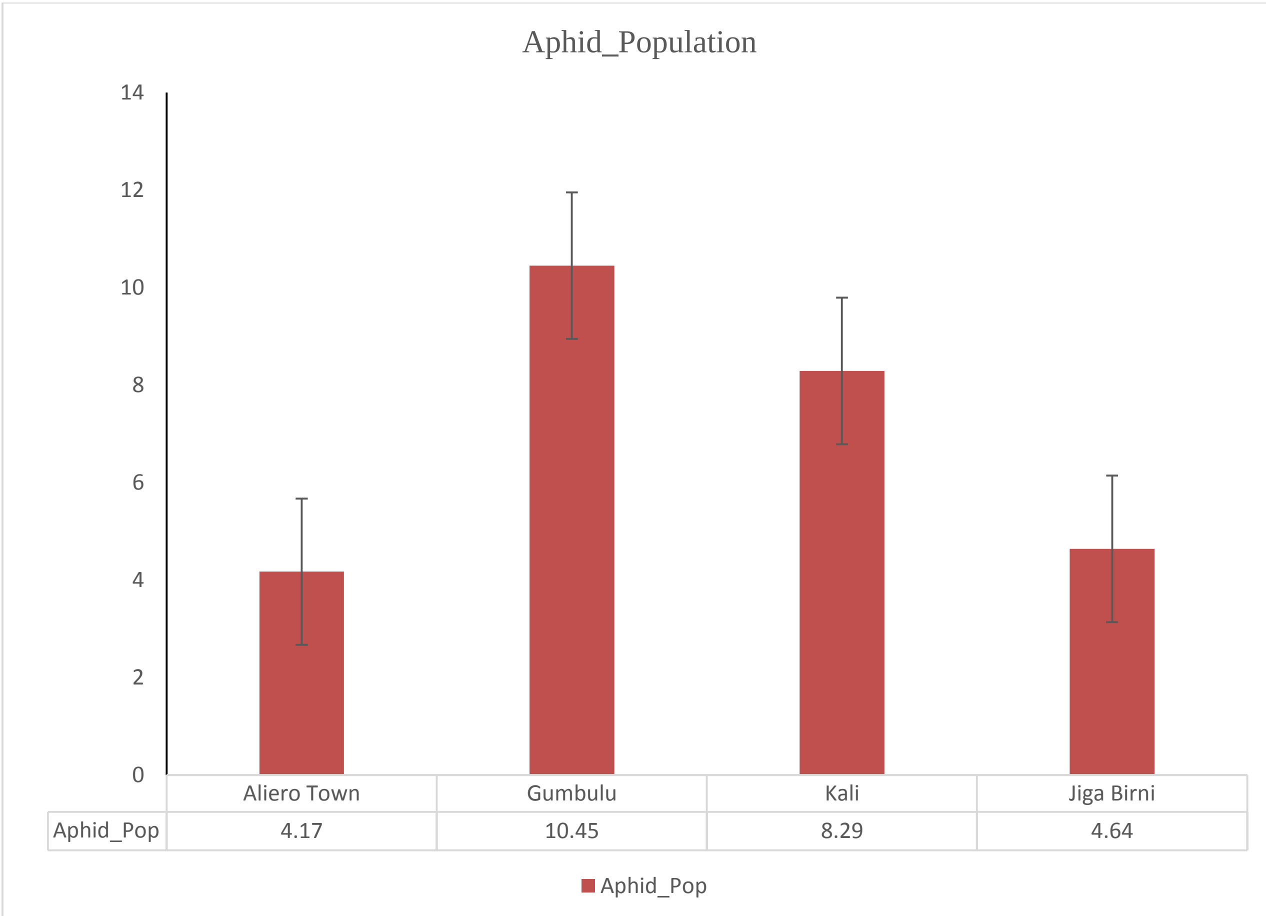

Figure 4: Aphid population infesting pepper farms in Aliero Local Government Area of Kebbi State during the 2021 dry season. Bars indicate standard error of means at 5 % probability level.

RESPONSE OF SWEET POTATO (*Ipomoea batatas* L.) ECOTYPES TO SWEET POTATO LEAF CURL VIRUS (SPLCV) IN ALIERO, KEBBI STATE, NIGERIA

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ABSTRACT

Experiment was conducted to evaluate the response of sweet potato (*Ipomea batatas* L.) ecotypes to *Sweet Potato Leaf Curl Virus* (SPLCV) infection at the Screen House of Kebbi State University of Science and Technology Aliero, Nigeria during the 2020/2021 dry season. The treatments consisted of three ecotypes of *I. batatas* (Dangote, Dangoronyo, and Danmadakali) domiciled and commonly cultivated in Kebbi State. The experiment was laid out in Completely Randomized Design (CRD) with three (3) replications. A single diseased-free vine of 30 cm was used for each treatment during the transplanting. The transplanting was carried out in a plastic pot containing a well-drained clay-loam soil. The uppermost leaves of each sweet potato ecotypes were mechanically inoculated with SPLCV at 2 weeks after transplanting using carborundum powder and cotton wool. Control plants (Plants inoculated with buffer alone served as controls) for each ecotypes were included. Data were collected at 2, 4 and 6 weeks after inoculation (WAI) on disease incidence and disease severity from sap-inoculated and control plants of each ecotypes. The results showed that the ecotypes screened had *Sweet Potato Leaf Curl* Disease (SPLCD) incidence range of 77. 79 – 100 % at 6 WAI with ecotype Dangote having the highest (100 %) SPLCD. The SPLCD was found to be generally mild (2 out of 5 rating scale) across all the ecotypes screened, however, Dangote was shown to significantly ($P \leq 0.05$) have highest disease severity (2.88 %) at 6 WAI compared to the other ecotypes. The results of the present study could be of importance to breeder for possible improvement of these ecotypes against SPLCD for increased production. There is need to determine the effect of SPLCD on the yield of the potato ecotypes screened in the study area.

Keywords: Ecotypes, screening, sweet potato, SPLCV

INTRODUCTION

The sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant that belongs to the bindweed or morning glory family, Convolvulaceae. It's large, starchy, sweet-tasting with tuberous roots (Woolfe and Jennifer, 1992). *Ipomoea batatas* is native to the tropical regions in the Americas. The plant is a herbaceous perennial vine, bearing alternate heart-shaped or palmate lobed leaves and medium-sized sympetalous flowers. The edible tuberous root is long and tapered, with a smooth skin whose colour ranges between yellow, orange, red, brown, purple and beige. Its flesh ranges from beige through white, red, pink, violet, yellow, orange, and purple. Sweet potato is the seventh most important food crop in the world in terms of production. They are grown on about 9 million hectares, yielding about 140 million tons; with an average yield of about 14 ton/ha. They are mainly grown in developing countries, which account for over 95% of world output. Roughly 80% of the world's sweet potatoes are grown in Asia, about 15% in Africa, and only 5% in the rest of the world. The cultivated area of sweet potato in China, about 6.6 million ha, accounted for 70% of the total area of sweet potato cultivation in the world. China produces about 100 million tons, circa 70% of the total world production (Maule *et al.,* 2007).

However, sweet potato yields are heavily reduced by viruses, which are carried from generation to generation through recycling of infected cuttings (Gibson and Kreuze, 2015). The most common viruses found infecting sweet potato in Africa are *sweet potato feathery mottle virus* (SPFMV), *sweet potato chlorotic stunt virus* (SPCSV) and *sweet potato leaf curl virus* (SPLCV) (Loebenstein, 2015), in combination, the two viruses have a synergistic effect and cause *sweet potato virus disease* (SPVD) which is the main 'virus disease' affecting the crop, often leading to 56–98% yield losses (Ndunguru *et al.,* 2009). In addition, a group of geminiviruses, collectively known as sweepoviruses, is increasingly being recognized as damaging and common worldwide, including Africa (Rey *et al.,* 2012). Managing such a complex set of viruses is challenging, especially as many of them show no, or only minor transient symptoms when infecting sweet potato alone, making it difficult to identify infected plants (Valderde *et al.,* 2007).

There are three major alternatives in managing viruses in sweet potato: (i) deploying resistant cultivars, (ii) using clean (virus-tested) seed, and (iii) employing proper on-farm management practices. Deployment of resistant cultivars is viewed as the most effective strategy in SPVD management (Maule *et al.,* 2007). In this context, the term 'seed' refers to quality (virus-indexed) cuttings or storage roots that have been selected for use in generating new plants; it does not refer to just 'any vine', or botanical seed that is used for breeding.), whereas landraces and cultivars with higher levels of resistance to SPVD do exist, no immunity to the disease exists, and depending on the virus pressure in the environment all genotypes can become infected in the field (Gibson and Kreuze, 2015).

Moreover, producing such planting material is expensive. And although this may work well in countries where sweet potato is grown as a cash crop and large-scale farmers can make the investments necessary to obtain such planting material, this has not been economically feasible for smallholder farmers producing mostly for subsistence. On-farm management strategies such as rogueing and positive selection for clean seed are therefore important. Rogueing is the removal of plants that have virus symptoms whereas positive selection is selection of vigorous healthy-looking plants as planting material/seed for the next season (Muturi *et al.,* 2007). The two approaches reduce virus inoculum and hence disease incidence.

Selection of planting material from symptomless plants has also been reported to reduce virus incidence (Aritua *et al.*, 2003). However, these methods require good farmer knowledge about disease identification. Alternatives that could enable farmers, or specialized local vine multipliers, to maintain a high sanitary status of planting material at low cost and minimum technical input exist. One such technology is a low-cost insect-proof net tunnel that can be constructed from locally sourced materials (Schulte-Geldermann *et al.*, 2012). This technology enables farmers to maintain a nuclear stock of high phytosanitary status vines, by protecting them against the virus vectors such as whiteflies and aphids (Loebenstein, 2015). Vines produced in the net tunnels can be harvested and used either directly, or after one or more cycles of field multiplication for root production and/or sale as quality planting material (Ogero *et al.*, 2015). However, it is important to know how well net tunnels perform in maintaining the phytosanitary status of sweet potato vines under farmer-multiplier management. In Nigeria, the virus occurrence is distributed in the Northern and South-Western States of the country where up to 30% yield reduction may occur if the infection is severe (Alegbejo, 2015). It is transmitted by whitefly (*Bemisia tabaci*).

Although over thirty (30) viruses were known to infect sweet potato worldwide, but few of these viruses (SPFMV, SPMMV, SPCSV and SPLCV) have been reported in Nigeria. These viruses are however, among those considered to be of major global economic importance to sweet potato production, therefore the economic concern to sweet potato farmers in Nigeria for better alternatives is paramount.

There is a need for diagnosis of economically important viruses of sweet potato in the country as a prerequisite for their management; this could be done through the use of resistant varieties, management of the virus vectors and tactical manipulation of the routine cultural practices of sweet potato against viruses or their vectors. Hence, the objective of this study was to screen some ecotypes of sweet potato for resistance to *Sweet Potato Leaf Curl Virus* in Aliero, Kebbi State, Nigeria. This research work may provide base line information on resistant cultivars to *Sweet Potato Leaf Curl Virus* that could be harnessed by breeders for potato improvement against the menace cause by SPLCV on sweet potato production. (Muturi *et al.*, 2007).

Materials and methods

Experimental site

The experiment was conducted in dry season of 2020/2021 at screen house of Kebbi State University of Science And Technology Aliero. Aliero is located at the (Latitude N 12^0 18'17.61588" and Longtitude E 4^0 2951.37188" Altitude: 268m). The climate of the area is characterized by the high temperature ranging between March and May with annual temperature varying between 38 to 42 ^oC mostly with cold between late November and early February. The area lies in Sudan Savannah agroecological zone of Nigeria with annual rainfall between 500mm to 850mm that support Agricultural activities.

Experimental treatment, design and inoculation

The treatments consisted of three (3) sweet potato ecotypes (Dangote, Dangwaranyo and Danmadakali). The treatments were laid out in a Completely Randomized Design (CRD) with three replicates. Each replicate consisted of three plants of one ecotype giving a total number of nine plants in each replication. The healthy vines were identified and sourced from the local farmers around Gindi and Mayalo Villages of Jega and Mayama local government areas of Kebbi State respectively. The leaves of sweet potato infected with *Sweet Potato Leaf Curl Virus* were mechanically inoculated into the healthy sweet potato plants by the use of carborundum and cotton wool to cause wound to the plants one week after transplanting. Solution of 0.6 M K_2HPO_4 was prepared by dissolving 10.45 g of K_2HPO_4 in 100 mL of sterile distilled water (SDW) while potassium phosphate buffer (Inoculation buffer) was prepared by mixing 80.2 mL of 0.6 M K_2HPO_4 solution with 19.8 mL 0.6 M KH_2PO_4 solution, this was diluted to a final volume of 1000 mL to obtain 0.06 M potassium phosphate buffer. Buffer pH was adjusted to 7.4 with HCl and autoclaved. The buffer was used to prepare virus inoculum for sap inoculation. Sap-inoculation experiments were conducted mechanically and each treatment was comprised of 9 plants for each ecotype giving a total number of 27 inoculated plants. Plants inoculated with buffer alone was serve as controls. The inoculated plants were further observed for symptom development for at least one week before the data collection.

Cultural practices

Diseased-free vine of about thirty (30cm) long was used for transplanting. The transplanting was carried out in a plastic pot containing a good well drained soil mixture. One vine was transplanted in each pot. Weeds were controlled by hand pulling subsequently; weeding was done regularly depending on the weed emergence. Irrigation was done using watering can twice a week.

Data collection

Disease incidence

Disease incidence was calculated according to the method developed by **(**Sseruwagi *et al.*, 2004)

$$\text{Disease incidence (\%)} = \frac{\text{Number of plant with SPLCD}}{\text{Number of plant}} \times 100$$

Disease severity

The severity status was assessed based on the severity rating scale of 1-5 developed by **(**Sseruwagi*et al.*, 2004)

Where;

1- Healthy/symptomless

2-Mild

3-Severe

4-Very Severe

5-Extremly Severe

Data analysis

Data obtained on incidence, symptom severity, mean whitefly population and sprouting ability were subjected to Analysis of variance (ANOVA) while mean was separated using Least Significance Difference (LSD) at 5% level of significance ($P \leq 0.05$).

RESULTS AND DISCUSSION

Disease incidence (%) on sweet potato ecotypes after inoculation with Sweet potato leaf curl virus

All the three ecotypes screened were susceptible to Sweet potato leaf curl virus (SPLCV) because they were infected when inoculated with the virus. There was significant difference at ($P \leq 0.05$)

among the three ecotypes screened for disease incidence due to SPLCV after inoculation (Table 1). Dangote ecotype recorded the highest disease incidence (77.78%) at two weeks after inoculation while, Dangoronyo and Danmadakali ecotypes obtained the lower and same mean disease incidence. Moreover, at 4WAI after inoculation, the results showed thatDangote ecotype obtained the higher mean disease incidence with (88.89%) followed by Dangoronyo with (77.79 %) while Danmadakali recorded the lower disease incidence of (56.67%). At (3WAI) Dangote recorded the highest mean disease incidence with (100.00%) followed by Dangoronyo (77.80 %) and Danmadakali was ranked third with (77.79 %).This is in line with the reports of Hedge *et al.*, (2012) Who reported that, symptoms may appear seasonally and often disappear with time. The higher disease incidence observed on Dangote could be attributed to the susceptibility of the land races. This is in conformity with the findings of ICTVdB Management, (2006) that reported various Ipomoea species were found to be susceptible to SPLCV on their studies.

Disease severity on sweet potato ecotypes after inoculation with sweet potato leaf curl virus

The results in Table 2 showed the disease severity (%) on three potato ecotypes after inoculation with SPLCV. The results showed that there was no significant ($P \leq 0.05$) difference among the potato ecotypes except at 6 WAI. At 6 WAI, Dangote had the highest disease severity (2.88 %) followed by Danmadakali (2.66 %) while the lowest disease severity of (2.33%) was recorded on Dangoronya.

CONCLUSION

The current research findings revealed that, all the ecotypes tested were susceptible to sweet potato to SPLCV infection, except for the Danmadakali ecotype which had some degree of resistance to SPLCV. Therefore, it could be concluded that, Danmadakali ecotype is recommended for the farmers for a better production in the study area coupled with the field sanitation and good agronomic practices which serves as strategies in battle the vector responsible for the transmission of SPLCV.

REFERENCES

Alegbejo, M. D. (2015). Virus and virus-like diseases of crops in Nigeria. Zaria, Kaduna State, Nigeria, Ahmadu Bello University Press Limited, p 272.

Aritua, V., Bua, B., Gibson, R. W., Mwanga, R. O. M. and Adipala, E. (2003). Toward integrated management of sweet potato virus disease: lessons from Uganda. *African Crop Science Conference Proceedings* 6, 307–14.

Austin, D. F. (1988). The taxonomy, evolution and generic diversity of sweet potatoes and related wild species. In P. Gregory (ed.) Exploration, Maintenance and *Utilization of* sweet Potato Generic Resources. CIP, Lima, Peru, pp. 27 – 60.

Gibson, R. W. and Kreuze, J. F. (2015). Degeneration in sweet potato due to viruses, virus-cleaned planting material and reversion: a review. Plant Pathology 64, 1–15.

Huang, J. C. and Sun, M. (2000). Genetic diversity and relationships of sweet potato and its wild relatives In: *Ipomoea batatas* (Comvolvulaceae) as revealed by inter- Simple sequence repeat (1SSR) and restriction analysis of chloroplast DNA. *Theoriorical and Applied Genetics,* 100:1050-1060.

Loebenstein, G. (2015). Control of sweet potato virus diseases. *Advances in Virus Research* 91, 33–45.

Maule, A. J., Caranta, C. and Boulton, M. I. (2007). Sources of natural resistance to plant viruses: status and prospects. *Molecular Plant Pathology* 8, 223– 31.

Muturi, P. W., Mwololo, J. K. and Mburu, M. W. K. (2007). Strategies of maintaining sweet potato nurseries free from insect vectors that spread sweet potato virus disease. *African Crop Science Conference Proceedings* 8, 2071–4

Ndunguru, J., Kapinga, R. and Sseruwagi, P. (2009). Assessing the sweet potato virus disease and its associated vectors in northwestern Tanzania and central Uganda. *African Journal of Agricultural Science* 4, 334–43.

Nwankwo, E. U. and Opara, I. I. M. (2015). The role of virus vectors in orange fleshed sweet potato genotypes infection – a case study. *Global Journal of Science Frontier Research* 15, 2-D.

Ogero, K., McEwan, M. and Jeremiah, S. (2015). Towards Improved Seed System Management: Use of Affordable Net Tunnels and Decentralized Inspection Schemes. Nairobi, Kenya: International Potato Center.

Rey, M. E. C., Ndunguru. J. and Berrie, L. C. (2012). Diversity of dicotyledonous-infecting geminiviruses and their associated DNA molecules in southern Africa, including the south-west Indian Ocean islands. *Viruses* 4, 1753–91.

Schulte-Geldermann, E., Agili, S., Ndolo, P. and Low, J. (2012). Net Tunnels to Protect Sweet potato Planting Material from Disease: A Guide to Construct and Maintain Tunnels. Lima, Peru: International Potato Center, Peru.

Valderde, R. A., Clark, C. A. and Valkonen,J. P. T. (2007). Viruses and virus disease complexes of sweet potato. *Plant Viruses* 1, 116–26.

Woolfe, and Jennifer, A. (1992). Sweet Potato: An Untapped Food Resource. Cambridge, UK: Cambridge University Press and the International Potato Centre (CIP). ISBN 9780521402958.

Yen, D. E. (1982). Sweet potato in historical perspective. In R. L. Villareal and T. D. Griggs (eds.) Sweet Potato. *Proceedings of the First International Symposium*. AVRDC, Tainan, Taiwan, pp. 17-30.

Yen, D. E. (1991). Domestication: The lessons from New Guinea. In A. Pawley, (ed.) Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer. *The Polynesian Society*, Auckland, pp. 558-569.

Table 1: Disease incidence (%) on sweet potato ecotypes after inoculation with sweet potato leaf curl virus during the 2020/2021 dry season.

Ecotypes	**Disease incidence (%)**		
	2 WAI	**4 WAI**	**6 WAI**
Dangote	77.78[a]	88.89[a]	100.00[a]
Dangoronyo	44.44[b]	77.79[b]	77.80[b]
Danmadakali	44.44[b]	56.67[c]	77.79[b]
Control	00.00	00.00	00.00
Sig.	*	*	*
LSD ($P \leq 0.05$)	38.45	64.76	31.37

Mean values with the same letter(s) within a column are no significantly different at (P≤0.05). WAI= Weeks after Inoculation.

Table 2: Disease severity (%) on sweet potato ecotypes after inoculation with Sweet potato leaf curl virus during the 2020/2021 dry season.

Ecotypes	**Disease severity**		
	2 WAI	**4 WAI**	**6 WAI**
Dangote	2.00	2.66	2.88[a]
Dangoronyo	2.10	1.89	2.33[b]
Danmadakali	1.67	2.22	2.66[ab]
Control	00.00	0.00	0.00
Sig.	NS	NS	*
LSD ($P \leq 0.05$)	0.80	1.14	0.48

Mean values with the same letter(s) within a column are no significantly different at (P≤0.05). WAI= Weeks after Inoculation

INFLUENCE OF WEED CONTROL METHOD AND SOWING DATE ON GROWTH PERFORMANCE OF GROUNDNUT (*Arachis hypogea* L.) VARIETIES IN SUDAN SAVANNA

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ABSTRACT
An experiment was carried out in the field at Agricultural Research Farm Tambu-Daura (11^0 33' N, 8^0 23' E and 481m above sea level) in the rainy season of 2024 with a view to investigate the influence of weed control measures and sowing dates on groundnut. The treatments consisted of four weed control methods (application of imazethapyr at 3 and 6WAS, application of imazethapyr + hoe weeding at 3 and 6 WAS, two manual weeding at 3 and 6 WAS, and control), three groundnut varieties (SAMNUT 24, SAMNUT 26, and *Kwan-Kwasiya*) and three sowing dates (4^{th} week of June, 1^{st} Week of July and 2^{nd} week of July, 2024) were used and replicated three times using Split plot design (SPD) layout for all the treatments. The result indicated that groundnut variety had a significant influence on groundnut growth where SAMNUT 24 and 26 were statistically similar but produced significantly ($P \leq 0.05$) higher growth values than the local variety (KWANKWASIYYA). The results also showed that planting groundnuts in the last week of June and the first week of July recorded a significant ($P \leq 0.05$) increase in growth and application of imazethapyr at 3WAS + 1hoe weeding at 6WAS and hoe weeding at 3 and 6WAS were statistically similar but significantly ($P \leq 0.05$) outperformed the other weed control methods tested. Conclusively, the results indicated that sowing of SAMNUT 24 and 26 at June end and the first week of July and application of imazethapyr at 3WAS + 1hoe weeding at 6WAS/2hoe weeding at 3 and 6WAS seems to be most effective in the study area

Keywords: Groundnut varieties, manual weeding, sowing date, weed control methods .

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leguminous crop that is grown in semi-arid and subtropical climates all over the world; it's also an oilseed crop. In Nigeria, the crop is referred to be the "king" of oilseeds. It is one of the most important staple foods and a valuable income crop. According to Vabi *et al.*, (2019), Nigeria's main agro-ecological zones for groundnut production include Sahel, Sudan, northern, southern guinea, and derived savannah. The Sudan Savannah Zone of Nigeria receives most of its groundnut production from small-scale farmers who use poor quality native varieties, limited input, and poor management; as a result, the yield of groundnuts has remained low (Mitchell and Donald, 2012). The production of groundnut yield in Nigeria was not encouraging between 1990 and 2015; no substantial increase in yield was observed. This could have been caused by local farmer's attitude of continuing to use poor groundnut varieties, the impact of weeds, pests, and diseases, the farmers' use of weed control techniques and the proper timing of sowing (FAO, 2021). Nigeria grows groundnuts under rain-fed, dry season circumstances in its northern regions and solely wet season conditions in its southern regions. The same climatic factors that make groundnut cultivation feasible during the rainy season also hold true in the savanna zones during the dry season, and irrigation offers a sufficient amount of water to satisfy the moisture requirements of groundnuts (Ibrahim *et al.*, 2021). The crop has a very low mineral content and is incredibly high in oil, protein, fatty acids, carbohydrates, and vitamins. Nutritionally, it is quite valuable (Ibrahim *et al.*, 2021). Gulluoglu *et al.*, (2016a) reported that groundnuts contain 45–55% oil, 20–25% protein, 16–18% carbs, and 5% minerals. Nigeria is the top producer of groundnuts in West Africa, accounting for 51% of the crop (Vabi *et al.*, 2019). With an average yield of 1649 kg ha^{-1}, groundnut production reached 48.8 million tonnes worldwide in 2019 from29.6 million hectares (FAO, 2021).Nigeria produced 4.4 million tonnes of groundnuts in 2019, ranking third globally after China (17.1 million tonnes) and India (6.7 million tonnes), according to the FAO 2021 annual groundnut output report (FAO, 2021).

Bolaji and Emmanuel (2016) stated that weed infestation is one of the main barriers to groundnut production and that early weeding is necessary due to the crop's failure to develop a crop canopy, which would effectively shade the ground and prevent weed growth. Before herbicides were developed, African farmers used a manual method termed traditional hoeing to manage weeds. This was reported by Chikoye *et al.*, (2007). Weeds caused output losses by up to 40% and decreased the efficiency of harvesting groundnuts (Clewis *et al.*, 2007). Research indicates that weeds typically impair production by 30%, and that improper management techniques might result in a 60% yield loss (Bedry, 2007).

According to Sajo and Mohammed (2004), farmers actually begin planting as soon as the rains arrive and continue until the end of July. They plant in various locations based on the type and maturity time of the crop, and if caution is not exercised, this planting may be lost. The purpose of this study was to determine how the planting date and weed management methods used in Sudan Savannah Zone affected the groundnut *(Arachis hypogea* L.) on growth in the study area.

MATERIAL AND METHODS

Field experiment was conducted during 2024 rainy season at Agricultural research farm Tambu-Daura and 4x3x3 factorial combination of treatments were used (SAMNUT 24, SAMNUT 26, and KWAN-KWASIYA), four weed control methods (application of Imazethapyr at 3 and 6 WAS, application of Imazethapyr at 3 WAS + 1 hoe weeding at 3 and 6WAS, Manual weed control at 3 and 6WAS and Control, three sowing dates June ending (24th June), first week of July (4th July), and second week of July (14th July). Weed control methods and varieties were allocated to main plots while sowing dates were put in the sub plots and was factorized and laid out in a split plot design (SPD) and replicated three times. Prior to the conduct of the trial soil samples were collected randomly from the experimental site at 0 - 30 cm soil depths diagonally across the field. The composite sample was analyzed for some physical and chemical properties using standard procedures as described by (Black, 1968). The soil of the area is sandy loamy. Data on rainfall distribution, temperature, sunshine and relative humidity for the growing seasons were collected. The field was cleared, harrowed, and ridged. The ridges were also sub-divided into plots of 6 ridges per plot at 9 meters in length and 4.5m width for main plot and 3m x4.5m as sub plot while the net plot consisting of two inner rows at a spacing of 0.75m x 3 x 2 = 4.5m. A Pass way of 1 m was made between the boundary of the trial site and 1m between the replications. The seeds of the two varieties (SAMNUT 24 and SAMNUT 26) were sourced from Katsina State Agricultural and Rural Development Authority (KTARDA) while the local variety (*Kwankwasiya*) was sourced from the market. The seeds were treated with Difenoconazole at 10g per 3 kg of seed to protect the seeds against soil pathogens and pests. The seeds were sown manually at inter and intra-row spacing of 75 cm x 15 cm at 5 cm depth using two seeds per hole. The seeds were sown on 24th June, 4th July and 14th July, NPK fertilizer at the rate of 30:30:30 was applied three weeks after sowing. At 3 and 6 WAS weed control were made as per treatment. The data on plant growth were collected at 3, 6, and 9WAS from five (5) tagged plants per plot the data collected were subjected to statistical analysis of variance (ANOVA) as described by Gomez and Gomez. (1984) using SAS package version 9.0. The treatment means were separated for the significant difference using Duncan Multiple Range Test (DMRT) Duncan, (Duncan, 1955) at 5% level of probability ($P \leq 0.05$).

RESULTS

The effect of weed control methods and sowing date on number of leaves and number of branches per plant of three groundnut varieties at 3, 6 and 9WAS is presented in Table 1. The results indicated that SAMNUT 24 and SAMNUT 26 are statistically similar and significantly (P>0.05) performed better than local variety (*Kwankwasiya*) in terms of number of leaves and number of branches per plant at 3, 6 and 9WAS. However, among the three number of sowing date evaluated sowing dates at the end of June and at 1st week of July were statistically the same but considerably performed better than sowing date at 2nd week of July with a significant value. On weed control methods the result revealed that Application of imazethapyr at 3WAS + 1hoe weeding at 6WAS significantly (P<0.05) outperformed better than 2hoe weed control method at 3 and 6WAS and application of imezathapyr at 3 and 6WAS consequently weedy check was found to be the weakest method of weed management in all the parameters measured. All the interactions were not significant (P>0.05) at both locations (Table 1).

Plant height and canopy spread had a significant effect ($P \leq 0.05$) on variety (Table 2). The result indicated that SAMNUT 24 recorded the highest value on plant height and canopy spread per plant followed by SAMNUT 26 while the lowest value was recorded from the local variety (KWANKWASIYYA) except plant height at 3WAS and canopy spread per plant at 9WAS both SAMNUT 24 and SAMNUT 26 are statistically the same but significantly ($P \leq 0.05$) higher than *Kwankwasiyya*. Planting of groundnut at the end of June recorded a significant increase in plant height and canopy spread per plant while the sowing date at 1st week of July became second best followed by 2nd week of July respectively, although at 6 and 9WAS the results shows that the two sowing dates (end of June and 1st week of July) were statistically similar but still they are far better than sowing date at the 2nd week of July on plant height and canopy spread per plant. However, manual method of weed control using hoe had a significant effect ($P \leq 0.05$) on plant height and canopy spread at 3, 6, and 9WAS, followed by application of imazethapyr at 3WAS + 1hoe weeding @6WAS while the least value was obtained from the control plots. All the interactions were not significant ($P \geq 0.05$) at both locations Table 2.

DISCUSSION

The results indicate that SAMNUT 24 and SAMNUT 26 exhibit statistical similarity in some of the growth parameters tested, except two areas where SAMNUT 24 was found to be superior to all other varieties evaluated. Plant height at 6 and 9WAS and canopy spread per plant at 3 and 9WAS. The genetic makeup of the crop may be the reason for this superiority displayed by SAMNUT 24 over SAMNUT 26 and the local variety. However, the similarities between SAMNUT 24 and SAMNUT 26 on growth could be interpreted as evidence of their similarity in terms of growth performance, and their high potential ability to utilize photosynthesis and assimilation over local variety (KWANKWASIYYA). These results are consistent with the findings of Ajeigbe *et al.* (2015), which state that the groundnut varieties (SAMNUT 24, KWANKWASIYYA and SAMNUT 26) differ in terms of their genetic composition as well as their physiological capacity for growth and yield. According to Patel *et al.* (2008), there are variations in the potential growth and production of groundnut types. There was a significant difference in the planting date of groundnuts across a few investigated parameters; this could have been caused by seasonal temperature fluctuations, which are linked to variables that promote growth and development (photosynthesis). This supports the findings of Stalker (1997) who found that although groundnut does not seem to be particularly sensitive to day length; it requires a lot of sunshine and warmth for normal development. Generally, lengthy days result in more blossoms being produced. The results of the testing of various weed control techniques also showed that the application of imazethapyr at 3WAS + 1hoe weeding at 6 WAS resulted in much higher groundnut growth than the application of imazethapyr twice at 3 and 6 WAS and weedy check, which had lower values in all growth components. This may be because there are many different types of weeds in groundnut fields, each with unique properties. It could also be explained that the fact that physical weeding encourages plants to develop and produce more oxygen through aeration, water, light, and nutrient intake. These results are consistent with those of Mubarak (2004), who found that twice-weeded crops had better growth components. This could be explained by robust plants that have less competition from weeds for light, nutrients, and available space. But according to Kumar *et al.*, (2013), pre-emergent pendimethalin treatment combined with manual weeding at 45 degrees above the soil surface (DAS) assisted in weed management, potentially lowering competition amongst weed crops for soil moisture, light, nutrients, and space.

CONCLUSION

SAMNUT 24 and SAMNUT 26 had comparable growth rates but are still significantly superior to the local variety (KWANKWASIYYA). The results also showed a significant difference in the planting date, but groundnut sown at the end of June and the first week of July performed better than those sowed during the second week of July. Application of imazethapyr at 3 WAS + 1hoe weeding at 6 WAS and hoe weeding at 3 and 6 WAS gave, significantly higher growth values of groundnut than other control methods. Consequently, it is appropriate to sow SAMNUT 24 or SAMNUT 26 in the study area at the end of June and the first week of July, along with the application of imazethapyr at 3WAS + 1hoe weeding at 6 WAS for weed control.

REFERENCES

Ajeigbe, H. A.; Waliyar, F.; Echekwu, C. A.; Ayuba, K.; Motagi, B. N.; Eniayeju, D. and Inuwa A. (2015). A Farmer's Guide to Groundnut Production in Nigeria. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 36. https://oar.icrisat.org/id/eprint/8856

Bedry K. A., (2007). Effect of weeding regimes on faba bean (*Viciafaba*l.) yield in the Northern State of Sudan. University of Khartoum Journal of Agricultural Science, 15: 220-231.

Black, C. A. (1968). Methods of Soil Analysis. Part I, American Society of Agronomy. Madison, Wisconsin USA. 1572 p. https:// www. Sciepub.com/reference/98568

Bolaji Umar Olayinka and Emmanuel Obukohwo Etejere (2016).Weed Control Methods affect Growth, Yield andEconomic Returns in Groundnut.*Annals of West University of Timişoara, ser. Biology, vol. 19 (1), pp. 17-24*

Chikoye D., Ellis-Jones J., Riches C., Kanyomeka L. (2007). Weed management in Africa experiences, challenges and opportunity. *XVI International Plant Protection Congress, 652*-653.

Clewis, S.B., Everman, W.J., Jordan, L.D. and Wilcut, J.W. (2007). Weed Management in North Carolina Peanut (*Arachishypogaea*L.) with S-metolachlor, Diclosulam, Fiumioxazin and Sulfentrazone system. *Weed Technology* 21:629-635.

Duncan, D. B. (1955). Multiple Range and Multiple F test Biometrics 11, 1- 42. https://doi.org/10.2307/301478 https://www.jstor.org/stable/3001478

FAO. (2021). Faostat. Retrieved May 13, 2021 http://www.fao.org/faostat/en/#data/QC

Gulluoglu, L., H. Bakal, B. Onat, C. Kurt, and H. Arioglu(2016a). Effect of Harvesting Dates on Yield and Some Agronomic and Quality Characteristics of Peanut Grown in Mediterranean Region (Turkey).*Turk J Field Crops*, 21(2): 224-232 DOI:10.17557/tifc.20186)

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. 2nd Edition, John Wiley and Sons, New York, 680 p. http://www.scrip.org/reference/ReferencesPapers?ReferenceID=2253

Ibrahim A.M., Sanusi J., Adesoji A.G, (2021). Influence of variety, intra-row spacing and irrigation interval on growth and yield of groundnut (*Arachis hypogaea* L.) at Sudan Savannah Zone of Nigeria. *Fudma journal of science* (FJS), Vol. 5(1), pp 395-403. https://doi.org/10.33003/fjs-2021-0501-xxx

Kumar, Y., R. Saxena., K. C. Gupta., V. D. Fagaria and R. Singh, (2013). Yield attributes and yield of groundnut (*Arachis hypogaea* L.) as influenced by weed management practices in semi-arid region. *J. Crop Weed.* **9**:185-89. https://oar.icrisat.org/id/eprint/9356

Mitchell, C.C. and Donald, J. 0. (2012). The Value and Use of Poultry Manures as Fertilizer. Alabama Cooperative Extension System Circular ANR-244 (11/95). Alabama A & M and Auburn Universities.

Mubarak H. A., (2004). Studies on weed management in irrigated groundnuts (*Arachis hypogaea* L) In Sudan. Ph.D. Thesis. Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, 109pp.

Patel, P.G., Patel, V.A., Chaudhari, P.P. and Patel, A.M. (2008). Effect of different weed control methods on weed flora, growth and yield of summer groundnut (*Arachis hypogaea* L.) In: Biennial conference on weed management in modern agriculture, Emerging challenges and opportunity, 27-28 February, Organized by ISWS, NRCWS, Jabalpur (M.P.) and Ranjendra Agricultural University, Pusa (Bihar) Pp.150.

Stalker, H.T. (1997). Peanut (Arachis hypogaea L.). *Field Crops Research* 53:205-217.

Sajo and Mohammed (2004).Effect of Date of Planting on The Performance of Groundnut *(Arachishypogaea)* In Yola Adamawa State. Nig. J. Biotechn. 15(I): 72 -82

Vabi, B.M., Mohammed S.G., Echekwu C.A., Mukhtar A.A., Ahmed B., Ajeigbe, H.A. and Eche C.O. (2019). Best choices for enhancing groundnut productivity in Nigeria. ICRISAT Patencheru. 30 pp. https://oar.icrisat.org/id/eprint/7531

Table 1: Effect of variety, sowing date and weed control method on number of leaves and Number of branches per plant at 3, 6 and 9 WAS at Tambu-Daura during the 2024 rainy season

Treatment	Number of Leaves per Plant			Number of Branches per Plant		
	Weeks after sowing (WAS)					
	3	6	9	3	6	9
Varieties (V)						
SAMNUT 24	28.83[a]	29.36[a]	92.60[a]	7.69[a]	8.89[a]	12.94[a]
SAMNUT 26	28.08[a]	29.47[a]	91.10[a]	7.55[a]	8.72[a]	12.64[a]
Kwankwasiyya	22.36[b]	25.44[b]	79.50[b]	5.97[b]	7.50[b]	10.56[b]
S.E(±)	0.75	0.63	2.76	0.17	0.30	0.52
Level of Significance	**	**	*	**	**	**
Sowing date (T)						
4th Week of June	27.31	28.72[a]	94.20[a]	7.78[a]	9.00[a]	12.81[a]
1st Week of July	25.89	29.17[a]	90.60[a]	7.25[b]	8.69[a]	12.72[a]
2nd Week of July	26.08	26.39[b]	78.40[b]	6.19[c]	7.42[b]	10.61[b]
S.E(±)	0.75	0.63	2.76	0.18	0.30	0.52
Level of Significance	NS	*	*	**	**	**
Weed control method (W)						
Imazethapyr at 3 and 6 WAS	27.48	29.74[a]	84.80[b]	7.85[a]	8.56[b]	11.22[b]
Imazethapyr at 3 +HW at 6WAS	26.41	29.78[a]	97.47[a]	7.85[a]	9.74[a]	13.78[a]
Hoe weeding at 3 and 6 WAS	26.89	27.67[a]	95.87[a]	6.85[b]	7.59[c]	13.63[a]
Weedy check	24.93	25.19[b]	72.80[c]	5.74[c]	7.59[c]	9.56[c]
S.E(±)	0.87	0.72	3.19	0.20	0.35	0.60

Level of Significance	NS	**	**	**	**	**
Interaction						
V × T	NS	NS	NS	NS	NS	NS
V × W	NS	NS	NS	NS	NS	NS
W × T	NS	NS	NS	NS	NS	NS
V × T × W	NS	NS	NS	NS	NS	NS

Note *= Significant, NS= Not Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

Table 2: - Effect of variety, sowing date and weed control method on plant height and canopy spread per plant at 3, 6 and 9WAS at Tambu-Daura during the 2024 rainfed season

	Plant height (cm)			Canopy spread (cm)		
	Weeks after sowing (WAS)					
Treatment	3	6	9	3	6	9
Varieties (V)						
SAMNUT 24	9.44[a]	18.92[a]	32.22[a]	6.42[b]	10.47[a]	13.94[a]
SAMNUT 26	9.53[a]	16.94[b]	28.78[b]	7.39[a]	9.47[b]	13.39[a]
Kwankwasiya	7.69[b]	12.06[c]	26.31[c]	5.78[b]	8.14[c]	11.39[b]
S.E(±)	0.33	0.67	1.09	0.40	0.44	0.57
Level of Significance	**	*	*	*	**	*
Sowing Date (T)						
4th Week of June	10.78[a]	17.61[a]	29.64[a]	7.94[a]	9.94[a]	13.50
1st Week of July	8.08[b]	16.89[a]	30.36[a]	5.94[b]	9.94[a]	13.14
2nd Week of July	7.81[c]	13.42[b]	27.3[b]	5.69[b]	8.19[b]	12.08
S.E(±)	0.33	0.67	1.09	0.40	0.44	0.57
Level of Significance	**	*	*	*	**	NS
Weed control method (W)						
Imazethapyr at 3 and 6 WAS	9.22	15.07[b]	29.48[a]	6.63	9.70[b]	12.67[c]
Imazethapyr at 3 +HW 6WAS	8.70	15.67[b]	31.00[a]	6.96	8.56[b]	13.81[b]
Hoe weeding at 3 and 6 WAS	8.93	19.70[a]	31.44[a]	6.44	11.81[a]	15.59[a]
Weedy check	8.70	13.44[c]	24.48[b]	6.07	7.37[c]	9.56[d]
S.E(±)	0.38	0.77	1.26	0.46	0.51	0.66
Level of Significance	NS	**	*	NS	*	*
Interaction						
V × T	NS	NS	NS	NS	NS	NS
V × W	NS	NS	NS	NS	NS	NS
W × T	NS	NS	NS	NS	NS	NS
V×T × W	NS	NS	NS	NS	NS	NS

Note *= Significant, NS= Not Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

SURVEY ON THE INCIDENCE AND SEVERITY OF TERMITE ON TREES IN BEBEJI LOCAL GOVERNMENT AREA

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ABSTRACT

Termites are group of social insects that are known for their ability to feed on wood and other materials containing cellulose, making them a significant pest in many parts of the world. The objective of this study is to determine the incidence and severity of termites on trees and shrubs in Bebeji Local Government Area of Kano State. The sampling procedure used in the study area was cluster sampling technique and the severity of infestation was assessed based on a scale of 1 to 5 severity rating scale. Assessment were based on visual rating scale that is 0% = no attack, 1-25% = low damage, 26-50% = moderate damage, 51-75% = high damage and 76-100% = very high damage. The results of this study show that, Gmelina *arborea* (Gmelina) and Mango trees (*Mangifere indica*) were highly susceptible to termite damage, while species like *Ziziphus obtusifolia* (Lot-bush) and *Khaya senegalensis* (Mahogany) exhibit resistance, likely due to natural compounds in their wood. Other species showed varying levels of susceptibility, with factors like environmental conditions and tree anatomy playing a role. In conclusion, the environmental conditions and tree anatomy play crucial roles in determining susceptibility. While some species exhibit natural resistance, others are highly vulnerable. It's recommended that, promoting the planting of termite-resistant species could help mitigate damage in affected areas. Integrated pest management approaches should be explored, including cultural practices, biological controls, and judicious use of chemical treatments. Public awareness campaigns could also be beneficial to educate communities on the importance of tree species selection in areas prone to termite infestation.

Keywords: Termite, infestation, food crops, trees, shrubs

INTRODUCTION

Termites are a group of detritophagous eusocial insects which consume a variety of decaying plant material, generally in the form of wood, leaf litter, and soil humus. Termites, belonging to the order Isoptera, with a rich evolutionary history that spans over 250 million years (Thorne *et al*., 2003). This diverse group of insects is renowned for its remarkable ability to shape ecosystems through intricate social structures, sophisticated behaviours, and ecological contributions. The evolution of termites is of great interest, due to their diversity of diet, social structures, and phenotypes. Termites evolved from wood-feeding cockroaches, and form a sister group with the cockroach genus *Cryptocercus* (Lo *et al.,* 2000). The precise timing of the appearance and subsequent diversification of termites is not well understood, although fossil records do provide a glimpse into the evolutionary history of these insects. The first undisputed termite fossils are from the early Cretaceous, 110–135 Ma, and all belong to Mastotermitidae, Hodotermitidae, Kalotermitidae or to extinct families (Krishna *et al*. 2013). The oldest known fossil of Rhinotermitidae is *Archeorhinotermes* from the mid-Cretaceous, 98 Ma (Krishna and Grimaldi 2003; Krishna *et al*. 2013). The first Termitidae fossil is much more recent and dated to the early Eocene, 50 Ma (Engel *et al*., 2011).

Termites, as integral components of tropical ecosystems, play a crucial role in nutrient cycling and decomposition. However, their activities can also have detrimental effects on trees, causing structural damage and influencing overall forest dynamics. Termites, particularly those belonging to the family Termitidae, are known for their wood-feeding habits. They tunnel through the wood, creating galleries and compromising the structural integrity of trees. The extent of damage varies among termite species and tree types, with certain species being more aggressive in their foraging behavior (Jones & Eggleton, 2000). In severe cases, termite damage can contribute to tree mortality (Evans *et al*., 2013). The loss of mature trees can have cascading effects on the forest ecosystem, affecting habitat structure and biodiversity (Su, 2003). Additionally, termites may influence the regeneration of trees by targeting seedlings and saplings, impacting the composition of tree species within a given area (Eggleton *et al*., 1997). Termite activity can contribute to changes in forest structure. Mound-building termites, in particular, create prominent physical structures that alter the topography of the landscape. The construction of termite mounds influences water flow, soil composition, and vegetation patterns, leading to a modified forest environment (Jones and Eggleton, 2000; Abe *et al*., 2000). In Nigeria, an estimate of the annual loss caused by termite attacks is currently unavailable due to the difficulty in collecting such information from individual (Jouquet *et al*., 2011). However, there has been an increased appreciation of the importance of termite damage to farms, orchards and this has resulted in the use of Solignum and used engine oil as a preventive measure during construction and planting of trees in a vegetation and shelterbelt establishment. In Kano South region, Bebeji local government area inclusive a diverse array of trees and shrubs contribute to the local ecosystem, understanding the incidence and severity of termite infestation becomes imperative. This study endeavors to investigate the impact of termite activity on trees and shrubs in Bebeji local government area of Kano State, shedding light on the specific dynamics of termite-vegetation interactions in this region. The specific objectives of this study are rooted in the need to quantify the prevalence and severity of termite infestation, identify the species responsible for the damage, and explore the environmental factors influencing termite activity.

METHODOLOGY

Description of the study area

Bebeji local government area is located in the southern part of Kano State, western region of Nigeria. It has an area of 717 km2 and a population of 188,859 according to the 2006 census. The headquarters of Bebeji LGA is in the town of Bebeji, which is located 45 km southwest of Kano, the state capital. The coordinates of Bebeji town are 11°40′N 8°16′E. The survey on incidence and severity of termites on trees was conducted in Bebeji local government area. Three farmlands were randomly selected for the survey.

Sampling Procedure

Prevalence of termite infestation on examined trees and their presentations

The sampling procedure used in the study area was cluster sampling technique according to Nasiru *et al*., (2015). The presence of mud tubes or arboreal nests will be equal to an infestation (Ugbomeh *et al.,* 2019). Five clusters were selected, and the size of each selected clusters was 10m × 10m. In each, the following parameters were measured;

- Total number of trees in each cluster,
- Total number of trees infested and
- Total number of non-infested trees were counted and recorded.

Sample collection for identification

Samples of termites were collected by cutting open and collecting termites from mud tubes and nests on live and dying trees. All samples collected were sorted, labelled and preserved in 70% formalin and it was taken to laboratory for identification.

Severity assessment

For infested plants, the severity of infestation was assessed based on a scale 1 to 5. Assessment were based on visual rating scale that is 0% = no attack, 1-25% = low damage, 26-50% = moderate damage, 51-75% = high damage and 76-100% = very high damage.

Data analysis

The data obtain was subjected to analysis using descriptive statistic tools such as percentage and frequency distribution table using IBM SPSS V16 × 86V version.

RESULTS

Severity of damage caused by termites to the identified trees and shrubs in Bebeji LGA

The result of the survey (severity) was presented in table (1). In Bebeji Local Government Area, farm 1, there was 66.7% severity on the first cluster dominated by *Gmelina arborea*

(Gmelina tree) (Highly damaged) as shown in Table 1. In the second cluster, the tree identified is Zizziphus obtusifolia (Lot-bush tree), with 20% severity (Low damage). However, the highest severity of 88.9% in the fourth cluster, with *Gmelina arborea* (Gmelina) as the tree identified.

In Farm 2, *Acacia nilotica* (Gum Arabic tree) was reported to have high incidence of termite damage with 40% severity (Moderate damaged). However, the highest and the lowest severity index of 50% and 25% in second and fourth cluster respectively as shown in Table 2. Lastly, Lemon Scented Gum (*Corymbia citriodora*) was reported to have higher severity percentage 50% in Farm 3 in cluster 3 at Bebeji LGA (Table 3). The lowest was recorded on *Gmelina arborea* in cluster four with severity index of 28.6%.

DISCUSSION

This study delineated the severity of termites' infestation on trees in Bebeji Local Government Area. *Gmelina arborea* (Gmelina) suffers from the highest damage severity in most of the clusters. While termites can be a threat, other factors like diseases, pests, or environmental stressors could also be involved. These align with Kumar *et al*., (2018) who reported in their studies that Gmelina is susceptible to various diseases and pests, including termites. In another study, *Ziziphus obtusifolia* (Lot-bush) and *Khaya senegalensis* (Mahogany) exhibit lower damage level of 20% severity index, suggesting potential resistance to the damaging agent such as termites (Nasiru *et al.*, 2015). This is in agreement with the study by Ahmed *et al*., (2012) who reported in their study that, the presence of antifeedant and insecticidal compounds in various Meliaceae species, including *Khaya senegalensis* might deter termite feeding to some extent. It also align with the study by Kumar *et al.*, (2010) who reported in their studies on Khaya's wood anatomy can provide clues about its potential resilience, that anatomical features like high wood density and the presence of extractives (compounds embedded in wood) can offer some resistance to termite attack. The resistance compounds was also reported by Moyo *et al*. (2022) on *Ziziphus* species who suggested that *Ziziphus* species might possess other inherent defence mechanisms such as chemical defences or physical attributes that could offer broader resilience against various threats, potentially including termite attack to some extent.

The damage of 80% severity was reported on *Corymbia citriodora* (Lemon scented gum) also suffers from high damage indicating a potential threat, but the cause remains unclear without further investigation. *Acacia nilotica*, and *Anacadium occidentale* they were also reported to be moderately damaged by termites which shows they are susceptible to termite attack. This is in agreement with the studies of Kumar and Kushwaha, 2010 who reported in their separate study that *Acacia nilotica* (Gum Arabic tree) have vulnerability to termite attack. This work is also in agreement with the study by Jeb et al., 2019 who reported that *Anacadium occidentale* (Cashew) have susceptibility to termite damage. In our experiment, Neem tree was shown to be moderately damaged by termites in Bebeji LGA. However, neem trees were shown to possess a chemical compound responsible for its less susceptibility to termite damage. According to National Research Council of USA, (1992), *Azadirachta indica* (Neem tree) are generally considered termite-resistant due to the presence of the natural insecticide *azadirachtin*, they can still be susceptible to termite attack under certain conditions.

In addition, *Acerola Cherry* (Barbados cherry), there is 50% severity termite damage, which shows that they are susceptible to termite attack although other factors like fungal diseases or nutrient deficiencies can also contribute to the damage. This is in agreement with the study by McManus, 2010, who reported in his study that, termites can infest Mango trees, particularly subterranean species that attack the roots and lower trunk. Similarly, kumar *et al*., (2021) reported that mango trees are susceptible to termite attacks, especially younger trees. However, other insects and diseases can also cause similar damage (Food and Agriculture Organization of the United Nations, 2002). According to Yêyinou *et al*., (2017), *Psidium guajava* (Guava), there was 30% severity of termite attack which shows that termite can attack guava under some condition although it is known to be resistance to termite attack. Similarly, Verma and Tomar, 2019 reported that, termites can attack guava trees under stress. Lastly, *Acacia farnesiana* (Aroma Tree) was observed to have moderate severity in Bebeji Local Government Area in this study and that of Fakae *et al*., 2017. Although, Hussain *et al.*, (2011) who reported that, Aroma tree has some level of resistance to termites due to its spiny nature and presence of secondary metabolites.

CONCLUSION

Environmental conditions and tree anatomy play crucial roles in determining susceptibility to termite infestation. While some species exhibit natural resistance, others are highly vulnerable. Further research is needed to understand the mechanisms of resistance and develop effective management strategies.

REFERENCES

Abe, T., Bignell, D. E., & Higashi, M. (2000). Termites: Evolution, sociality, symbioses, ecology. Springer.

Eggleton, P., Davies, R. G., Connetable, S., Bignell, D. E., Rouland, C., & Bordereau, C. (1997). The termites of the Mayombe Forest Reserve, Congo (Brazzaville): transect sampling reveals an extremely high diversity of ground-nesting soil feeders. *Journal of Tropical Ecology*, 13(6), 795-802.

Engel MS, Grimaldi DA, Nascimbene PC, Singh H. The termites of Early Eocene Cambay amber, with the earliest record of the Termitidae (Isoptera), ZooKeys, 2011, vol. 148 (pg. 105- 123).

Evans, T. A., Forschler, B. T., & Grace, J. K. (2013). Biology of invasive termites: a worldwide review. *Annual Review of Entomology*, 58, 455-474.

F.O. Ayuke, M.M. Pulleman, B. Vanlauwe, R.G.M. de Goede, J. Six, C. Csuzdi, L. (2002). Brussaard, Agricultural management affects earthworm and termite diversity across humid to semi-arid tropical zone.

Fakae, O. A., Akintola, A. J., & Ogunwusi, A. A. (2017). Effects of neem seed oil, engine oil and termite shield on the mortality of Macrotermes bellicosus (Smeathman) (Isoptera: Termitidae). *Journal of Entomology and Zoology Studies*, 5(6), 1422-1426.

Hussain A, Ahmed S, Shahid M. (2011). Laboratory and field evaluation of Metarhiziumanisopliaevar. anisopliaefor controlling subterranean termites. *Neotropical Entomology* 40(2): 244-50.

Jeb, H., Ramli, A. S., & Rahim, R. A. (2019). Evaluation of potential of local plant extracts as termite repellents. *Pertanika Journal of Tropical Agricultural Science*, 42(4), 1670-1681.

Jones, D. T., and Eggleton, P. (2000). Sampling termite assemblages in tropical forests: testing a rapid biodiversity assessment protocol. *Journal of Applied Ecology*, 37(1), 191-203.

Jouquet, P., Traoré, S., Choosai, C., Hartmann, C., & Bignell, D. (2011). Influence of termites on ecosystem functioning. Ecosystem services provided by termites. *European Journal of Soil Biology*, 47(4), 215-222.

Krishna K, Grimaldi DA, Engel MS. Treatise on the Isoptera of the world: Vol 1, *Introduction, Bull Am Mus Nat Hist*., 2013, vol. 377 (pg. 1-200).

Krishna K, Grimaldi DA. (2003). The first Cretaceous Rhinotermitidae (Isoptera): a new species, genus, and subfamily in Burmese amber, Am Mus Novit., 2003, vol. 3390 (pg. 1-10)

Kumar, A., Singh, S. K., and Dwivedi, S. K. (2018). Screening of *Gmelina arborea* genotypes for resistance against major insect pests and diseases under field conditions.

Kumar, S., and Kushwaha, K. S. (2010). Antifeedant and insecticidal activities of *Melochia corchorifolia* L. leaves against subterranean termite, Odontotermes obesus (Rambur). *Journal of Entomological Research*, 34(1), 71-75.

Kumar, S., and Upadhyay, R. K. (2021). Anti-termite potential of various bio-organic constituents with special reference to family asteraceae. *World Journal of Pharmaceutical Research*, 10, 1109-1149.

Lo N, Tokuda G, Watanabe H, Rose H, Slaytor M, Maekawa K, Bandi C, Noda H. Evidence from multiple gene sequences indicates that termites evolved from wood-feeding cockroaches, Curr Biol., 2000, vol. 10 (pg. 801-804).

Moyo, B., Adugna, T., and Gebreslasie, M. (2022). Comparative assessment of drought tolerance mechanisms in *Ziziphus mauritiana* and *Ziziphus spina-christi*.

Nasiru A. M, Shehu, K., Salau, I.A., Aliyu, U., & Abdullahi, S (2015). Infestation of Termites on *Azadirachta indica* (Neem) in Forest Plantation of Wamakko Local Government in Sokoto, Nigeria.

National Research Council (US). (1992). Neem: A tree for solving global problems. Washington, DC: National Academies Press.

Thorne, B. L., Traniello, J. F., Adams, E. S., & Bulmer, M. S. (2003). Reproductive dynamics and colony structure of subterranean termites of the genus *Reticulitermes* (Isoptera: Rhinotermitidae): a review of the evidence from behavioral, ecological, and genetic studies. *Ethology, Ecology and Evolution*, 15(2), 135-149.

Ugbomeh, A. P., Membere, O., Efuka, A., and Bawo, D. D. S. (2019). A rapid survey of the arboreal termites in a university environment in Port Harcourt, Nigeria. *The Journal of Basic and Applied Zoology*, 80(1), 1-6.

Yêyinou Loko, L.E., Orobiyi, A., Agre, P. (2017).Farmers' perception of termites in agriculture production and their indigenous utilization in Northwest Benin. *Journal of Ethnobiology Ethnomedicine* 13, 64. https://doi.org/10.1186/s13002-017-0187-2.

Table 1: Farm 1, Bebeji Local Government Area

Cluster	Common Name of Trees	Scientific Name	Total Trees	Total Healthy	Total Incidence	Severity (%)	Remark
1	Gmelina	*Gmelina Arborea*	6	2	4	66.7	High Damage
2	Lot- bush	*Zizziphus obtusifolia*	10	8	2	20.0	Low Damage
3	Mahogany	*Khaya senegalensis*	8	6	2	25.0	Low Damage
4	Gmelina	*Gmelina arborea*	9	1	8	88.9	Very High Damage
5	Lemon scented gum	*Corymbia citriodora*	5	1	4	80.0	Very High Damage

Source: Field Survey, 2023.

Table 2: Farm 2, Bebeji Local Government Area

Cluster	Common Name of Trees	Scientific Name	Total Trees	Total Healthy	Total Incidence	Severity (%)	Remark
1	Gum Arabic	*Acacia nilotica*	10	6	4	40.0	Moderate Damage
2	Aroma tree	*Acacia farnesiana*	6	3	3	50.0	Moderate Damage
3	Cashew	*Anacadium occidentale*	11	7	4	36.4	Moderate Damage
4	Lot bush	*Zizziphus obtusifolia*	4	3	1	25.0	Low Damage

5	Lemon scented gum	*Corymbia citriodora*	6	4	2	33.3	Moderate Damage

Source: Field Survey, 2023.

Table 3: Farm 3, Bebeji Local Government Area

Cluster	Common Name of Trees	Scientific Name	Total Trees	Total Healthy	Total Incidence	Severity (%)	Remark
1	Lot Bush	*Zizziphus obtusifolia*	5	3	2	40.0	Moderate Damage
2	Mahogany	*Khaya senegalensis*	8	5	3	37.5	Moderate Damage
3	Lemon Scented Gum	*Corymbia citriodora*	6	3	3	50.0	Moderate Damage
4	Gmelina	*Gmelina arborea*	7	5	2	28.6	Low Damage
5	Neem	*Azadirachta indica*	10	6	4	40.0	Moderate Damage

Source: Field Survey, 2023.

COMPOST RATES AND IRRIGATION INTERVALS ON THE YIELD AND YIELD COMPONENTS OF ONION (*Allium cepa* L.) AT KANO, SUDAN SAVANA OF NIGERIA

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ABSTRACT

The field trial was conducted during the 2017 dry season from March to June in Birji Community, Madobi Local Government Area (11^{0}46'38" N 8^{0}17'18" E), Kano State within Sudan Savannah of Nigeria. The aim was to determine the response of onion (*Allium cepa* L.) to compost rates and irrigation intervals. The treatments consisted of five rates of compost (0, 5, 10, 15 and 20 t ha^{-1}) and three irrigation intervals (5, 10 and 15 days). The treatments were laid out in a split plot design with three replications. Irrigation intervals was assigned to the main plots while compost rate was assigned to sub plots. Data were collected on bulb diameter, average bulb weight, fresh and cured bulb yield and subjected to analysis of variance (ANOVA) using GenStat 17th Edition. Treatment means were separated using Student-Newman-Keuls Test. The results showed that compost application and irrigation intervals had significant effects on the parameters investigated. Application of 10 t ha^{-1} of compost and 5 days of irrigation intervals produced the highest cured bulb yield and is suggested for adoption to the local farmers in the study area.

Keywords: Onion, Compost rates, Irrigation intervals, Cured Bulb Yield

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the genus *Allium* of the family *Alleacea*, which is originated in southwest Asia and the Mediterranean regions. The crop is one of the oldest cultivated vegetables which traced back 5000 years and has been in cultivation for more than 4000 years (Gessesew *et al.*, 2015). Total world production stood at 5, 725, 132 metric tonnes. Nigeria ranked 8th in the world with an output of 247, 475 metric tonnes (FAOSTAT, 2016). It is the most widely grown and popular vegetable crop among the alliums as well as cash crops. Onion is an indispensable item in every kitchen as condiment and vegetable (Mallor *et al.*, 2011). Onion cultivation in Nigeria is confined to the **semi-arid** Northern Guinea and Sudan Savannah zones where it is normally transplanted in November and harvested in April in the cool dry season under irrigation. It is an important part of the human diet in the world. It is a rich source of several minerals and vitamins (Raemaekers, 2001). It can be eaten raw, boiled, baked, fried, dried or roasted and commonly used in salads, soups, spreads, curries and other dishes (Ageless, 2009; Belay *et al.*, 2015). Despite the ranking of onion as the second most important vegetable in Nigeria, the present production levels do not meet the demand of the teeming populace. Limited changes in the traditional production practices may still be lagging behind the national demand (Denton and Ojeifo, 1990). Though, the consumption of onion cuts across the country, its production is limited to the northern part of the country, where even in the north, production is restricted to fadama areas, and grown mostly during the dry season under irrigation. On the other hand, several factors are responsible for this discrepancy, ranging from agronomic practices, nursery raising, transplanting, plant population, provision of good quality seeds and seedlings, weeding, irrigation, fertilizer application and the prevalence of pests and diseases. The mineral fertilizers are considered to be an important source of major and minor elements in crop production. Continuous application of mineral fertilizers may adversely affect soil chemical composition, nutrient imbalance, soil degradation, reduced crop yield and can even generate several deleterious effects to the environment and human health (Ojeniyi, 2000). Therefore, non-renewable petrochemical resources should be replaced by biologically-based renewable inputs (Quimby*et al.*, 2002). Sustainability in agro-ecosystems involves environmentally-friendly techniques based on biological and non- chemical methods (Bonato and Ridray, 2007). To reduce and eliminate the adverse effects of synthetic fertilizers and pesticides on human health and environment, new agricultural practices have been developed (Aksoy, 2001; Chowdhury, 2004). The organic fertilizers take the place of inorganic fertilizers in sustainable agriculture. The organic fertilizers provide the nutritional requirements of plants and also suppress the plant pests' populations. Additionally, they increase the microbial activity in soil, anion and cation exchange capacity, organic matter and carbon-content of soil. Irrigation scheduling is one of the most important tools for developing best management practices for irrigated areas (Al-Jamal *et al*., 1999 and Pejic, 2008). This study was therefore carried out to determine the effect of compost rates and irrigation intervals on yield and yield components of onion.

MATERIALS AND METHODS

The research work was conducted during 2017 dry season from March to June in Birji community, Madobi Local Government Area (11^{0}46'38" N 8^{0}17'18"E), Kano State under

Sudan Savannah of Nigeria. The treatments consisted of five rates of compost (0, 5, 10, 15 and 20 t ha^{-1}) and three irrigation intervals (5, 10 and 15 days). The treatments were arranged in 3 x 5 factorial combination in split plot design with three replications. Irrigation interval was assigned to the main plot while compost was assigned to sub plot. The gross plot size was 1.5m x 2.0m (3.0m^2) consisting of 10 rows of 2 m length, while the net plot size was 0.9 m x 2.0 m (1.8 m^2) consisting of 6 innermost rows. Seedlings (Red creole variety) were raised for 6 weeks in seedbeds before transplanting at a spacing of 15 cm x 10 cm. The compost was prepared in compost bin at Soil Science Department, BUK using cow dung, poultry litter, cereal by-product (rice bran), sawdust, vegetables scraps, fresh and dry biomass. Eight weeks was allowed for composting process and an additional one week was allowed for curing. The compost was applied as per treatments to the plot during land preparation two weeks before planting to facilitate decomposition. Data was collected on bulb diameter, average bulb weight, fresh and cured bulb yield. Data collected were subjected to analysis of variance using GENSTART and significant treatment means were compared using SNK

RESULTS AND DISCUSSION

Table 3 shows the effect of compost rates and irrigation intervals on Bulb diameter of onion at Birji during 2017 dry season. There was significant difference between compost rates on bulb diameter of onion. Application of 10 t ha^{-1} of compost produced plants with wider bulb diameter (3.07cm) while those that received 0 t ha^{-1} of compost produced plants with narrow bulb diameter (1.52cm). Similar trends were observed on the average bulb weight, fresh and cured bulb yield of the onion. Plots without compost produced plants with lighter bulb weight. Irrigation intervals had significant effect on bulb diameter, average bulb weight and fresh bulb yield. Plots irrigated at 5 days interval had the wider bulb diameter, higher average bulb weight and yield (3.08cm, 22.78g and 21.96 t ha^{-1} respectively) although statistically at par with 10 days interval while the plots irrigated at 15 days interval had narrower bulb diameter, lower average bulb weight and yield (1.82cm, 16.64g and 11.20 t ha^{-1} respectively). The interaction between compost rates and irrigation intervals on bulb diameter, average bulb weight and fresh and cured bulb yield was not significant.

The wider bulbs diameter of onion observed may be due to fact that application of organic fertilizer was reported to increase the availability and uptake of N, P, K, Ca, and Mg nutrients from the soil, which might have improved the crop performance (Nyathi and Campbell, 1995).

The applied compost might have acted synergistically to increase bulb diameter with the supply of mineral nitrogen to the plants. This result was also in line with the findings of Rahman *et al.* (1976), who reported that application of 10 t ha^{-1} of organic manure produced wider bulbs as compared to the control. Ali *et al*. (2007) and Mohammad *et al*. (2016) observed similar results. The significant differences observed for compost rates on bulb weight of onion at both locations could be due to the increased uptake of nutrients and build-up of sufficient assimilates enabling the increase in size of bulbs (length and breadth), ultimately resulting in the increased average bulb weight. Yogita *et al.* (2012) reported similar results. The heavier fresh bulb yield observed implies that increased quantity of organics up to certain levels, improved soil physical conditions which might have resulted in better root growth, nutrient absorption and better bulb development. Muhammad *et al.* (2019) reported that organic manure serves as slow-release reservoir for plant macronutrients, aids in plants micronutrient absorption, and facilitates water and air infiltration. Aliyu and Kuchinda (2002) also reported significant improvement in growth and enhanced yield of onion with organic fertilizer. The heavier cured bulb yield of onion observed as influenced by compost rates could be attributed to the role of organic fertilizer as valuable as sources of many essential macro and micronutrients to plants. It also increases availability and uptake of nitrogen, phosphorus and potassium which positively reflected on plant cell elongation and division as well as stimulate photosynthesis and metabolic processes of organic compounds in plant, thus increasing total bulbs yield ha^{-1}. Application of farmyard manure significantly improved the growth and yields of onions (Lal *et al*., 2002 and Reddy, 2005). This result supported the findings of Ewais *et al.* (2010), El-Shatanofy, and Manar (2011), Yoldas *et al.* 2011 and Dina *et al.* 2010 also observed similar result. The highest onion bulb weight recorded at 10 days irrigation interval that the water applied increased photosynthetic area of the plant (height of plants and number of leaves), which increased the amount of assimilate partitioned to the bulbs and increased bulb diameter. This resultd was in contrast with the findings of Abdulaziz (2003) and Biswas *et al*. (2003) who reported that wider bulbs of onions was increased at higher levels of irrigation. These results contradicted that of Olalla *et al*. (2004) who reported that plots which received higher irrigation intervals yielded heavier bulb with higher percentages of large-size bulbs whereas frequent irrigation led to higher percentages of small-size bulbs. The significant differences observed for irrigation intervals on the average bulb weight and fresh bulb yield of onion could be attributed to a higher number of leaves and higher LAI and hence, heavier bulb yield. This

Result support the findings of Alam (2006) who observed the highest yield of onion at 5 days intervals. Pejic *et al.* (2014) also reported that onions yield and quality decreased with increasing soil-water stress. This result is closely related to the findings of Muhammad *et al*. (2011) who reported that irrigation at 6 days interval produced the highest onion bulb yield. This result was in contrast with the findings of Khan *et al.* (2007), who reported that total fresh bulb yield of onion increased with increase in irrigation frequency. Nourai (2008) confirmed that irrigation every five days resulted to markedly increase in onions yield. Khan *et al*. (2005) also reported maximum bulb yield obtained with 5 days irrigation intervals.

CONCLUSION AND RECOMMENDATION

Based on the results of this study use of compost at at 10 t ha^{-1} with optimum soil moisture significantly improved the performance of onion. To achieve a high yield potential of onion, appropriate soil moisture should be maintained during entire growing season. Application of compost at 10 t ha^{-1} with irrigation at 10 days interval could be suggested to farmers in the study area. The use of compost in onion production could serve as an alternative to costly inorganic fertilizer and will the soil healthy environmental conditions. Further research is recommended under various climatic and soil conditions to draw sound recommendation for the combined effects of compost and irrigation intervals for increased onion productivity.

REFERENCES

Abd El-Kader, A.A.; Shaaban, S.M. and Abd El-Fattah, M.S. (2010). Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus*L.) grown in sandy calcareous soil. *Agric. Biol. J. N. Am.*1(3):225-231.

Abdulaziz, R. Al., Harbi. 2003. Effect of irrigation regimes on growth and yield of onion (*Allium cepa* L.). http://digital.library.ksu.edu.sa/paper315.html. Accessed date 30/7/2008.

Al-Jamal, M. S., Sammis, T.W., Ball S., Smeal, D. (1999). Yield-based, irrigated crop coefficient. *Appl. Eng. Agric.* 15(6): 659-668.

Ali A.H, Rizk FA, Shaheen AM & Abdel-Mouty MM (2007). Onion plant growth, bulbs yield and its physical and chemical properties as affected by organic and natural fertilization. *Res J Agri and Biological Sci* 3(5): 380-388.

Aksoy, U (2001). Ecological Farming. II. Ecological Farming Symposium in Turkey. 14-16 December. Antalya.

Amans, E.B. (1989). Effect of intra-row spacing and nitrogen application on early and late sown irrigated onions. 1. Growth and bulb yield. Ph.D. Seminar, pp: 38.

Ageless. (2009).Properties and therapeutic uses of onion. Available from: *www.ageless.co.za/herbonion.htm*. Access date: 25-4-2009.

Alam, M. M.2006. Performance of Low-Cost Sprinkler Irrigation System of Onion Cultivation. Research Report of Spice Research Center, BARI, Bogra. pp. 82-85.

Belay S, D Mideksa, S Gebrezgiabher and W Seifu, 2015 Yield components of adama red onion (*Allium cepa* L.) cultivar as affected by intra-row spacing under irrigation in fiche condition. Department of Horticulture, College of Veterinary Medicine and Agriculture, Addis Ababa University, Fiche, Ethiopia

Biswas, S.K., P.K. Sarker, A. K. M, Mazharulislam, M.A. Bhuyan and B.C. Kundu. 2003. Effect of irrigation on onion production. *Pakistan Journal Biology Science*, 6(20): 1725-1728.

Block, E., (1985).The chemistry of garlic and onions. *Scientific American* 252: 94–99.

Chowdhury, R. (2004). Effects of chemical fertilizers on the surrounding environment and the alternative to the chemical fertilizers IES- ENVIS NEWSLETTER, 7(3): 4-5.

Dina, M. S., Shafeek, M. R., Abdallah, M. M. F. (2010): Effect of different nitrogen sources and soil solarization on green onion productivity for exportation. – Annals of Agric. Sci., Cairo Univ. 55(1): 97-106.

Denton, Lanre and Ojeifo, I.M (1990). Onion production practices and their improvement in Nigeria. *Onion Newsletter for the Tropics,* 2:10 – 13.

El-Sahookie, M. M, Alfalahi, A.O, Almehemidi, A. F (2009). Crop and Soil Management and Breeding for Drought Tolerance. Iraq. *J. Agric. Sci.* 40(2):1-28.

El-Shatanofy, Manar, M. E. (2011): Influence of organic manure and inorganic fertilizers on growth, yield and chemical contents of onion (*Allium cepa,* L.). – M.Sc. Thesis, Fac. of Agric. Alex. Univ.

Ewais, M. A., Mahmoud, A. A., Khalil, A. A. (2010): Effect of nitrogen fertigation in comparison with soil application on onion production in sandy soils. – *Alex J Agric Res* 55(3): 75-83.

FAOSTAT. (2016). Food and Agriculture Organisation Production. Statistics Available on http://www.faostat.fao.org

Hasegawa, A., Yabuki, H., Nabeura, T., FukuI, H. and Iwata, T. (2001). Evaluation of bulb shape and fresh weight of different onion cultivars. *Tech. Bull. Agric. KagawaUniv.* 53, 71-77.

Kayuki, K. C. and Wartmann, C.S. (2001). Plant Materials for Soil Fertility Management in sub humid tropical areas. *Tropical soil management Agronomy Journal*, 93: 929-935.

Khan, A.A, Zubair, M, Bari, A and Maula, F. (2007).Response of onion (Allium CepaL.) growth and yield to different levels of nitrogen and zinc in Swat Valley. *Sarhad J. Agric.* 23(4): 934-936.

Khan, H. M., Imran, M. & Chattha, T. H. (2005). Effect of irrigation intervals on growth and yield of onion varieties 5WAT-1 and Phulkara. *J. Appl. Sci. Res*. 1(2):112-116.

Lal, S.; Yadav, A. C.; Mangal, J. L.; Avtar , S. and Batra, V. K. 2002, Effects of FYM and irrigation levels on growth and yield of onion cv. Hisar-2. Haryana *J. Hort. Sci.,* 31(3-4): 256-258.

Mohamed, A., and Fahal, A. (2006). Effects of irrigation interval, sowing date and clove size on yield and some yield components of local garlic (*Allium sativum* L.) in the Northern Sudan. *Sudan Journal of Agricultural Research,* 7: 35-42.

Muhammad, A., Gambo, B.A., and Ibrahim, N.D. (2011). Response of Onion (*Allium cepa* L.) to Irrigation Intervals and Plant Density in Zuru, Northern Guinea Savanna of Nigeria. *Nigerian Journal of Basic and Applied Science*, 19(2):241- 247

Mohammad, S., Abul Hasnat M. S., Khairul K. M., Abdullah, A, and Shakil, A. Z. (2016). Influenced of Yield and Yield Contributing Characters of Tuberose by the Application of Bulb and Fertilizers. *International Journal of Environmental & Agriculture* Research, Vol.2(10) SSN:2454-1850

Mallor, C., Balcells, M., Mallor, F. and Sales, E. (2011). Genetic variation for bulb size, soluble solids content and pungency in the Spanish sweet onion variety Fuentes de Ebro. Response to selection for low pungency. *Plant Breed.* 130, 55-59.

Nyathi, P. and Campbell, B.M. (1995). The effect of tree leaf litter, manure, inorganic Fertilizer and Their combination on above ground production and grain yield of Maize. *Africa Journal Crop Science,* 3:451-456

Nourai A. H. (2008). Effect of transplanting date, nitrogen nutrition and watering regime on yield, quality and storage of the red onion. Proceedings of the meeting of the National crop Husbandary committee (NCHE). Agricultural Research Corporation (ARC) Sudan.

Ojeniyi, S. O. (2000): Effect of goat manure on soil nutrients content and okra yield in a rain forest area of Nigeria. *Applied Tropical Agric*. 5: 20-23.

Olalla, F.S., A. D. Padilla and R. Lopez. 2004. Production and quality of the onion crop (*Allium cepa* L.) cultivated under controlled deficit irrigation conditions in a semi-arid climate. *Agricultural Water Management*, 68: 77-89.

Pejic, B., Gvozdanovic-Varga, J., Vasic, M., Maksimovic, L., Milic, S. (2008). Yield and evapotranspiration of onion depending on different pre-irrigation soil moisture. (In Serbian) A Periodical of Sci. Res. *Field and Veg. Crops*, 44: 195-202.

Pejic, B., Gajic, D.J., Bosnjak, R., Stricevic, K. Mackic, and Kresovic, B. (2014). Effects of water stress on water use and yield of onion. *Bulg. Journal of Agricultural Science*, 20: 297-302.

Sharma, S.K. and Mehta, H. (1991). Manifestation of genetic diversity for physiological traits and soybean under two cropping system. *Tropical Agriculture* 68(3): 203 -213.

Tekalign, T. (1991). Soil, Plant, Water, Fertilizer, Animal Manure and Compost Analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa, Ethiopia.

Tonfack, L.B, Bernadac, A., Youmbi, E., Mbouapouognigni, V.P. and Akoa, A. (2009). Impact of organic and inorganic fertilizers on tomato vigor, yield and fruit composition under tropical andosol soil conditions. *Fruits,* 64: 167-177.

Tarfa, B.D., Uyovbisere, E. O., Chude, V. O., Raji, B. A. and Yaro, D. T. (2001). Effect of the Complementary use of NPK and foliages of Azadirachta and Parkia on yield and nuteient uptake of maize in savanna soils. Pp 224-237.

Reddy, K.C. and Reddy, K.M. 2005. Different levels of vermicompost and Nitrogen on Growth and Yield of in Onion (*Allium cepa* L.) Radish (Raphanus sativus L.) cropping system. *J.Res., ANGRAU.*, 33(1):11-17.

Quimby, P.C., King, L.R. and Grey, W.E. (2002). Biological control as a means of enhancing the sustainability of crop/land management systems, *Agr. Ecosyst. Environ*. 88, 147–152.

Yoldas, F., Ceylan, S., Mordogan, N., Esetlili, B. C. (2011): Effect of organic and inorganic fertilizers on yield and mineral content of onion (*Allium cepa* L.). – *African J. of Biotech*. 10(55): 11488-11492.

Zayton, A. M. 2007. Effect of soil-water stress on onion yield and quality in sandy soil. *Misr Journal of Agricultural Engineering*, 24(1): 141-160.

Table 1. Physical and Chemical Properties of the Soil at Birji during 2017 Dry Season.

Soil Properties	0 – 15cm
Physical composition (%)	
Sand	80
Clay	3
Silt	17
Textural Class	Loamy Sand
Chemical Compositions	
pH(H_2O)	6.73
pH($CaCl_2$)	5.97
Organic Carbon (%)	1.20
Total (%) Nitrogen	0.51
Available Phosphorus (m kg^{-1})	16.37
Exchangeable bases (c mol kg^{-1})	
Ca	4.83
Mg	0.18
K	0.36
Na	0.11
CEC	5.8

Table 2. Nutrient Composition of the Compost used in this study.

Compost Properties	Analyzed Value
pH(H_2O)	7.37
pH(KCl)	7.11
OC (%)	27.56
Total N (g kg^{-1})	1.57
Total P (g kg^{-1})	1.33
Available P (mg kg^{-1})	41.34
Total K (ppm)	1.42
C/N Ratio	15.3:1

Table 3. Effects of Compost Rates and Irrigation Intervals on Bulb Diameter (cm), Average Bulb Weight (g), Fresh Bulb Yield (t ha^{-1}) and Cured Bulb Yield (t ha^{-1}) of Onion.

Treatments	Bulb Diameter (cm)	Average Bulb Weight (g)	Fresh Bulb Yield (t ha^{-1})	Cured Bulb Yield (t ha^{-1})
Compost Rates (C) t ha^{-1}				
0	1.52c	15.66c	10.51d	5.24d
5	2.89ab	21.23b	20.37b	8.59b
10	3.07a	24.23a	23.60a	8.99a
15	2.76b	21.19b	16.62c	7.41c
20	2.92ab	21.34b	19.34b	8.37b
SE±	0.093	0.309	0.393	0.081
Irrigation Intervals (I) days				
5	3.08a	22.78a	21.96a	8.11
10	2.99a	22.77a	21.10a	7.94
15	1.82b	16.64b	11.20b	7.12
SE±	0.128	0.413	0.896	0.340
Interaction				
C x I	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of probability using Student-Newman-Keuls Test , NS= not significant

EFFECT OF SOIL MANAGEMENT AND PLANT DENSITY ON GROWTH AND YIELD OF MILLET IN KADUNA, NORTHERN GUINEA SAVANNA

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ABSTRACT

Mulching is an important soil management technique in the northern guinea savanna. Equally, plant density is a common agronomic practice in rain-fed crop production. However, the effects of combining mulching and plant density on millet yield have not been thoroughly elucidated to date. Hence, a field experiment was conducted during the 2021/22 wet season at the teaching-research farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria, to evaluate the influence of mulching and plant density on the growth and yield of millet in the Northern Guinea Savanna, Nigeria. The treatments include two varieties of millet (Super *sosat* and *Jirani*), three mulching (plastic, sawdust and control) and three plant densities (44,444, 53,333 and 66,666 plants ha^{-1}) These were combined factorially and laid out in a randomized complete block design (RCBD) in three replicates. The results were both treatments showed significantly little variation with regards to growth parameters though differences were minor (<1°C) and within error margins as such shows no significant meaningful differences. Mulching increased soil water retention during the entire period of millet growth, this led to higher grain yield per hectare in mulched fields than in control plots similarly, medium plant density produced the highest grain yield but panicle and dry matter weight were higher under high and low plant density respectively. The combination of medium density and plastic mulch produced highest yield (t ha^{-1}). Super sosat (V1) is recommended for higher biomass production, while Jirani (V2) may be preferable for potentially higher reproductive efficiency.

Keywords: *Mulching, Density, Super sosat, Jirani and Sawdust*

INTRODUCTION

Crop production in the Northern Guinea savanna is increasing in scope and intensity (Highman and Kowal, 2017). Crops commonly grown under rain fed conditions in this region include millet, maize, sorghum, rice, cowpea, groundnuts, cotton and soybeans. In these areas, pearl millet is one of the most reliable cereal crops grown under short duration (3 to 4 months) rainfed condition (Uzoma *et al.,* 2010). It is a drought tolerant, warm season crop predominantly grown as a staple food grain and a great source of both feed and fodder (Sathya *et al.,* 2013). Pearl millet is regarded as a high-quality forage crop in developed countries like the United States and Australia and considered as a new experimental forage crop in South America and Korea (Khairwal *et al.*, 2007).

Soils in the Nigerian savanna are increasingly being degraded by soil erosion (wind and water), overgrazing and poor management practices amongst others (Adeleke and Olorunfemi, 2017). Consequently, the soils do not contain sufficient plant nutrients (micro and macro) to support vigorous crop growth and high productivity. Pearl millet is however able to produce reasonable yields on marginal soils, where other crops would fail. It is the only cereal that reliably provides grain and fodder under dry land conditions in shallow and sandy soils with low fertility and water holding capacity (Wilson *et al*., 1995). Because of its tolerance to drought, it can be grown in areas where other cereal crops such as maize and sorghum would not survive (Basavaraj *et al*., 2010) and can yield in areas that receive as low as 200 to 250 mm rainfall per annum. Improved pearl millet varieties accounted for 34.8% adoption among farmers with a total 1,154,261 ha cultivated across the Sudano-sahelian zone of Nigeria (Ndjeunga *et al*., 2011). Though long term analysis (20 years) of millet production indicated national average yield of 1170 kg ha^{-1} (FAOSTAT, 2016), significant downward yield production (2011 to 2016), indicated most smallholder farmers still produce as low as average yield of 500 $kgha^{-1}$ (Ndjeunga *et al.*, 2011). Hence, modalities to augment or intensify its production will help to increase food security and reduce poverty among the increasing human population in the country. The present low yield could be attributed to low inherent soil fertility, lack of use of improved varieties and the use of low plant population (Doumbia *et al.*, 2008) and variability of moisture related to the erratic rainfall patterns especially in the Northern Guinea and Sudan savanna leading to water stress at some critical plant growth phases. The increased worldwide shortage of rain due to climate change and high cost of irrigation are leading to an emphasis on developing soil management techniques like mulching that minimize water loss (Sokoto and Gaya, 2016).

Plant density has an important effect on growth and yield component of most annual crops. It is one of the important factors of crop production, because appropriate spacing of crops makes for efficient use of space and reduction of competition among plants with the same cultural requirements, enriches the nutrient content of the soil, repels pests and provides shade, improves the micro climate with reference to wind and moisture and enhances the interaction between beneficial microorganisms within the rhizosphere of the soil (Nnoke, 2001). The importance of plant population is not only in terms of the number of plants per unit area, (i.e.

plant density), but also in terms of the arrangement of the plants on the ground. West African pearl millet farmers traditionally plant low plant populations of approximately 5000 hills ha^{-1} in order to reduce risk of yield loss from water stress and allow plants to scavenge large soil volumes for the limited nutrients and moisture available (Mason *et al.,* 2015). Pearl millet recommendations for plant population and spacing vary with anticipated seasonal rainfall and soil water holding capacity. Some farmers keep low plant populations to enhance intercropped cowpea and or ground-nut yield in intercropping systems but increased pearl millet yields can be produced by plant populations that are two to four times greater than traditionally used (Maman *et al.*, 2000). Though several high yielding millet varieties are available in the region, there is little information on their response to mulching and increased plant population given the long term practice of growing millet at very low populations in the region.

Mulching with organic or inorganic materials aims to cover soils and forms a physical barrier to limit soil water evaporation, control weeds, maintain a good soil structure, protect crops from soil contamination and to some extent, improve soil temperature. Natural mulching materials if effectively used, can offer all the benefits of other types of mulches (Massaccesi *et al.,* 2020). Natural mulches are those derived from animal and plant materials. On the other hand, polyethylene mulches are widely used in the cultivation of vegetables, temperature moderation and salinity reduction. It also influences earliness, yield and quality of crop. Mulching plays a critical role in the restoration of soil health, addition of plant nutrient, improvement of the microbial population and increase of organic carbon content (Akhtar *et al.*,2019). Mulches affect the plant microclimate, by modifying the energy balance of the environment and decreasing soil water loss (Massaccesi *et al.,* 2020). The main benefits of mulching are early crop production, higher yields, better product quality, more efficient water use, reduced leaching of fertilizers, reduced soil and wind erosion, reduced herbicide application, weed control and others related to pest and disease management (Lamont, 2005). The objective of this study was to evaluate the influence of mulching and plant density on the growth and yield of millet in the Northern Guinea Savanna, Nigeria

MATERIALS AND METHOD

Experimental site

The study was conducted at the Experimental Farm of the Institute for Agricultural Research (IAR), Samaru, Kaduna state in the Northern Guinea Savanna of Nigeria. Samaru is located at the geographic coordinates of latitude 11° 11'N and longitude 07° 38'E, with an altitude of 686m above sea level. The Mean annual rainfall of the study area is reported to be 1015.9 mm, the mean maximum air temperature is 29.7°C while the mean minimum air temperature is 13.3°C (Yamusa and Abdulkadir, 2020).

Treatments and Experimental Design

The treatment combinations consist of three mulching treatments; plastic mulch, saw dust and no mulch (control), three levels of plant densities 44,444, 53,333 and 66,666 plants/ha and 2 pearl millet varieties (Super sosat and Jirani). The treatment combinations were laid out in a Randomized Complete Block Design (RCBD) and replicated 3 times. Before land preparation, representative soil samples were taken at the depth of 0-15 and 15-30cm for physico-chemical analysis. Gross plot size was 3 m X 4.5 m ($13m^2$), while net plot size was 3 x 3 (9m2) ridges were 3m long and spaced 75 cm apart. Prior to ploughing, weeds were controlled by spraying chemical herbicide (Atrazine). The field was then marked out into 3 blocks (replications) each consisting of 18 plots. The recommended rate of 60kg N ha^{-1}, 30kg P_2O_5 $ha^{-1}$and 30kg K_2O ha^{-1}. The compound (NPK) was applied about two weeks after sowing; second dose of Nitrogen (Urea, 46% N) was applied at four weeks after sowing.

Data collected

Data were obtained from the sample plants during the experiment. From each net plot, five plants were selected at random to collect data. The following parameters were measured in the course of the trial: Number of leaves, Plant height, panicle weight, dry matter weight, stover weight, yield kg/ha^{-1} and harvest index

Data Analysis

Data collected on growth and yield parameters include number of leaves, plant height, panicle weight, dry matter weight, stover weight, grain yield and harvest index. Data means were subjected to analysis of variance (ANOVA) while means separation was used using Duncan Multiple Range Test (DMRT) were significant differences are observed at 5% probability level.

RESULTS AND DISCUSSION

From the results on Table 1, it's evident that number of leaves increased over time across all treatment levels for both varieties. Mulching led to higher leaf number at week 8 where a significant difference occurred especially between M1 and the control plot. The moisture retention from mulch may be the reason for this difference as similarly observed by Vurukonda *et al.* (2016). Plant density did not have a clear effect on leaf number, though P1 produced higher number of leaves as compared to P2 and P3 meaning competition for resources may not yet constrain leaf growth and or development (Thorup-Kristensen, 2006).

Plant height increased across all factors and weeks (Table 2). This is expected, as increased nutrients and resources generally lead to more plant growth over time Lee *et al.* (2010). However, significant difference exists in plant height between the two varieties (super sosat and jirani) at 10WAS with super sosat plants been taller. This suggests an inherent genetic growth potential difference between the varieties (Pandey *et al.* 2021). Contrary to variety, mulching produced statistically the same plant height in 2, 4, 6 and 8 WAS, except at 10WAS where plastic mulch (M2) and control plots (M3) had plants of similar height. Control is at par with the tallest plants produced under saw dust mulch (M1) but a significant difference exists between saw dust (M1) and plastic mulch (M2) with saw dust (M1) plants been taller. This disagrees with previous research by Chakraborty *et al.* (2008) showing plastic mulch increases moisture retention and nutrient availability in soils enabling better plant growth and results in taller plants than organic mulch and control plots. No significant effects were influenced by plant density on millet height. It will be safe to say competition for resources at higher densities may not yet be restricting growth (Thorup-Kristensen, 2006).

The effect of variety, mulching and plant density on several yield parameters of millet such as panicle weight (PW), dry matter weight (DMW), stover weight (STW) and grain yield is presented in Table 3. Super sosat (V1) had significantly greater panicle weight (2.36kg) and higher Stover weight (5.55kg) compared to Jirani (V2). This indicates super sosat has a genotypic potential for more vigorous biomass and straw production (Liu *et al.*, 2013). However, Dry matter weight and grain yields were statistically similar between varieties, meaning the additional vegetative growth in super sosat (V1) did not translate to higher yields, this agrees with the findings of (Gu *et al.*, 2014) in which Jirani (V2) is said to may have a greater reproductive partitioning efficiency than super sosat.

Similarly, M1 showed the highest PW (2.41kg) which is statistically higher than M2 (1.87kg) however, similar to control, M2 had higher grain yield than the other mulch treatments even though all are statistically at far. The absence of a significant difference in grain yields between mulching types indicates soil moisture availability was sufficient across all treatments. Dry matter weight remains similar in all 3 mulch treatments, the same can be said of stover weight

(STW) although M1 had slightly higher stover weight of 5.29 as compared to the 4.25 and 4.58 values of M2 and control M3 respectively. Mulching can enable sustained plant growth under drought by conserving soil moisture and plant nutrients (Vurukonda *et al.*, 2016).

Despite increased competition between plants resulting from higher densities, (P3, 66,666plants/ha) still managed to produce the highest PW and STW as was observed by Niu *et al.* (2009). However, grain yield peaked at close spacing (P2) as compared to wider spacing. This suggests optimal plant arrangements to maximize reproductive output (Thorup-Kristensen 2006). Interestingly, P1 and P3 the least and highest number of plants per plot respectively produced the highest PW and STW. Grain yield increased with increase in plant density from P1 to P2 however, grain yield decreased with further increase in density from P2 to P3 this is explained by the work of Schmitt *et al*. (1993) in which it was reported that a contradictory results concerning the response of grain yield to plant density was reported in previous studies while several researchers indicated that grain yield, generally increased with increasing plant density. Sun *et al.* (2018) also reported that higher plant densities may lead to competition for water and nutrients among maize and millet plants and can result in decreased yield.

Overall, it can be said that variety genetics, soil temperature preservation from mulching and plant population interacted in complex ways to influence different aspects of millet crop productivity.

REFERENCES

Adeleke, O. A., & Olorunfemi, F. (2017). Soil Degradation in the Nigerian Savanna: Causes, Effects and Control Measures. *Journal of Environmental Science and Resource Management*. 9(1), 1-3.

Agber Akhtar, K., Wang, W., Khan, A., Ren, G., Afridi, M. Z., Feng, Y. and Yang, G. (2019). Wheat straw mulching offset soil moisture deficient for improving physiological and growth performance of summer sown soybean. *Agricultural Water Management*, 211, 16-25.

Basavaraj G, Rao P.P, Bhagavatula S, Ahmed W, (2010). Availability and utilization of pearl millet in India.SAT *e-Journal*, 8: 1-6.

Chakraborty, D., Nagarajan, S., Aggarwal, P., Gupta, V.K., Tomar, R.K., Garg, R.N., ... & Kalra, N. (2008). Effect of mulching on soil and plant water status, and the growth and yield of wheat (*Triticum aestivum* L.) in a semi-arid environment. Agricultural Water Management, 95(12), 1323-1334.

Doumbia M, Jarju A, Sene M, Traore K, Yost R, Kablan R, Brannan K, Berthe A, Yamoah C, Querido A, Traoré PCS, Ballo A, (2008). Sequestration of organic carbon in West African soils by Aménagement en Courbes de Niveau.AgronSustDev, 29: 267–75

FAOSTAT (2016). Food and agriculture organization of the United Nations, FAOSTAT database. http://faostat.fao.org/site/362/Desktop Defaultaspx?PageID=362.

Gu, J., Yin, X., Zhang, C., Wang, H., & Struik, P. C. (2014). Can increased leaf photosynthesis be converted into higher crop mass production? A simulation study for rice using the crop model GECROS. *Journal of experimental botany*, 65(9), 2345-2360.

Highman, T.F.G., & Kowal, J.M. (2017). Agricultural Intensification in the Northern Guinea Savanna: Sustainable Agriculture Reviews, 24, 245-264. doi: 10.1007/978-3-319-58694-8_11

Khairwal I S, Rai K N, Diwakar B, Sharma Y K, Rajpurohit B, S, Bindu N, Ranjana B, (2007). Growth and Development of Pearl Millet Plant.International Crops Research Institute for the Semi-arid Tropics, Andhra Pradesh, India. P. 104

Lamont, J. (2005). Modifying the microclimate to the production of vegetable crops.horticulture technology, 15:477-481.481.

Lee, C. D., Egli, D. B., & TeKrony, D. M. (2010). Soybean response to plant population at early and late planting dates in the Mid-South. Agronomy Journal, 92(3), 412-418.

Liu, E. K., Mei, X. R., Yan, C. R., Bing, S. H., Ding, L. P., Liu, Q., ... & Fan, T. W. (2013). Long-term effect of chemical fertilizer, straw, and manure on soil chemical and biological properties in northwest China. Geoderma, 193, 150-159.

Maman N, Mason SC, Sirifi S, (2000). Influence of variety and management level on pearl millet production in Niger. I. Grain yield and dry matter accumulation. *African Crop Science Journal*, 8: 25–34.

Mason S.C, Maman N, Palé S, (2015). Pearl millet production practices in semi-arid West Africa: A review. Expl Agric. Cambridge University Press.

Massaccesi, L., Rondoni, G., Tosti, G., Conti, E., Guiducci, M. and Agnelli, A. (2020). Soil functions are affected by transition from conventional to organic mulch-based cropping system. Applied Soil Ecology, 153, 103639.

Niu, G., Rodriguez, D. S., Wang, Y. T., Vonderohe, C., & Yang, S. (2009). Effect of daytime soil temperature on cuticular transpiration of soybean plants grown under two soil moisture regimes. *Journal of experimental botany*, 60(13), 3861-3869.

Ndjeunga J, Umar J, Ahmed B, Aba A, Ibro A, Abdoulaye A, Gwadi K, (2011). Adoption and impacts of modern sorghum and pearl millet varieties in Northern Nigeria, ICRISAT.

Nnoke, F.N. (2001). Essentials of pedology and edaphology, Fedico Ventures, Abakaliki, Nigeria 71 pp

Pandey, P., Irulappan, V., Bagavathiannan, M. V., & Senthil-Kumar, M. (2021). Impact of combined abiotic stresses on crop physiology and food security-current status and future perspectives. Frontiers in plant science, 12, 594.

Schmitt, J. and R.D. Wulff, 1993. Light spectral quality, phytochrome and plant competition. Trends Ecol. Evol., 8: 47-51.

Sokoto, M.B., and Gaya, M.I., (2016). Growth and Yield of Sweet Potato (*Ipomoea batatas* (L.)) as Influenced by Irrigation Interval and Variety in Sokoto Sudan Savanna, Nigeria. International Journal of Plant & Soil Science 11(3): 1-12, 2016; Article no. IJPSS.25964 ISSN: 2320-7035

Sun, S.J., Z.J. Chen, H. Jiang, and L.L. Zhang. (2018). Black film mulching and plant density influencing soil water temperature conditions and maize root growth. Vadose Zone J. 17:180104. doi:10.2136/vzj2018.05.0104

Thorup-Kristensen, K. (2006). Effect of deep and shallow root systems on the dynamics of soil inorganic N during 3-year crop rotations. Plant and Soil, 288(1), 233-248.

Uzoma A.O, Eze P.C, Alabi M, Mgbonu K, Aboje JE, Osunde AO, (2010). The effect of variety and planting date on the growth and yield of pearl millet in southern guinea savanna zone of Nigeria. *Journal of Agriculture Veterinary Science*, 2: 122-129.

Vurukonda, S. S. P., Vardharajula, S., Shrivastava, M., & SkZ, A. (2016). Enhancement of drought stress tolerance in crops by plant growth promoting rhizobacteria. Microbiological research, 184, 13-24.

Wilson J. P, Hanna WW, Gascho G, Wilson GM, (1995). Pearl millet grain loss from rust infection. In: Proceedings of the First National Grain Pearl Millet Symposium, 17-18 Jan (Teare ID. ed.) Tifton, Georgia, USA: University of Georgia and USDA; 54-56.

Yamusa A.M and A. Abdulkadir (2020). Rainfall and Temperature trends in Samaru and Minjibir, Northern Guinea and Sudan Savannas of Nigeria. Journal of Sustainable Agriculture and the Environment, Micheal Okpara University, Umudike vol-18 (i) pp 110-125.

Table 1: Effect of variety, mulching and plant density on number of leaves at Samaru during 2021/22 wet season

Treatment	Number of Leaves Weeks after sowing				
	2	4	6	8	10
Variety (V)					
Super Sosat (V1)	2.88	4.96	6.59	9.18	10.81
Jirani (V2)	3.25	5.14	7.14	9.22	11.25
SE ±	0.21	0.36	0.35	0.33	0.39
Mulching (M)					
Sawdust (M1)	3.27	5.38	7.05	9.55[a]	11.16
Plastic mulch (M2)	3.00	5.00	7.00	9.50[a]	10.77
Control (M3)	2.94	4.77	6.55	8.55[b]	11.16
SE ±	0.09	0.16	0.15	0.14	0.17
Plant density (P)					
44,444 (P1)	3.22	5.27	7.00	9.61	11.66
53,333 (P2)	3.16	5.16	7.00	9.27	10.72
66,666 (P3)	2.83	4.72	6.61	8.72	10.72
SE ±	0.09	0.16	0.15	0.14	0.17
Interaction					
M*P	NS	NS	NS	***	NS
M*V	NS	NS	NS	NS	*
P*V	NS	NS	NS	NS	NS
M*P*V	NS	NS	NS	NS	*

Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability, NS= not significant.

Table 2: Effect of Variety, Mulching and Plant density on plant height (cm) at Samaru

Treatment	Plant height (cm) Weeks after sowing				
	2	4	6	8	10
Variety (V)					
Super sosat (V1)	52.0	74.7	108.9	137.9	149.5[a]
Jirani (V2)	52.1	72.0	106.8	132.7	139.8[b]
SE ±	2.88	2.14	3.40	4.50	2.97
Mulching (M)					
Sawdust (M1)	54.9	72.2	107.9	132.0	139.1[b]
Plastic mulch (M2)	49.4	77.0	112.2	139.7	148.5[a]
Control (M3)	52.0	70.7	103.5	134.2	146.3[ab]
SE ±	1.92	1.43	2.26	3.00	1.32
Plant density (P)					
44,444 (P1)	53.1	70.5	106.2	134.0	144.3
53,333 (P2)	53.1	75.9	110.7	138.0	145.5
66,666 (P3)	50.0	73.5	106.7	133.8	144.0
SE ±	1.92	1.43	2.26	3.00	1.32
Interaction					
M*P	NS	NS	NS	NS	***
M*V	NS	NS	NS	NS	NS
P*V	NS	NS	NS	NS	***
M*P*V	NS	NS	NS	NS	***

Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability,

Table 3: Effect of Variety, Mulching and Plant density on some yield parameters of millet at Samaru

Treatment	PW (g)	DMW (kg)	STW (kg)	Yield t/ha
Variety (V)				
Super sosat (V1)	2.36[a]	0.0055	5.55[a]	2.27
Jirani (V2)	1.97[b]	0.0059	3.86[b]	2.24
SE ±	0.16	0.59	0.56	0.14
Mulching (M)				
Sawdust (M1)	2.41[a]	0.0055	5.29	2.36
Plastic mulch (M2)	1.87[b]	0.0057	4.25	2.38
Control (M3)	2.21[ab]	0.0058	4.58	2.04
SE ±	0.07	0.26	0.25	0.06
Plant density (P)				
44,444 (P1)	2.23[a]	0.0050	5.62[a]	2.24[ab]
53,333 (P2)	1.66[b]	0.0063	4.01[b]	2.49[a]
66,666 (P3)	2.61[a]	0.0058	4.48[ab]	2.05[b]
SE ±	0.07	0.26	0.25	0.06
Interaction				
V*M	NS	NS	NS	NS
V*P	NS	NS	NS	NS
M*P	NS	NS	NS	NS
V*M*P	NS	NS	NS	NS

Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability

ASSESSING OF SOIL NUTRIENTS USING LABORATORY AND REMOTE SENSING METHODS IN NORTHERN GUINEA SAVANNAH

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ABSTRACT

In order to understand soil properties and how they might be used sustainably, mapping of soil attributes is a crucial activity. The study was carried out in four local government area of Kaduna State of Nigeria in order to map out some soil properties and assess their variability within the area. From the study area, a total of 16 soil samples (0–20 cm) were collected from different cropping patterns. A portable global positioning system (GPS) was used to collect the coordinates of each sampling site. Then, the soil properties, that is, soil organic carbon (SOC), total nitrogen (Total N), soil organic matter (SOM), and soil available nutrients (P and K) were measured in the laboratory. Correlation analysis between laboratory and remote sensing data showed positive relationships for carbon (r=0.23), total nitrogen (r=0.14), and organic matter (r=0.68), but negative correlations for available phosphorus (r=-0.48) and potassium (r=-0.42). These variable results highlight the greater reliability of remote sensing for assessing total carbon and organic matter versus limitations in quantifying phosphorus and potassium availability. Interactive effects of climate variables on soil nutrients were not directly assessed but remain a critical area for further research.

Keywords: Remote sensing, Laboratory analysis and Soil nutrients

INTRODUCTION

Soil is a complex material that is extremely variable in physical and chemical composition. The influence of soil and crop management practices such as fertilization, cropping systems, and land-use change exert considerable changes to such soil compositions over time. Over the years, routine analysis of such chemical and physical changes remains the only way to access and maintain the fertility of soil. The importance of the soil analysis cannot be over-emphasized since low nutrient values limit plant growth and excessive rainfall may result in loss of nutrients from the soil, causing soil fertility degradation and water pollution (Chi *et al.*, 2019). Therefore, soil analysis is the basic frame for providing the nutrient requirements of every crop.

Comparative assessment of soil nutrients under different cropping systems and changing climate conditions requires a combination of ground-based soil sensing and laboratory analytical methods along with remote sensing technologies. Ground-based sensors like portable X-ray fluorescence (pXRF) analyzers allow rapid in-situ quantification of major and trace nutrients in soils (Towett *et al.,* 2015). Laboratory methods using combustion analysis, titrations, and spectroscopic techniques offer accurate and precise measurements of total and plant-available nutrient pools (Robertson *et al.,* 1999). Satellite and aerial remote sensing provide spatial data on vegetation characteristics and soil properties related to soil fertility at broader scales (Mulder *et al.*, 2011). Together, these approaches can provide a comprehensive assessment of soil nutrient dynamics across landscapes.

This study synthesizes research utilizing integrated soil laboratory, ground-based sensing, and remote sensing methods to evaluate the impacts of climate and agricultural land use on soil nutrients. The focus is on comparative studies across different cropping systems under current and projected future climate scenarios, concentrating on research conducted in sub-Saharan Africa.

Monitoring agriculture from remote sensing is a vast subject that has been widely addressed from

multiple viewpoints, sometimes based on specific applications (e.g. precision farming, yield prediction, irrigation, weed detection), on specific remote sensing platforms (e.g. satellites, Unmanned Aerial Vehicles - UAV, Unmanned Ground Vehicles - UGV) or sensors (e.g. active or passive sensing, wavelength domain, spatial sampling) or specific locations and climatic contexts (e.g. country or continent, wetlands or dry lands).

In recent years, digital soil mapping has been identified as a low-cost and efficient method for predicting the spatial distribution of soil nutrients. Most digital soil mapping methods are based on soil-landscape models, which establish mathematical or statistical relationships between soil properties and related environmental variables (Zhang *et al.,* 2019) by predicting soil characteristics and fertility status with the help of remote sensing data. Remote sensing in itself is the process of detecting and monitoring the physical characteristics of a particular soil by measuring its reflected and emitted radiation at a distance. The nature and working principle of remote sensing give it the advantages of being an extensive, non-invasive, timeliness, and flexible method of soil analysis, and it has the potential to increase the availability of high-resolution remote sensing data by providing a new opportunity for predicting soil characteristics with acceptable accuracy. The objective of the study was to map out some soil properties and assess their variability within the area.

MATERIALS AND METHOD

Study Area Description

This study was conducted in the northern and southern Guinea savannahs of Kaduna State. The locations in the northern savannah were Kubau and Makarfi while the southern Guinea savannah were Kagarko and Lere LGAs. Nigeria's climatic zone encompasses the tropical humid forest in the south and the savannah in the north. Nigeria's climatic zone encompasses the tropical humid forest in the south and the savannah in the north. The derived savannah is a transition zone between the rainforest and savannah biomes caused by forest clearance as stated by Ofomata (1975). The study was carried out in Kaduna state (Longitude/Latitude 9°26' to 11°13' N and 7°47 to 8°42' E) respectively, which is located in the Northwest of Nigeria (Fig. 1). The climate belt of the area is tropical Guinea Savanna, with an annual average temperature of 25.2℃ and an annual average rainfall of 1,323mm (Akinbode *et al.*, 2008).

Soil Laboratory Analysis

The chemical properties of the soils were determined at the Soil Science Laboratory, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria. The soil samples were determined by using the following methods: The organic carbon was analyzed by the wet oxidation method of Walkley and Black as modified by (Nelson and Sommers, 1982). Total nitrogen by the micro-kjeldahl distillation procedure according to (Bremmer, 1996), available phosphorus was determined by the Bray No. 1 acid fluoride method (Nelson and Sommers, 1982).

Field Sampling and Spatial Analysis

The remote sensing samples were collected in the same 4 LGAs of Kaduna state distributed evenly between the northern and southern parts of the state; and for each farm, a sample was collected for each 4 points at 0-20cm depth. This is because most satellite data for soil properties are within the top-soil range (Hengl *et al.*, 2015). Therefore, restricting the ground-based sampling in this study to 0-20 cm aligns with the typically sensed depth ranges from satellite platforms. The remote sensing samples were collected same time during the soil sample collection on the field. A data streaming pipeline is used to query and download multispectral data from the Sentinel-2 repository which is then processed using a proprietary algorithm. The result from the satellite image and how it correlates with those from chemical analysis is the subject and primary objective of this study.

Correlation Analysis

Python programming language version 3.11.4 was used as the correlation analysis tool using Pearson to compare the laboratory analysis and remote sensing results (Virtanen *et al.*, 2020). Scatter plots allow visualization of the relationship between two variables, while correlation analysis provides a quantitative measure of the strength and direction of the relationship (Graham, 2023). Python was selected due to its extensive libraries for statistical analysis and data visualization along with the flexibility to handle diverse data types from both laboratory and satellite sources (Qiusheng *et al.*, 2009). Utilizing the Python environment for integrated analysis of remote sensing imagery and laboratory soil analytics follows established best practices for digital soil mapping and precision agriculture applications (Padarian *et al.*, 2019). Python provides a flexible open-source platform for handling diverse datasets and performing correlation analysis (Hengl *et al.,* 2022). Two datasets were employed, one from remote sensing and the other from the laboratory, each containing 16 instances of soil chemical properties across 12 columns. These datasets were collected from four distinct communities in Kaduna State: Gubuchi, Kuli, Krosha, and Kubacha, each located in different Local Government Areas.

RESULTS AND DISCUSSION

Correlation between the remote sensing nitrogen and the lab nitrogen result

The result of correlation between total nitrogen of remote sensing data and laboratory analysis is presented in Figure 2. From the result, there was a weak positive correlation between the determined parameters and this indicates an existing relation between nitrogen levels assessed through the remote sensing and the laboratory analysis. The weak positive correlation (r=0.14) found between the laboratory and remote sensing soil nitrogen could be associated with the high mobility and volatilization nature of nitrogen that may encourage leaching, run-off and other nitrogen losses from the soil, hence very difficult to measure. Towett *et al.* (2015) found a weak correlation (r=0.19) between laboratory and portable X-ray Fluorescent sensor nitrogen measurements in Kenyan soils due to difficulties estimating subsurface nitrogen indirectly from the spectral response. The low correlation highlights challenges in using remote sensing alone to accurately predict soil nitrogen across agricultural landscapes. The need for further ground-based sensing ground-truthing of satellite data to improve nitrogen prediction aligns with Piikki *et al.* (2013), who used on-ground sensors to calibrate satellite imagery for soil clay mapping.

Vågen and Winowiecki (2019) also emphasized multi-scale calibration of remote sensing using soil analytical lab data for accurate digital soil mapping.

The finding that neither remote sensing nor laboratory methods fully capture soil nitrogen complexity agrees with Hengl *et al.* (2017), who concluded that integrated approaches are essential given the intricacies of nitrogen biogeochemistry. The variability between sites also reflects Towett *et al.* (2015), who found location-specific differences in remote sensing accuracy for soil nutrients. Further coordinated research and data integration will help improve soil nitrogen assessment and enhance remote sensing capabilities for nutrient management.

Correlation between the remote sensing organic matter and the lab organic matter result

The statistical analysis indicates a significant positive correlation between the remote sensing-derived organic matter data and the laboratory organic matter data (Figure 3). The strong positive correlation (r=0.68) between remote sensing and laboratory soil organic matter data is consistent with findings from other studies. Shepherd and Walsh (2002) reported R-values from 0.76 to 0.89 between lab and field spectroscopy organic matter measurements across diverse African agricultural soils. Towett *et al.* (2015) found the highest correlation (r=0.86) between laboratory and portable XRF sensor organic carbon content compared to other nutrients in Kenyan soils. The reliability of remote sensing for organic matter mapping aligns with Vågen and Winowiecki (2019), who used MODIS satellite data to map soil organic carbon across Sub-Saharan Africa with reasonable accuracy compared to ground-based sensing. The robust relationship between spectral response and organic matter is attributed to the direct impacts of surface organic content on crop growth patterns detectable through remote imaging (Hengl *et al.*, 2017). However, some researchers note challenges in relating surface organic matter to total profile carbon stocks using remote sensing alone (Piikki *et al.*, 2013). Integrated approaches incorporating soil sampling, terrain analysis, and digital soil mapping techniques may further improve organic matter quantification across landscapes (Hengl *et al.*, 2017). Still, the strong positive correlation demonstrates the particular potential of remote sensing for cost-effective wide-area mapping of this important indicator of soil quality and health.

Correlation between the remote sensing potassium and the lab potassium result

A negative correlation was observed between the remote sensing-derived potassium data and the laboratory potassium data, with a correlation value of -0.42 (Figure 4). The negative correlation (r=-0.42) between remote sensing and laboratory soil potassium aligns with other studies showing the complexity in using spectral data to estimate plant-available potassium. Piikki and Söderström (2019) found poor correlation (r=0.38) between remote sensing vegetation indices and exchangeable potassium measured in top soils across agricultural fields in Sweden. They attributed this to the dependence of spectral response on multiple soil factors like mineral composition influencing potassium availability. Mulder *et al.* (2011) noted challenges in relating leaf potassium absorption to total soil potassium pools given intricacies of potassium chemistry and soil interactions. Vågen and Winowiecki (2019) were unable to map exchangeable potassium at sufficient accuracy using solely MODIS (moderate resolution imaging spectroradiometer) satellite data for Sub-Saharan African soils. This could indicate that the remote sensing data might not accurately capture the true potassium levels in the soil or that there are other factors affecting the results. The finding highlights the need for integrated approaches combining spectral data with soil chemistry analysis, geologic surveys, and crop modeling to improve potassium prediction noted by both Piikki and Söderström (2019) and Vågen and Winowiecki (2019).

While it shows promise for assessing organic matter, it may have limitations in accurately estimating potassium levels. Understanding these correlations is vital for the appropriate interpretation of remote sensing data in agricultural and environmental applications. Further research and validation may be needed to better understand the factors contributing to these correlations and improve the accuracy of remote sensing techniques for soil property assessments.

Correlation between the remote sensing carbon and the lab carbon data

Based on Figure 5 below, it shows that a weak positive correlation of 0.23 was observed between the remote sensing-derived carbon data and the laboratory carbon data. The weak positive correlation (r=0.23) between remote sensing and laboratory soil carbon aligns with other studies showing the limitations of using vegetation indices alone to estimate total soil organic carbon. Mulder *et al.* (2011) found poor correlations between satellite data and measured soil carbon, as remote sensors only detect surface carbon versus total profile stores. Piikki *et al.* (2013) reported underestimation of soil carbon by 40-60% using solely remote sensing due to difficulties assessing subsurface carbon. Hengl *et al.* (2017) concluded that integrated approaches are needed to improve carbon mapping, given uncertainties in relating land cover to soil carbon balances and the importance of environmental covariates like climate, topography and parent material. The potential reasons for the weak correlation noted here are supported by the literature, including mismatches between surface and profile carbon and the indirect nature of spectral indicators relying on biomass proxies (Vågen and Winowiecki 2019). Recommendations for further analysis align with emphasis on multi-source data integration and digital soil mapping advancements to strengthen carbon prediction (Towett *et al.*, 2015).

Lastly, the carbon correlation analysis reflects consistent findings in the literature on the benefits and limitations of remote sensing for soil carbon assessment, highlighting the particular importance of integrating spectral data with soil analytics, terrain attributes, land use data and process-based models to support carbon monitoring and management.

Correlation between the remote sensing phosphorus and the lab phosphorus data

Figure 5 revealed a significant negative correlation of -0.48 between the remote-sensing phosphorus data and the laboratory phosphorus data. The moderate negative correlation (r=-0.48) between remote sensing and laboratory soil phosphorus aligns with other studies demonstrating challenges in using spectral vegetation indices to estimate plant-available phosphorus.

Mulder *et al.* (2011) found a poor correlation between remote sensing data and soil test phosphorus due to difficulties detecting complex soil phosphorus chemistry from leaf reflectance. Piikki and Söderström (2019) reported an underestimation of Mehlich-3 extractable phosphorus by 80% using solely remote sensing across agricultural fields in Sweden.

Hengl *et al.* (2017) concluded that machine learning approaches combining remote sensing with soil data, terrain attributes, geology maps, and land use improved the prediction of plant-available phosphorus compared to spectral data alone. The negative correlation suggests reliance on indirect plant phosphorus proxies from remote sensing is insufficient to capture dynamics of sorption, precipitation, and labile phosphorus forms in the soil (Vågen and Winowiecki 2019). Integrating targeted soil sampling and digital soil mapping techniques could potentially strengthen phosphorus assessment noted by Towett *et al.* (2015).

The finding calls for further investigation to ascertain the fundamental reasons for the negative correlation. It may indicate limitations in the accuracy of remote sensing techniques for assessing phosphorus levels, or it could be influenced by other factors affecting the data.

Understanding and addressing the reasons for this negative correlation are essential for improving the reliability of remote sensing-based assessments of phosphorus in soil.

Heat-map representation of the correlations among all the variables

A heat map is a powerful visual tool for representing the correlations among variables which is also known as the "R" value table. The heat map visualization provides a clear overview of the variable relationships between soil properties measured through remote sensing and laboratory methods, as noted in other studies. The positive correlations for nitrogen, carbon, and organic matter reflect the reliability of remote sensing for total concentrations of these parameters found by Towett *et al.* (2015) and Hengl *et al.* (2017) in African agricultural soils. In contrast, the negative correlations for phosphorus and potassium align with the literature on the challenges of using spectral vegetation indices to estimate plant-available nutrient pools given complex sorption dynamics (Mulder *et al.*, 2011; Piikki and Söderström 2019).

Vågen and Winowiecki (2019) effectively used similar heat map matrices to represent validation results between ground-based sensing and laboratory measurement of soil organic carbon and texture fractions. The visualization format allows clear interpretation of correlations and discrepancies essential for selecting appropriate remote sensing approaches for different soil nutrients (Towett *et al.*, 2015).

By summarizing multiple correlation analyses in one figure (Figure 6), the heat map enables the identification of strengths and limitations across soil parameters to guide integrated data collection and analysis strategies (Hengl *et al.*, 2017). Conversely, a negative correlation is observed in the Phosphorus (P) and Potassium (K) data. A negative correlation implies that as one variable increases, the other tends to decrease. In essence, it means that there is a discrepancy or difference between the measurements obtained through remote sensing and lab analysis for Phosphorus and Potassium. This negative correlation could be indicative of some level of inaccuracy in the remote sensing data for these specific soil properties or perhaps differences in how these properties are measured using the two methods.

In practical terms, the positive correlations for Nitrogen, Carbon, and Organic Matter suggest that remote sensing can be a valuable tool for assessing these soil properties, offering a time and cost-effective alternative to laboratory analysis. However, for Phosphorus and Potassium, the negative correlations highlight the need for further investigation into the reasons behind the discrepancies and whether adjustments are necessary in the remote sensing methodology or calibration.

Conclusion

This study demonstrated the potential of integrated laboratory and remote sensing techniques for the comparative assessment of soil nutrients. Laboratory and remote sensing techniques showed varying degrees of correlation and accuracy for different soil properties. Strong positive correlations were found for carbon and organic matter having r=0.23 and r=0.68. Weak positive correlation was seen for total nitrogen having r=0.14. And poor negative correlations existed for phosphorus and potassium having r=0.48 and r=0.42 respectively. Remote sensing provided useful climate and environmental data to characterize the cropping systems. But incorporation of additional climate variables could further improve biophysical crop-soil system characterization.

REFERENCE

A. K. Stum (2010). *Random forests applied as a soil spatial predictive model in arid Utah [M.S. thesis]*, Utah State University.

Bielders, C.L., Gérard, B. (2015). Millet response to microdose fertilization in south–western Niger: Effect of antecedent fertility management and environmental factors. Field Crops Research, 171, 165-175.

Black C.A. (1965) method of soil analysis Agronomy No 9-part 2 American society Agronomy

Bouyoucos G.J. (1951). Hydrometer method improved for marking particle size analysis of soils.

Brady, N.C. and Well, R.R. (2002). The nature and properties of soil, 13th edition. Prentice Hall,

Brady, N.C., and R.R. Weil. (2000). Elements of the nature and properties of soils. 12th ed. Prentice RaIl, New Jersey

Bray, R. H., and Kurtz, L.T. (1945). Determination of total organic and available phosphorus in soils. *Soil Science,* 59: 39-45.

Bremner, J. M. (1996). Nitrogen total. *In:* D. L. Sparks *et al*. (Ed.). Methods of soil analysis, Part 3. Chemical Methods. Soil Science Society of America Book series. 5. *Soil Science Society of America and American Society of Agronomy*. Madison, Wisconsin. p. 1085-1121.

Chi, Y.; Zhao, M.; Sun, J.; Xie, Z.; Wang, E. (2019). Mapping soil total nitrogen in an estuarine area with highland scape fragmentation using a multiple-scale approach. *Geoderma* 2019,339, 70–84.

Graham, A. (2023). Evaluating correlation in Excel, SPSS Statistics and R. Statistics How To.

G. R. Blake (1965). “Bulk density,” in *Methods of Soil Analysis Agron*, C. A. Black, Ed., Part I, No. 9., pp. 374–399, American Society of Agronomy, Madison, Wis, USA, 1965.

Hengl, T. Heuvelink, G.B., Walsh, M.G. (2017). Soil nutrient maps of Sub-Saharan Africa: assessment of soil nutrient content at 250m spatial resolution using machine learning. Nutrient Cycle Agroecosystem, 109, 77–102.

Mulder, V.L., de Bruin, S., Schaepman, M.E. and Mayr, T.R. (2011). The use of remote sensing in soil and terrain mapping—A review. *Geoderma*, 162(1-2), 1-19.

Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. In A. L. Page (Ed.), Methods of soil analysis. Part 2. Chemical and microbiological properties (pp. 539-579). American Society of Agronomy, Soil Science Society of America.

Nelson, D.W., and L.E. Sommers (1996). Total carbon, organic carbon, and organic matter. p. 961-1010 In J.M. Bartels et al. (ed.) Methods of soil analysis. Part 3 Chemical methods. SSSA Book Ser No.5. SSSA, Madison, WI. Nigeria. *Geoderma*, 48: 113-129.

Ofomata, G. E. K. (1987). Soil erosion in Nigeria: The views of a geomorphologist. University of Nigeria Inaugural Lecture Series.

Padarian, J., Minasny, B. and McBratney, A.B. (2019). Using machine learning to predict soil organic matter and particle size distribution from VIS-NIR spectra. *Soil Tillage Res* 195, 104400.

Piikki, K. and Söderström, M. (2019). Digital soil mapping of arable land in Sweden – Validation of performance at multiple scales. *Geoderma*, 352, 342-350.

Piikki, K., Söderström, M., and Stenberg, B. (2013). Sensor data fusion for topsoil clay mapping. *Geoderma*, 199, 106-116.

Qiusheng, W. (2009). What is Python and Why is it a Good Language Choice for Science and Scientific Computing.

Towett, E. K., Shepherd, K. D., Sila, A., Aynekulu, E., & Cadisch, G. (2015). Modelling of soil organic carbon stocks in the northern Rangelands of Kenya using remotely sensed covariates. Soil Use and Management, 31(1), 81-92.

Towett, E.K., Shepherd, K.D., Sila, A., Aynekulu, E., and Cadisch, G. (2015). Mid-infrared and total x-ray fluorescence spectroscopy complementarity for assessment of soil properties. Soil Science Society of America Journal, 79(5), 1375-1385.

Vågen, T. G., & Winowiecki, L. A. (2019). Predicting the spatial distribution and severity of soil degradation in East Africa. Applied Geography, 94, 130-142.

Vågen, T.G., Winowiecki, L.A., Tondoh, J.E., Desta, L.T. and Gumbricht, T. (2016). Mapping of soil properties and land degradation risk in Africa using MODIS reflectance. *Geoderma*, 263, 216-225.

Virtanen, P., Gommers, R., Oliphant, T.E. et al. (2020). SciPy 1.0: fundamental algorithms for scientific computing in Python. *Nat Methods* 17, 261–272.

Zhang, M.; Shi, W. (2019). Systematic comparison of five machine-learning methods in classification and interpolation of soil particle size fractions using different transformed data. Hydrol. Earth Syst. Sci. Discuss.1–39.

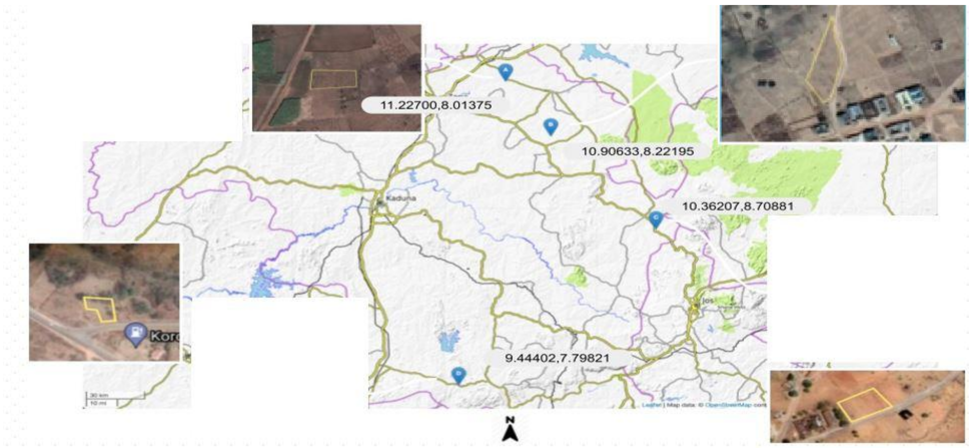

Figure 1: Location of area(s) of interest in Kaduna state (Kubau, Makarfi, Lere, and Kagarko Local Government Areas) and distribution of samples.

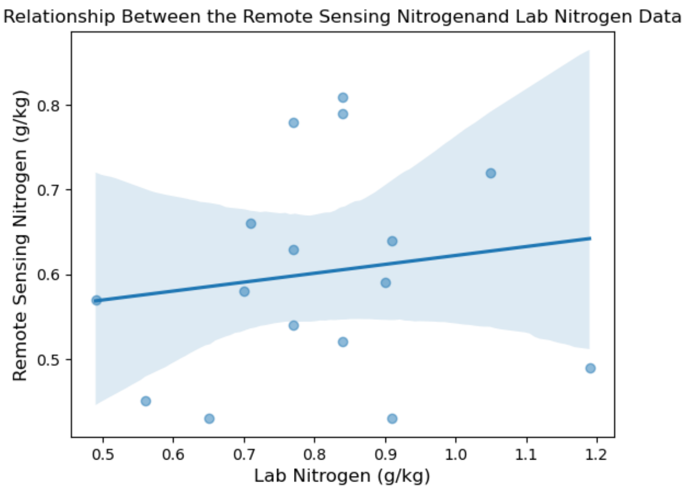

Figure 2: Correlation between the Remote Sensing Nitrogen and the Lab Nitrogen result

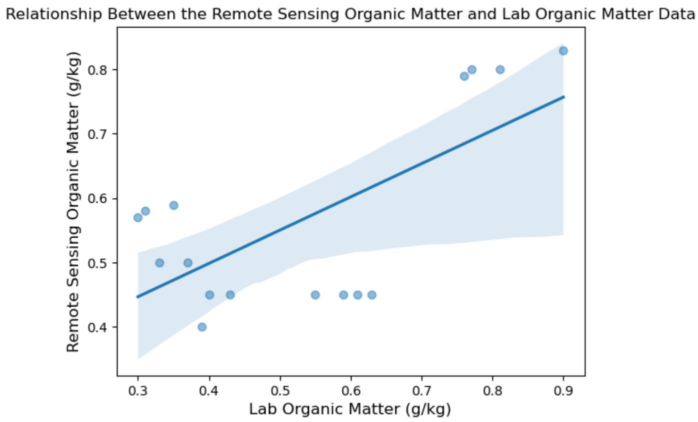

Figure 3: Correlation between the remote sensing organic matter and the lab organic matter result

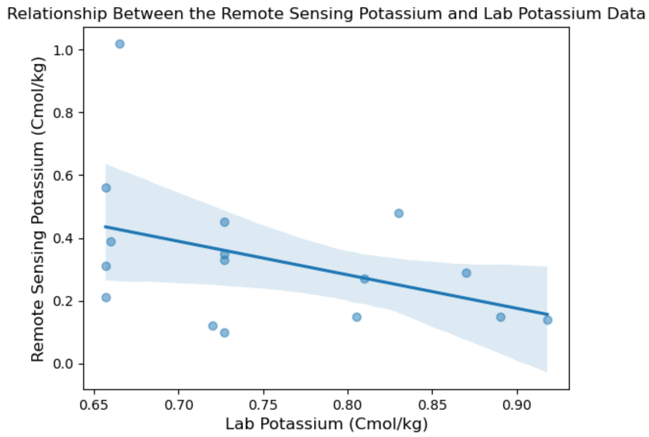

Figure 4: Correlation between the remote sensing organic matter and the lab organic matter result

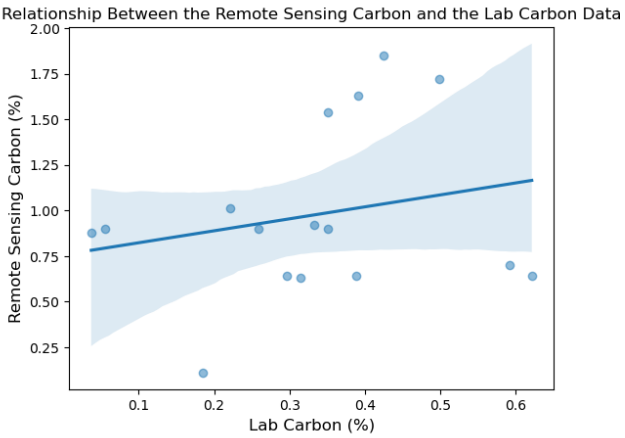

Figure 5: Correlation between the remote sensing organic matter and the lab organic matter result

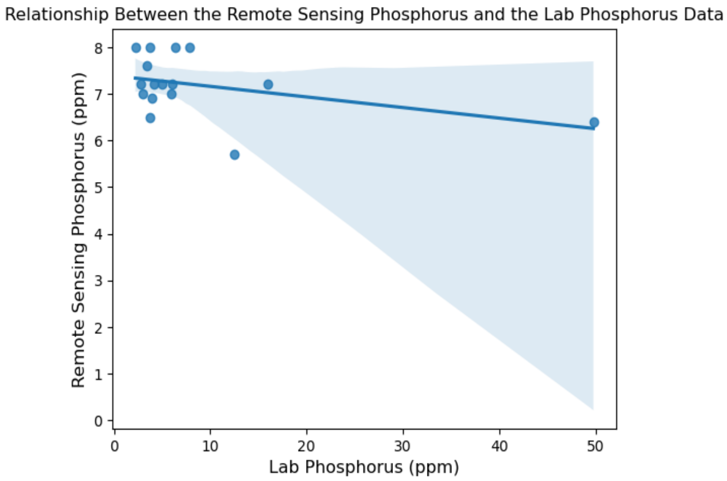

Figure 6: Correlation between the remote sensing organic matter and the lab phosphorus result

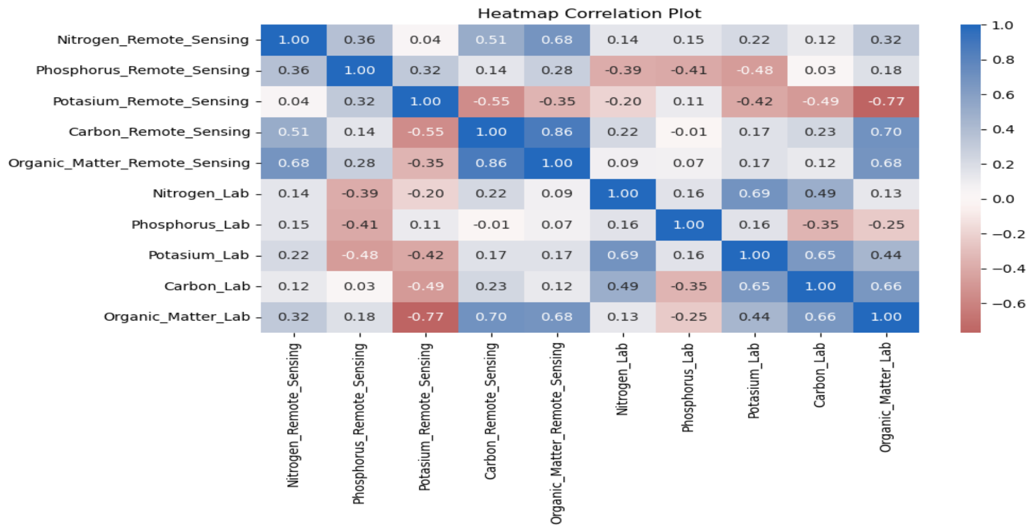

Figure 7: Correlations among all the variables

RESPONSE OF CASTOR (*Ricinus communis* L.) TO DIFFERENT FERTILIZER TYPES, RATES UNDER DIFFERENT PLANTING SPACING

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ABSTRACT

The trials were conducted for two years during the rainy seasons of 2019 and 2020 at two locations; the Teaching and Research Farm of the Faculty of Agriculture, Bayero University Kano, located at $11^0 58'$ N $8^0 25'$ E and 457m above sea level in the Sudan Savanna Zone of Nigeria, and the National Cereals Research Institute Badeggi Niger State located at $9^0 45'$ N and 06^0 07'E and 70m above sea level in the Southern Guinea Savanna Zone of Nigeria (FDALR, 1985). Sudan savannah is characterized by two seasons the wet season (June-October) and the dry season (November-May) with annual rainfall of 800-1000mm. The zone is characterized by a high annual average temperature of between 28^0C-32^0C, a short wet season and long dry season of 6-9 months), abundant short grasses of < 2m, and a few scattered trees (Sownnmi and Akintola, 2010). A large expense of arable land exists in the Sudan Savannah of Nigeria with the potential for production of largely grain crops like maize, Sorghum, Millet, Wheat, and rice (FFD, 2012). Meteorological data comprising minimum and maximum temperatures, rainfall, humidity, and sunshine hours for the periods were collected from the Centre for Dry Land Agriculture (CDA). The results of this study showed significant differences among the treatments on the number of leaves of castor plants. The application rate of N, P, and S at 30 kg ha^- recorded the highest mean number of leaves, leaf area index, and plant height, at Badeggi and Kano during the 2019 and 2020 rainy seasons. The highest mean number of branches per plant, Capsule weight, and 100 seed weight were equally obtained with the highest dose of N, P, and S, across the two locations and during the two seasons. The result also indicated that. The highest yield was obtained from plots with the highest N application rate of 30 kg ha^{-1} and narrow spacing. The heaviest seed weight was noticed on plots with the widest intra-row spacing. The highest 100 seed weight was also noticed with the highest N application rate of 30 kg ha^{-1} and intra-row spacing of 0.75 m indicating that the Castor plant requires high nitrogen rates and wider planting space for maximum yield and hence recommended.

Keywords: Response, Castor, fertilizer, types, rates, different, spacing

INTRODUCTION

Castor *(Ricinus commuunis* L.) is one of the oilseed crops belonging to the family Euphorbiaceae, known for its oil-rich seeds containing hydroxyl fatty acid (Natalia *et al*., 2017) and plays an important role in the country's vegetable oil economy. Castor seed contain 50-55 percent oil and occupies the second position in the production of non-edible oil in the world. It is sticky, dissolved slowly in petrol and other organic solvents, and does not freeze at very low temperatures (-12 to-18 o C) which makes it a superb lubricating material It is indigenous to Eastern Africa and originated in Ethiopia. The revival of industrial crops, including castor, has caught the attention of the Nigerian government, leading to a focus on diversifying the economy and increasing the GDP (Salihu *et al.*, 2013a). However, despite its economic potential and environmental benefits, castor has yet to be fully utilized as a valuable resource (Malik *et al.*, 2018). To unlock its full potential, scientists, farmers, and the government must work tirelessly to achieve higher yields and develop cost-effective technologies for castor production (Cesar and Batalha, 2010). Exploiting Nigeria's agricultural potential, including the production of castor for food and feed, is crucial for achieving economic balance in the country (Cesar and Batalha, 2010).

MATERIALS AND METHOD

The trials were conducted for two years during the rainy seasons of 2019 and 2020 at two locations; Faculty of Agriculture, teaching and research field Bayero University Kano, located at $11^0 58^0$N 8^0,25E and 457m above sea level in the Sudan Savanna Zone of Nigeria which is characterized by two seasons the wet season (June-October) and the dry season (November-May) with an annual rainfall of 800-1000 mm (FFD, 2012) and National Cereals Research Institute Badeggi Niger State located at 9^0,45N and 06^0’07’E and 70m above sea level in the Southern Guinea Savanna Agro-Ecological Zone of Nigeria (FDALR 1985) with rainy season lasts for about 180-210 days. The area has an average annual rainfall of 1100-1124mm unevenly distributed.

Treatments and experimental design

The treatment consisted of a factorial combination of three levels of Nitrogen (0, 15, and 30 kg ha^{-1}), phosphorus (0, 15, and 30 kg ha^{-1}) and Sulfur (0, 15 and 30 kg ha^{-1}), and three intra-row spacing (0.50, 0.75, and 1 m). The treatments were laid in a split-split plot, designed with nitrogen allocated to the main plots, a combination of phosphorus and intra-row spacing allocated to subplots while Sulphur was allocated to sub-sub plots.

Soil samples were collected randomly from twelve (12) points from each of the sites at a depth of 0-30 cm using a soil auger The samples were analyzed for determination of physic-chemical properties using standard procedures as described by Black (1965).

Growth Attributes

Plant height: Three plants were selected randomly from each plot and tagged. The mean value was computed at 4, 8and 16 WAS.

Number of branches per plant: The total number of branches that emanated on the tagged plants was counted and the mean imputed at 4, 8, and 12 WAS.

Seed yield (kg ha-^{1})

Individual produce from the net plots was harvested and dried threshed cleaned and weighed and the products of the mean were taken and computed.

RESULTS AND DISCUSSION

The analysis of the physico-chemical properties of soil at the experimental sites in Kano and Badeggi during the 2019 and 2020 rainy seasons showed distinct characteristics. The soils at Kano were sandy loam in texture with moderately acidic pH levels in water. Organic carbon content was low (4.86 and 4.57 g/kg), while total nitrogen was relatively high to moderate (2.45 and 2.16 g/kg). Phosphorus was moderate (17.10 and 16.40 g/kg), but the exchangeable bases, including calcium, magnesium, potassium, and sodium, were low. The cation exchange capacity (CEC) was also very low. In contrast, soils at Badeggi were loam sandy and sandy loam, with a moderately acidic pH (5.84 and 5.75). Organic carbon (0.15 and 0.14 g/kg) and total nitrogen (1.26 and 1.30 g/kg) were low, while phosphorus was high (26.22 and 22.45 mg/kg). Exchangeable calcium and sodium were moderate, magnesium was high, and potassium was very high. The CEC at Badeggi was moderate. Regarding castor plant height, no significant difference was observed for nitrogen application rates at Kano, but at Badeggi, 30 kg N/ha significantly increased plant height at various growth stages. Phosphorus application had a significant effect on plant height at Badeggi, with 30 kg P/ha consistently producing the tallest plants, while no differences were observed at Kano. Sulfur application significantly increased plant height at both locations, while intra-row spacing had no noticeable impact on plant height at either site.

Regarding 100-seed weight, phosphorus, and sulfur applications showed no significant effects at either location across the years. Intra-row spacing also did not affect 100-seed weight.

In terms of yield, nitrogen application at 30 kg N/ha resulted in the highest yield at both sites in 2019 and 2020, followed by 15 kg N/ha. Phosphorus and sulfur rates showed no significant effect on yield, but intra-row spacing had a significant impact, with 0.5 m spacing producing the highest mean yield at both locations.

DISCUSSION

The application of plant nutrients increases crop production (Chaves et al., 2011). Antinio et al. (2020) highlights that different fertilizer types and rates improve castor plant growth, seed, and oil production. The analysis of soil samples revealed high cation exchange capacity (5.43–6.0 cmol/kg-1), indicating good soil quality and nutrient availability during both seasons. The sandy loam texture at the sites is ideal for castor plants, promoting root establishment and nutrient absorption. Soil pH, which influences many soil properties, was moderately acidic at Badeggi (5.75) and slightly acidic at Kano (6.4) in 2019 and 2020 (Hong, Gan, and Chen, 2019). Changes in pH over time, particularly at Kano, may be linked to factors like rainfall leaching calcium and magnesium. Organic matter decomposition also lowers soil pH by producing organic acids. Proper soil management is crucial for sustaining agricultural productivity and environmental health (Ashenafi et al., 2010).

The study confirmed lower soil organic carbon levels, aligning with findings that continuous cultivation reduces organic carbon, affecting soil structure and water retention (Li et al., 2014; Alcantera et al., 2016). Total nitrogen levels were low to medium (1.26–2.45 g/kg), indicating that nitrogen is a limiting factor in the study areas, consistent with research by Kiflu and Beyene (2013) and Muche et al. (2015).

The highest mean plant height observed at Kano and Badeggi during the two rainy seasons with the nitrogen (N) application rate of 30 kg ha-1 was attributed to the increased N application. Patel et al. (2017) suggest that plant vigor can be enhanced with high doses of N, which boosts branch formation and photosynthetic activity, resulting in maximum plant height (Patil et al., 2018; Yousaf et al., 2018). Increased N application also led to a higher number of branches, promoting better dry matter production (Patil et al., 2018).

The higher yield at this N rate could be due to the improved availability of resources, leading to better plant growth parameters such as the number of racemes, increased branches, capsule count, 100-seed weight, and total yield (Kashyap et al., 2018; Jamil et al., 2018; Maryam et al., 2012). Yousaf et al. (2018) found that increasing N to 40 kg ha-1 further boosted yield, while no fertilizer application produced the lowest yield. Increased N levels also promoted more capsules per plant (Jamil et al., 2017), although the potential yield is influenced by variety and spacing (Garba et al., 2006).

REFERENCES

Ashenafi, A; Abayneh, E; and Sheleme, B. (2010) Characterizing soils of Delbo Wegene watershed. Wolaita Zone, Southern Ethiopia for planning appropriate land management J. *Soil Sci Environ- manag. 1,184 – 199.*

Federal Department of Agricultural Land Resources (FDALR) (1985). The Reconnaissance soil survey of Imo State, Nigerian (1: 250,000). Soils report 133PP.

FFD (2012).Effect of Plant and Row Spacing on the Yield and Oil Contents of Castor (*Ricinus communis* L.) in the Central Rift Valley, Ethiopia.*Ethiop. J. Agric. Sci.* 24:155-162.

Garba, A., Awwalu, B. M and Abdul, S. D. (2006).Effect of intra Row Spacing and Variability in seed size on the yield of Ten groundnut varieties in Bauchi Nigeria. *Savannah Journal of Agriculture*,1(1):1537- 9377.

Jamil, M., S.S. Hussain, M.A. Qureshi, S.M. Mehdi and M.Q. Nawaz. (2017). Impact of sowing techniques and nitrogen fertilization on castor bean yield in salt-affected soils. The J. *Anim.Plant Sci*. 27(2)**:** 451-456.

Kashyap TL, Khajanji SN, Praveen KV (2018) Economic Analysis of Linseed (*Linum usitatissimum*) Grown After Rice in Alfisols of Chhattisgarh Plain. International Journal Current Microbiology Applied Sciences 2018;6:1061-1067.

Kiflu, A. and Beyene, S (2013) Effects of different land use systems on selected soil properties in *South Ethiopia J. Soil Sci. Environ. Manag. 4(5), 100- 107*

Li, Y.F; Zhang, J.J; Chang, S.X; Jiang, P.K; Zhou, G.M Shen, z.m; Wu, j.s; Lin, l; Wang, Z.S; and Shen, M.C (2014) converting native shrubs forests to Chinese chestn. Plantations and subsequent intensive management affecting soil C and N pools *Fon. Eco. Mgt* 312, !61-169.

Malik, M.Y., Muhammad, M.R., Muhammad, Z. and Kazim, A. (2018). Yield Response of Castor (*Ricinus commnnis* L.) to NPK fertilizers under Arid climatic conditions. *Pakistan Journal of Agricultural Research*. Doi,10.17582/journal.pjar/2018/31.21.80. 185

Muche, M, Kokeb, A., Molla, F.F (2015) Assessing the physics chemical properties of the soil under different land use types. *J. Environ Anal, Toxicol*.5,309.

Patel R.K, Tomar G.S., Dwivedi S.K. (2017). Effects of irrigation scheduling and nitrogen levels on growth, yield, and water productivity of linseed (*Linum usitatissimum*L.) under Vertisols. *Journal of Applied and Natural Science*, 9(2):698-705.

Yousaf, M.M., M. Hussain, M.J. Shah, B. Ahmed, M. Zeshan, M.M. Raza and K. Ali. (2018). Yield response of castor (*Ricinus communis*L.*)* to NPK fertilizers under arid climatic conditions. *Pakistan Journal of Agricultural Research,* 31(2): 180-185.

Table 1: Physical and Chemical Properties of Soils of the Experimental Sites at Bayero University, Kano, and Badeggi During the 2019 and 2020 Rainy Seasons.

	BUK 2019	2020	Badeggi 2019	2020
Physical Properties (g kg^{-1})				
Sand	607.4	617.1	921.3	921.8
Silt	257.0	234.8	24.8	34.9
Clay	135.6	148.1	53.9	43.3
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy
Chemical properties				
pH (H_2O)	6.4	6.0	5.84	5.75
pH ($CaCl_2$)	6.0	5.8	5.44	5.43
Organic carbon (g kg^{-1})	4.68	4.57	1.26	1.30
Total nitrogen (g kg^{-1})	2.45	2.16	0.15	0.14
Available phosphorus (mg kg^{-1})	17.10	16.40	26.22	22.45
Exchangeable bases (Cmol kg^{-1})				
Ca	4.88	4.72	8.84	8.90
Mg	0.41	0.80	4.46	4.53
K	0.12	0.13	1.89	1.85
Na	0.07	0.13	0.23	0.22
C.E.C.	5.48	5.78	15.42	15.50

Table 2: Response of Castor Plant Height (cm) to Nitrogen, Phosphorus, Sulphur, and Intra-row Spacing at Badeggi and BUK During the 2019 Rainy Season.

Treatment	Badeggi				BUK			
	Weeks After Sowing				Weeks After Sowing			
	4	8	12	16	4	8	12	16
Nitrogen (kg N ha^{-1})								
0	16.96	39.26	64.46	99.25	17.21	41.09	46.6	87.1
15	17.97	39.58	66.54	97.45	17.36	38.11	49.3	88.7
30	18.14	42.44	67.04	98.69	17.64	39.21	58.8	89.8
SE±	0.019	0.011	0.013	0.010	0.028	0.008	0.031	0.009
P-value	0.202	0.0511	0.1041	0.1419	0.503	0.067	0.067	0.2214
Phosphorus (kg P ha^{-1})								
0	17.87	39.08b	63.49c	98.51ab	17.45	39.56	376b	83.2
15	17.86	40.99a	65.77b	96.88b	17.77	40.51	370b	88.9
30	17.35	41.21a	68.37a	100.00a	16.99	38.38	380a	89.9
SE±	0.019	0.011	0.012	0.010	0.028	0.008	0.013	0.009
P-value	0.250	0.0003	0.0001	0.0002	0.152	0.296	0.0001	0.2214
Sulphur (kg S ha^{1})								
0	16.28c	32.08c	58.30c	86.89c	17.38c	34.18c	52.78c	96.56
15	17.73b	40.99b	66.45b	96.25b	17.64b	38.18b	63.88b	108.20
30	19.07a	48.21a	72.89a	112.24a	19.61a	46.23a	74.63a	132.90
SE±	0.002	0.001	0.002	0.001	0.016	0.004	0.008	0.006
P-value	0.000	0.0001	0.0001	0.0001	0.000	0.000	0.0001	0.9076
Intr-Spacing (m)								
0.5	17.72	39.83	65.28	98.50	16.72b	39.50	37.3	81.6
0.75	17.47	40.50	65.89	98.53	17.44a	38.75	38.2	82.0
1.0	17.89	40.96	66.47	98.36	18.07a	40.20	39.0	85.7
SE±	0.022	0.013	0.015	0.011	0.005	0.002	0.003	0.002
P-value	0.483	0.2601	0.2002	0.9833	0.004	0.201	0.1553	0.0798

Means with the same letter are not significantly different at a 5% level of Probability using SNK. NS Not significant, **=Significant at 1%.

Table 3 Response of Castor Plant Height (cm) to Nitrogen, Phosphorus, Sulphur and Intra-row

Treatment	Badeggi				Kano			
	Weeks After Sowing				Weeks After Sowing			
	4	8	12	16	4	8	12	16
Nitrogen (kg N ha^{-1})								
0	15.96b	40.40	65.31	97.06	15.41c	40.94c	63.08	96.50
15	17.19a	40.57	65.63	98.17	15.64b	42.36b	63.64	96.82
30	17.43a	40.83	65.64	98.28	15.95a	43.72a	63.88	97.52
SE±	0.029	0.011	0.013	0.011	0.056	0.019	0.014	0.012
P-value	0.0002	0.1900	0.2856	0.4090	0.0001	0.0001	0.2884	0.1859
Phosphorus (kg P ha^{-1})								
0	16.56	40.22	64.83	98.14a	15.63	42.18	63.40	96.33
15	16.84	40.58	65.69	96.47b	15.64	42.34	63.51	96.56
30	17.18	41.04	66.06	98.89a	15.75	42.51	63.62	96.95
SE±	0.024	0.013	0.015	0.012	0.073	0.024	0.019	0.016
P-value	0.2475	0.3146	0.2679	0.0003	0.2971	0.5596	0.2507	0.3942
Sulfur (kg S ha^{-1})								
0	14.04c	32.57c	56.87c	85.49c	10.81c	30.52c	50.78c	78.69c
15	17.19b	40.97b	66.33b	96.67b	16.06b	43.44b	65.13b	96.87b
30	19.36a	48.29a	73.39a	11.35a	20.14a	53.07a	74.69a	115.28a
SE±	0.004	0.002	0.002	0.002	0.006	0.002	0.002	0.012
P-value	0.0001	0.0001	0.0001	0.0001	.0.0001	0.0001	0.0001	0.0001
Intr- Spacing (m)								
0.5	16.59	39.71	65.89	98.45	15.64	42.27	63.12b	96.62
0.75	16.64	41.34	64.99	98.69	15.67	42.53	63.05b	96.91
1.0	17.35	40.80	65.70	98.35	15.69	42.23	64.42a	97.31
SE±	0.024	0.013	0.015	0.012	0.068	0.023	0.018	0.029
P-value	0.1760	0.1365	0.4780	0.1492	0.8535	0.5805	0.0003	0.4793

Means with the same letter are not significantly different at a 5% level of Probability

Table 4: Response of Castor Seed Yield (kg ha^{-1}) to Nitrogen, Phosphorus, Sulphur, and Intra-row Spacing

Treatment	Badeggi		Kano	
	2019	2020	2019	2020
Nitrogen (kg N ha^{-1})				
0	849.50c	905.38b	790.97	932.68c
15	904.73b	913.09b	984.11	970.11b
30	1032.68a	1120.62a	1100.79	1100.50a
P-value	0.0001	0.0001	0.1196	0.0002
SE±	0.024	0.021	0.024	0.020
Phosphorus (kg P_2O_5 ha^{-1})				
0	907.83	919.21	905.31	907.21
15	913.92	924.65	908.57	913.92
30	915.16	937.12	910.00	915.16
P-value	0.1818	0.3212	0.1030	0.1221
SE±	0.021	0.022	0.023	0.021
Sulfur (kg S ha^{-1})				
0	904.97	923.46	903.82	904.97
15	807.27	924.54	905.18	906.65
30	924.66	933.10	914.88	924.66
P-value	0.1741	0.2304	0.1141	0.2427
SE±	0.024	0.021	0.022	0.021
Spacing (m)				
0.5	888.93	991.5a	920.13a	990.93a
0.75	919.04	970.17b	916.06a	919.32b
1.0	928.93	913.39c	887.69b	909.32b
P-value	0.1847	0.0001	0.0001	0.0002
SE	0.020	0.021	0.019	0.022

Means with the same letter are not significantly different at a 5% level of Probability using SNK.

COMPARATIVE ANALYSIS OF INDOOR AND OUTDOOR CONDITIONS ON THE CATCHABILITY OF *C. maculatus* INFESTING COWPEA

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ABSTRACT

Advancements in pest management, particularly in insect detection technologies, aim to reduce the reliance on chemical insecticides for storing agricultural produce. One such innovation is the insect probe trap, which is essential for inspecting cowpea for bruchid infestations during purchase and storage. This tool holds significant commercial value for grain stakeholders in Africa, who commonly store cowpea in bags. Effective utilization of the probe trap necessitates understanding the environmental differences between outdoor and indoor conditions, such as variations in light intensity and other abiotic factors. This study investigates the impact of trapping durations and environmental conditions on the efficacy of a naturally lighted insect probe trap for monitoring cowpea bruchid infestations. Results indicate that the probe trap effectively captures bruchids quickly, with increased catches over longer trapping durations, highlighting the importance of time in grain inspection. Additionally, no significant difference was observed in trap performance between indoor and outdoor settings, demonstrating the trap's versatility. Thus, the naturally lighted insect probe trap is suitable for use in both indoor and outdoor conditions for inspecting bulk cowpea grains.

Keywords: Pest management, *C. maculatus*, Insect probe trap, Cowpea, Environmental conditions.

INTRODUCTION

Meeting the food demand of a rapidly increasing global population is emerging as a big challenge to mankind. Approximately one-third of the food produced, is lost globally every year due to pest infestations. Despite many years of research in the field of pest management, researchers are not still close to winning the war against pests than law enforcement agencies are winning the war on drugs (Murray, 2019). We are losing a significant amount of food on a global scale to insect pests at a time when we must increase food production to feed a growing population. Over the years, the magnitude of losses in developing countries to major food crops average 30%, and poses a great risk to food security for the increasing world population by year 2050, thereby making postharvest loss reduction a global food security concern (Daniel *et al*, 2019). Therefore, demands for more food for the expanding world population has focused on the need for better control of stored product insects, especially those attacking comestible legumes in developing countries (Sarwar, 2015).

Cowpea, (*Vigna unguiculata* L. Walp) is one of the most important food legume crops in Africa. Cowpea is particularly attacked by *Callosobruchus maculatus* (F.), it could cause serious damage to stored leguminous seed (Anugwom *et al.*, 2022). Hence, in Africa grain handlers are peasant, under-educated, coupled with inefficient sampling methods available to them for monitoring infestation. This has led to reductions in storage of these agricultural commodities, and unnecessary chemical treatments which are costly. On the other hand, resultant exposure effects of synthetic insecticides have also led to severe use restrictions owing to their negative effects on humans; death included (Murray, 2019).

According to Anugwom *et al*. (2017 and 2022), proper sampling and identification of insect pest during post-harvest helps grain handlers to detect problems early and thereby prevent further damage as well as discourage the prophylactic use of pesticides. This helps to reduce the level of food wastage and contamination, gladly the inspection of cowpea for both the presence and level of bruchids infestation can be done using insect probe trap.

The insect trap exploits the wandering behaviour of insects which helps in timely detection of bruchids, thereby leading to timely control (Anugwom *et al*., 2017). Different designs of insect probe trap have been used, however, their performance so far either offer very limited improvements or require much more development before they are suitable for commercial application.

Considering findings by Anugwom *et al.* (2022), efficient use of the naturally lighted probe trap now quests for basic knowledge about the environment relative to differences (i.e. light intensities) in outdoor (open market) and indoor (store, warehouse, or laboratory) use of the trap; owing to the fact that both conditions have differences in light intensity, and both conditions can as well be involved in the usage of the insect probe trap during postharvest handling of cowpea (Lamichhane and Ricci, 2019). This research is therefore pointed towards presenting background information and specific guidance on outdoor or indoor usage of the probe trap designed by Anugwom *et al.* (2022) for monitoring *C. maculatus* infesting bulk cowpea. This information will help extend the device to farmers and relevant stakeholders in developing countries, promoting adoption and contributing to future global food security. Thus, this research was developed to determine the effect of different trapping duration (time) on the use of insect probe traps and evaluate the effect of indoor and outdoor conditions respectively on the use of insect probe traps for monitoring *C. macullatus* infestations in bulk cowpea.

MATERIALS AND METHODS

The experiment was conducted in the Entomology laboratory and environment of the Nigerian Stored Products Research Institute (NSPRI), Kano station (11°30'N, 8°30'E) Nigeria, with average temperatures of 29 ± 3°C and relative humidity between 52 to 75%. The probe trap used had a transparent cap with an average light illumination of 14.30 lx indoors and 1766 lx outdoors, as described by Anugwom *et al*. (2017). The trap's bottom was cone-shaped with a steel cylinder featuring 4mm diameter perforations to allow entry of cowpea bruchids but exclude grains. Trapped insects would pass through a funnel into a detachable reservoir for examination or disposal.

Adult *Callosobruchus maculatus* from a culture maintained in the laboratory were used. Cowpea grains (300 kg) were disinfested using the cold shock method (Anugwom *et al*., 2017). Artificial infestation involved placing live *C. maculatus* (70 adults) into each 10 kg cowpea lot within plastic storage buckets to ensure uniform insect distribution.

The experiment had two setups: indoor (laboratory) and outdoor (ambient). Each setup involved artificially infesting 10 kg cowpea lots with 70 adult insects (7 insects per kg). Four inspection durations were tested simultaneously in both conditions, with each treatment repeated three times:

Treatment 1: Traps inspected after 20 minutes; Treatment 2: Traps inspected after 40 minutes; Treatment 3: Traps inspected after 60 minutes; Treatment 4: Traps inspected after 80 minutes. Data collected included the number of insects caught per trap for each inspection duration under both indoor and outdoor conditions. The data were analyzed using ANOVA with the SAS (2000) statistical package, version 9.0, and means were separated using the Student-Newman-Keuls Test (SNK) at a 5% probability level.

RESULTS AND DISCUSSIONS

Indoor Trap Catch at Different Trapping Duration

The results from Table 1 indicate that the 80-minute trapping duration (treatment 4) achieved the highest mean trap catch of 2.97, significantly different ($P \leq 0.05$) from the 60-minute duration (treatment 3) with a mean of 1.97. While treatment 3's mean was higher than those of the 40-minute (1.68) and 20-minute (1.56) durations, these differences were not statistically significant ($P \geq 0.05$). This pattern shows that longer trapping durations result in increased trap catches. Extending the trapping duration to 80 minutes notably improves the number of bruchids caught, enhancing the trap's efficiency in detecting infestations. These findings support previous research by Anugwom *et al.* (2017 and 2022), emphasizing the importance of longer trapping durations for accurate and reliable infestation assessments in cowpea postharvest handling.

Outdoor Trap Catches at Different Trapping Duration

In outdoor conditions, treatment 4, with an 80-minute trapping duration, achieved the highest mean trap catch of 3.06, which was significantly different ($P \leq 0.05$) from treatment 3, with a mean of 1.68. Treatment 3 was statistically similar to treatment 2 (1.29). But significantly different ($P \leq 0.05$) from treatment 1, which had the lowest mean of 0.71^{c}. However, there was no significant difference ($P \geq 0.05$) between treatment 2 and treatment 1 (Table 2). This data indicates that longer trapping durations result in higher trap catches, consistent with the previously observed trend and supporting the findings by Anugwom *et al*. (2017; 2022). The significant difference between treatment 4 and the shorter durations underlines the importance of extended trapping time for maximizing bruchid capture in outdoor settings. These results reinforce the conclusion that extending the trapping duration enhances the effectiveness of the insect probe trap in detecting bruchid infestations in cowpea.

Trap Catches at Different Trapping Conditions and Duration

Under both trapping conditions, the mean trap catch was higher indoors (2.04) compared to outdoors (1.68). However, this difference was not statistically significant ($P \geq 0.05$), indicating that the performance of the trap was consistent across both environments. When combining the results from both indoor and outdoor conditions, treatment 4 (80-minute trapping duration) had a significantly higher mean trap catch ($P \leq 0.05$) compared to treatment 3 (60 minutes). Treatment 3's mean was similar to treatment 2 (40 minutes), but significantly different from treatment 1 (20 minutes). Treatments 2 and 1, however, were not significantly different from each other.

These findings suggest that the different abiotic conditions between indoor (32°C, 56% relative humidity, 14.30 lx light) and outdoor (44.4°C, 35% relative humidity, 1766 lx light) settings did not affect the trap's performance. The average trap catch in this study was lower than the expected range (between 12 and 5 bruchids) described for a mildly infested grain sample (7 insects per kilogram), as reported by Anugwom *et al*. (2022). This discrepancy can be attributed to the shorter inspection duration used in this study (a maximum of 80 minutes) compared to Anugwom *et al*.'s 24-hour duration.

The results indicate that to effectively use the probe trap for reducing insect populations in stored cowpea, it should be deployed for longer periods. Additionally, to utilize the trap for precise insect population estimates over specific periods, further research is necessary.

CONCLUSION

Based on the results obtained from the study, both indoor and outdoor conditions do not affect the effectiveness of the insect probe trap for monitoring cowpea weevil infestations in bulk commodities. However, trap catches were influenced by trapping duration, indicating that longer inspection times are necessary for the trap to detect insect infestations at levels described by Anugwom *et al.*, (2017).

REFERENCE

Anugwom, U. D., Bamaiyi, L. J., Magaji, B. T., Oparaeke, A. M., Arowora, K. A. (2017). Effects of Different Colors of Light Source on Probe Trap Catch of Cow-Pea Weevil Infesting Stored Cowpea. *International Journal of Biological and Environmental Engineering.* Vol. **2**(1):1-8.

Anugwom, U. D., Awotunde, D. R., Auwalu, A. I., Abba, K. A., Lucius, J. B., Magaji, B. T., and Oparaeke, A. M. (2022). Fabrication of probe trap for monitoring cowpea weevil infesting stored cowpea. *Arid Zone Journal of Engineering, Technology & Environment* (AZOJETE) Vol. **18**(4):643-658.

Fróna, D., Szenderák, J. and Harangi-Rákos, M. (2019). The Challenge of Feeding the World. *Multidisciplinary Digital Publishing Institute (MDPI).* Sustainability 2019, 11, 5816; doi:10.3390/su11205816.

Lamichhane, J. R. and Ricci, P. (2019). Research and Innovation Priorities as Defined by the Ecophyto Plan to Address Current Crop Protection Transformation Challenges in France. *Advances in Agronomy: Science Direct*. Volume **154**: 81-152. *https*://Doi.org/10.1016/bs.agron.2018.11.003.

Sarwar, M. 2015. Extermination of Insect Pests (*Coleoptera: Bruchidae*) and Damage of Stored Pulses by Different Methods in Market. *American Journal of Marketing Research* Vol. **1**(3): 99-105.

Murray B. Isman, 2019. Challenges of Pest Management in the Twenty-First Century: New Tools and Strategies to Combat Old and New Foes Alike. *Frontiers in Agronomy; Pest Management*. *https*://Doi.org/10.3389/fagro.2019.00002.

Table 1: Effect of indoor trapping on the number of *C. maculatus* per catch at different durations of trap inspection

Treatment	Mean trap catch
<u>Time of inspection (minutes)</u>	
Treatment **1** (20)	1.56b
Treatment **2** (40)	1.68b
Treatment **3** (60)	1.97b
Treatment **4** (80)	2.97a
SE+	**0.304**
Significance	*
Mean	2.05

Mean followed by the same letter(s) are not different statistically at *P=0.05* using SNK, *= Significant at (P≤0.05)

Table 2: Effect of outdoor trapping on the number of *C. maculatus* per catch at different durations of trap inspection

Treatment	Mean trap catch
<u>Time of inspection (minutes)</u>	
20	0.71c
40	1.29bc
60	1.68b
80	3.06a
SE+	0.211
Significance	**
Mean	1.69

Mean followed by the same letter(s) are not different statistically at *P=0.05* using SNK, **= Significant at (P≤0.01)

Table 3: Effect of trapping conditions and time of inspection on the number of *C. maculatus* caught per trap

Treatment	Mean trap catch
<u>Condition of trapping</u>	
Indoor	2.04
Outdoor	1.68
SE+	**0.129**
Significance	NS
<u>Time of inspection (minutes)</u>	
20	1.13c
40	1.48bc
60	1.82b
80	3.01a
SE+	**0.182**
Significance	**
<u>Interaction</u>	
Condition*Time	NS

Mean followed by the same letter(s) are not different statistically at *P=0.05* using SNK, NS= Not significant
**= Significant at (P≤0.01)

CROPS RESIDUE MANAGEMENT EFFECTS ON SOME AGRONOMIC CHARACTERISTICS AND YIELD OF SORGHUM (*Sorghum bicolor* L. Moench) IN SUDAN SAVANNA AGRO-CLIMATIC ZONE OF NIGERIA

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ABSTRACT

Field trials was conducted during the 2022 rainy season at the Research Farms of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Minjibir, Kano, located at the Sudan Savanna Agro-Climatic Zone of Nigeria, to examine the effect of different level residue removal on some agronomic characteristics and yield of Sorghum varieties. Three residue removal levels (0%, 50% and 100%v) and two Sorghum varieties (Local Kaura and Improved Deko varieties) were the treatments used. The treatments were arranged on a Randomize Complete Block Design and replicated four times. The gross plot size was 3.75m x 5m (18.75m^2), consisting of 5 ridges of 5m long. Data were collected on some agronomic characteristics and yield which were later subjected to analysis of variance (ANOVA) using Genstat 17th Edition. Treatment means were separated using Student-Newman Keuls Test. The results showed that residue removal had no significant effect on chlorophyll content, Leaf Area, plant height, number of stands at harvest and total yield ha^{-1}. Varietal difference was obtained to have significant effect on chlorophyll content, plant height and number of stands at harvest were their higher records were obtained with local variety, while higher total yield tones ha^{-1} and 1000 grain weight were obtained with improved Deko variety. Based on the finding of this work it can be suggested that farmers in area of study should adopt sowing of Improved Deko sorghum variety for high yield with or without of crop residue management.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L) Moench) belongs to the family Poaceae and is known as guinea corn in West Africa and locally called Okababa, Dawa, and Okili in three major languages of Nigeria (Adegbola, 2013). Sorghum is the fifth most important cereal in the world after corn, rice, wheat, and barley. It is considered as source of diet to over 500 million people in about 30 countries (Reddy *et al.,* 2010; Dahlberg *et al.,* 2011). Global sorghum production stood at 63.9 million tonnes in 2016. Nigeria being the world second largest producer accounted for 12% of global production with 6.9 million tonnes (FAOSTAT, 2017). Sorghum grows under relatively high temperatures of between 20^{0}C to 30^{0}C on a deep, well drained, fertile soil. It also requires a rainfall of between 400mm to 800mm distributed across the growing period. The crop is genetically suited to hot and dry agro-ecologies where it is difficult to grow other grains. Many countries will soon have limited new land for agricultural development leaving no alternative other than intensifying yield per unit area. Soil management and conservation must play a major role in increasing crop yields and soil productivity on a sustainable basis (Ofori, 2018). To improve production practices in semi-arid regions, an understanding of the effects of different levels of crop residue removal on the yield of important dry land crops such as sorghum is essential. This research aims to evaluate the effect of crop residue management at different level on the productivity of two sorghum varieties in the study area.

MATERIALS AND METHOD

The experiment was conducted during the 2022 rainy season at Research Farms of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Minjibir, Kano located at the Sudan Savanna Agro-Climatic Zone of Nigeria. The treatments consisted of three crop residue removal levels (0%, 50% and 100%) and two Sorghum varieties (Local Kaura and Improved Deko Variety). The treatments were arranged in a Randomized Complete Block Design and replicated four times. The gross plot size was 3.75m x 6m (18.75m^2), consisting of 5 ridges of 5m long. Data on growth and yield characters (chlorophyll content, Leaf Area, plant height, and number of stands at harvest, 1000 grain weight and total yield/ha) were collected and subjected to analysis of variance (ANOVA) using Genstat 17th Edition. Treatment means were separated using Student-Newman Keuls Test (SNK) at 5% probability level.

RESULTS

Table 1 shows the effects of residue removal and varieties on Leaf Area and chlorophyll content of sorghum at Minjibir during the 2022 rainy season. Result obtained revealed that there no was significant difference statistically in Leaf area and chlorophyll content among the different residue management strategies throughout the sampling period of the trial. However, highly significant statistical differences were recorded among the varieties on leaf area and chlorophyll content of sorghum. At 6 and 9 WAS, the result showed that the local variety was significantly higher in leaf area than the improved variety, while at 12 WAS the result shows that there was no significant difference among the residue management strategies on the leaf area of sorghum. But at 9 and 12WAS improved variety was significantly higher in chlorophyll content than the local variety, while at 6WAS there was no difference observed among the varieties.

Table 2 shows the effects of residue management strategies and varieties on Plant Height (m), stands count at harvest, total yield/ha and 1000 grain weight of Sorghum at Dambatta during 2022 rainy season. From the results recorded it showed that plant height was obtained to be statistically similar for residue management. But highly significant difference was however observed between Local and improved variety, where the Local variety recorded statistically taller plants than the improved variety. On residue management and varieties effect on number of stands at harvest of Sorghum the result obtained showed that there was no statistically significant difference observed between residue management strategies. But there was a highly significant difference in number of stands at harvest between the varieties where it shows that the improved was statistically higher than the Local variety in number of stands at harvest period.

The results in Table 2 show the effects of residue management and varieties on the yield and 1000 grain weight of Sorghum at Dambatta during the 2022 rainy season also. There was no significant differences in yield for residue management. However, 0% residue removal gave the highest yields. Highly significant difference was observed between varieties on total grain yield per hectare and 1000 grain weight, where the result shows that Improved variety gave statistically higher total yield/ha and 1000 grain weight than the Local variety.

DISCUSSION

There was no significant difference between the residue management on chlorophyll content of sorghum. This could due to the fact that chlorophyll content of plants was highly influenced by the availability of nitrogen and since the decomposition and subsequent release of nitrogen from the residues is gradual**,** it might take longer period than a single growing season to affect the chlorophyll contents of the plants significantly. The significant difference in chlorophyll content between the varieties could be due genetic makeup which results to higher nitrogen uptake and photosynthetic efficiency as a result of variations in genetic composition of the varieties. However, 0% residue removal gave the highest total yield per hectare. This may be due to increase in soil organic matter content and enhanced soil water retention due higher humus content as observed by Lindstrom *et al.*, 1984 and Brown *et al.*, 1989. The higher yield observed in Improved Deko over Local Kaura may be attributed to genetic composition, better adaptability of Improved Deko to the soil and weather conditions of the experimental site.

CONCLUSION AND RECOMMENDATION

From the results of this study, it can be concluded that even though residue management strategies did not have significant effect on yield and some growth parameters of Sorghum, varietal difference gave higher yield where the improved variety was obtained to produce significantly higher total grain yield in tons per hectare than the Local variety. Hence cultivation of improved variety is suggested to farmers in the experimental location. Also considering the promising results showed by 0% crop residues management strategies, it can be suggested that farmers should leave crop residue from previous cropping season (0% residue removal) on the field to improve soil conditions and by extension, the performance and yield of Sorghum.

REFERENCES

Adegbola, A. J., Awagu, E. F., Kamaldeen, O. S., and Kashetu R. Q., (2013). Sorghum: Most under-utilized grain of these mi-arid Africa. *Scholarly Journal of Agricultural Science,* Vol. 3(**4**), pp. 147-153.

Dahlberg, J., Berenji, J., Sikora, V. and Latkovic, D., (2011). Assessing Sorghum (Sorghum bicolor (L) Moenech) germplasm for new traits: Food, Fuels and Unique uses. Maydica. pp. 56 – 1750.

FAOSTAT, (2017). Food and Agricultural organization of the United Nation. Accessed via http://www.factfish.com/statistic/sorghum%2C%20yield accessed on 07/10/2019.

ICRISAT (2004). Sorghum: A Crop of Substance. Patancheru 502 324 Andhra Pradesh: International Crops Research Institute for the Semi – Arid Tropics.

Pollo, R & Sitompul, S.M. & Guritno, B & Tyasmoro, Y.S. (2018). Crop Growth Parameters of Grain Sorghum Varieties (Sorghum Bicolor (L.) Moench) At Different Crop Spacing. *Russian Journal of Agricultural and Socio-Economic Sciences*. 74. 224-233. 10.18551/rjoas.2018-02.25.

Rockstro¨ Reddy B.V.S., Ashok A.K and P.Sanjana Reddy, (2010). Recent Advances in Sorghum Improvement Research at ICRISAT: A Review Article. Kasetsart *Journal of Natural Sciences* 44: 499 –506.

Kaumbutho, P., Mwalley, P., Temesgen, M., (2001). Conservation farming among small-holder farmers in E. Africa: adapting and adopting innovative land management options. In: Proceedings of the First World Congress on Conservation Agriculture, vol. 1: Keynote Contributions, Madrid,Spain, October 1–5, 2001, pp. 363–374.

Thiefelder, Christian & C, Wall. (2009). Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe. Soil and Tillage Research. 105. 217-227. 10.1016/j.still.2009.07.007.

Table 1. Effects of Residue Management Strategy and Varieties on Leaf Area and chlorophyll Content of Sorghum at Minjibir during the 2022 rainy season.

	Leaf Area			chlorophyll content		
Treatment	6WAS	9WAS	12WAS	6WAS	9WAS	12WAS
Residue Mgt (S %)						
0	0.60	1.01	1.52	35.08	38.70	38.75
50	0.59	1.01	1.49	34.92	36.74	39.36
100	0.44	0.97	1.32	35.45	37.98	39.31
P of F	0.081	0.578	0.271	0.878	0.400	0.909
SE±	0.069	0.116	0.125	1.049	1.411	1.551
Variety (V)						
Improved Deko	0.42b	0.94b	1.35	35.85	40.43a	42.48a
Local Kaura	0.67a	1.14a	1.54	34.45	36.18b	36.80b
P of F	<.001	0.007	0.052	0.080	0.377	<.001
SE±	0.058	0.067	0.091	0.751	1.381	0.760
Interaction						
S x V	0.399	0.699	0.953	0.029	0.206	0.200

Means followed by the same letter(s) within the same column are not statistically significant at 5% level of probability using SNK.

Table 2. Effects Residue Management Strategy and Varieties on Plant height (m) Stand Count, Total Yield (kgha^{-1}) and 1000 seed weight (g) of Sorghum at Harvest in Minjibir during the 2022 rainy season.

Treatments	Plant Height (m),	Stand count	Yield (kgha^{-1}),	1000 seed weight (g)
Residue Mgt (S %)				
0	73	2.2	2256.6	24.25
50	70	2.10	2241.7	23.56
100	59	2.10	2014.3	23.44
P of F	0.317	0.188	0.293	0.808
SE±	9.192	0.090	164.60	1.327
Variety (V)				
Improved Deko	56b	2.77a	2728.0a	25.78a
Local Kaura	79a	1.60b	1613.7b	22.91b
P of F	<.001	<.001	<.001	0.017
SE±	5.630	0.083	202.96	0.792
Interaction				
S x V	0.987	0.421	0.616	0.903

Means followed by the same letter(s) within the same column are not statistically significant at 5% level of probability using SNK

EVALUATION OF BIOLOGICAL NITROGEN FIXATION (BNF) IN, AND THE GREEN MANURE POTENTIAL OF SOME FORAGE LEGUMES

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ABSTRACT
Nitrogen (N) is the most important soil-based element for plant growth. Except for water availability, it is N that limits crop growth frequently. The natural atmospheric air is 78% N_2 gas, but is unavailable to crops unless reduced to NH_3 in BNF. A pot experiment was conducted in 2013 at the Screen house, Faculty of Agriculture, University of Maiduguri. The experiment consisted of 8 forage legumes – *Mucuna pruriens* white, *Stylonsanthesis guianensis, Cajanus cajan* white, *Cajanus cajan* brown, *Centrosema pubscens*, Lablab purpereus black and sesbania rostrata. Objectives of the experiment were to evaluate N_2-fixing capacity in the forages and to recommend the best 5 N-fixers for use as green manure. The result showed *Mucuna, Sesbania, Cajanus cajan*, Stylosanthesis and Lablab were the top N_2-fixers, and recommended for use as green manure.
Keyword: Biomass, BNF, Forage Legumes

INTRODUCTION

Nitrogen (N) is the single most important soil-based element for plant growth. Except for water availability, it is nitrogen that limits crop growth most frequently (Ting, 1982). The natural atmospheric air is 78% dinitrogen (N_2) inert gas, even though in this form is unavailable to higher plants (Ting, 1982; Caddel *et al.,* 2017). Before N_2 is used by crop plants, it must be reduced to ammonia (NH_3) the most important compound in the ecosystems (Forage Information Systems-FIS, 2023). The agricultural requirements for nitrogen need to be fulfilled by the two major sources in the world (Ladtha *et al.,* 2022).:-

- Industrial N_2 fixation into fertilizers in the Haber-Bosch process, or
- Biological nitrogen fixation (BNF) in legumes.

Of the reported estimated 175 million metric tonnes of available or fixed nitrogen formed on earth each year, about 90 million tonnes (52%) are produced commercially by the Haber process while the other near half or 85 million tonnes are the direct result of BNF (Ting, 1982; Kebede, 2021). "Biological nitrogen fixation" refers to the bacteria mediated reduction of N_2 atmospheric gas to NH_3 (ammonia), the most important biological process for life on earth after photosynthesis (Ting, 1982, FIS, 2023). Nitrogen fixed in BNF by forage legumes is a well-known alternative to synthetically fixed N in fertilizers (Iancheva and Naydenova, 2022). Tropical forage legumes consist of a variety of herbaceous plants selected from undomesticated and cultivated forage species (International Centre for Agriculture in the Tropics - CIAT, 2019). Forage legumes had multiple uses in the low-input farming systems of the tropics, including N-fixation, restoration of soil fertility of degraded agricultural land and high potential for carbon sequestration – second only to forests (CIAT, 2019). Carbon sequestration is the process of capture and storage of carbon dioxide (CO_2) to mitigate dangerous climate change (Agroforestry, 2015). The N_2 fixation values in forage legumes under condition in Nigeria were in the order of 13 to 24 kg N/ha (Yakubu *et al.,* 2007) and 70 to 90 kg N/ha in *Sesbania rostrata* and 37 to 160 kg N/ha in pigeon pea (IITA, 1983; Egbe *et al,* 2006). These species if introduced into a farming system will fix sufficient N for increased crop yields in view of the scarce and expensive chemical fertilizers. The objectives of the study were to evaluate the biological nitrogen fixation capacity in 8 forage legumes, and recommend for use as green manure in the cropping systems of the savannah in northern Nigeria the top 5 N_2-Fixers in the experiment.

MATERIALS AND METHOD

Seeds of the forage legume species

Seeds of best-bet manure species were collected from the National Animal Production Research Institute- NAPRT shika, Zaria. These were *Mucuna pruriens* (T_2), *stylosanthesis guianensis* (T_3), *Cajanus cajan* brown (T_5), *Centrosema pubscens* (T_9), *Lablab purpereus* white (T_{11}) and *Lablab purpereus* black (T_{12}). *Cajanus cajan* white (T_7) was obtained from the Federal University of Agriculture Makurdi, Benue State. The undomesticated species of *Sesbania rostrata* (T_{15}) was collected from fields around Maiduguri, Borno State. Seeds of Pearl Millet variety 9702 were obtained from Lake Chad Research Institute, Maiduguri, as the test crop.

Experiment

A pot experiment was conducted in 2013 at the screen house faculty of Agriculture, University of Maiduguri. Treatments consisted of 8 forage plants. The plants were grown for six weeks, after harvest, biomass yield measured. The N, P and K contents in the forages were determined in the laboratory according to Bashir (2019).

RESULTS AND DISCUSSION

Biomass yields and nutrient composition of forage legumes

The biomass yields and nutrient composition of the legume species were presented in table 1. The result showed that the plants highest in biomass production in the experiment were

Mucuna pruriens, *Cajanus Cajan* brown, *Sesbania rostrata, Lablab purpereus* and *Cajanus cajan* white with 820, 1440, 375, 368 and 364 kg/ha respectively. Similar result trend were reported by FAO (2011) where such forage species produced variable biomass in field planting. Kusvuran *et al.* (2015) defined biomass in green manuring as the sum total weight of plant components above and below the soil line, and is an important concept, which directly affects soil productivity. The finding of this experiment was in agreement with FAO (2011) that Mucuna and pigeon pea are great producers of biomass even on extremely low fertility soils. Biomass produced by forage legumes is the precursor of biological nitrogen fixation, an important concept in tropical cropping systems. The nutrient composition of the legume species was also presented in table 1. The result showed that the species highest in NPK analysis are *Sesbania rostrata*, *Cajanus cajan* white, *Lablab purpereus* black, *Centrosema pubscens* and *Cajanus Cajan* brown with 8.55, 8.33, 7.17, 6.97 and 6.87 % respectively. Adesoji *et al.* (2014) reported lower result of NPK composition in green manure legumes in Samaru Zaria than the result of the present study, with Mucuna containing the lowest % NPK (4.39) in the study in Zaria. The average NPK content in legumes in the experiment was very high 7.0 %, comparative total NPK analysis of Farmyard manure according to Kuepper (2023) is a meagre 1.79 %. It might be deduced from Fig.1 the average NPK content in legumes in the experiment (7.0 %) was 291b% higher than the NPK analysis of barnyard manure (1.79 %). The forage species might probably enrich the soil for higher crop yield when used as green manure. Sullivan (2003) concurred with the finding of the present study that N, P, K, Ca, Mg, S and other plant essential micronutrients are contained in the tissue of forage legumes if used as green manure.

Nutrient uptake in forage legumes

Results for nutrient uptake (kg/ha) by the forage species are shown in table 2. Mucuna had the highest N uptake of 25.1 as well as uptake of total NPK of 46.2 kg/ha. The result is followed by an equal N uptake of about 15 kg/ha in *Sesbania* and pigeon pea. The result also showed total NPK uptake in *Sesbania* followed Mucuna with 32.1 and an equal amount of 30.33 kg/ha in pigeon peas. *Lablab* white, *Centrosoma* and *Stylosanthesis* had lower but substantial NPK uptake of 24.1, 21.6 and 15.9 kg/ha respectively. Bashir (2009) obtained lower N uptake result (5.46 kg/ha) but similar total NPK (29.38) in 8 weeks old *Sesbania* compared to result of the present study. These results were confirmed by FAO (2011) that pigeon pea and Mucuna are great producers of biomass weight even on low fertility soils.

Preston (2023) defined nutrient uptake as the amount of each nutrient element required for the crop to complete its life cycle. NPK uptake was highest in legumes, Mucuna with above 46 kg/ha in the present study. These plant species have shown high potential to improve soil properties for crop production if applied as green manure.

Biological nitrogen fixation (BNF) in forage legumes

The result for N-fixed was shown in table 3. Mucuna fixed the highest N (23.88 kg/ha), followed by that fixed in *sesbania* (14.27 kg/ha), *cajanus cajan* white (13.78 kg/ha) and *stylosanthesis guianensis* (9.18 kg/ha). That fixed in *lablab purperens* white was 8.51 kg/ha. The result for N_2- fixation in the present study were higher than those of Yakubu *et al.* (2007) in five forage legumes ranging from 13 to 24 kg N/tonne of dry matter. Result of N_2-fixation by forage legumes under condition in Nigeria reported by IITA (1983) and Egbe *et al.* (2006) include *sesbania rostrata* with 70 to 90 and pigeon pea 37 to 160 kg N/ha. This result was in agreement with FAO (2011) that pigeon pea is a great producer of biomass even on degraded soils. The legumes species in the experiment can be ranked based on level of BNF (kg/ha) as *Mucuna pruriens* (23.88), > *Sesbania rostrata* (14.27) > *Cajanus cajan* white (13.78) > *Cajanus cajan* brown (13.58) > *Stylosanthesis guianensis* (9.18) > *Lablab purpereus* white (8.51) > *Centrosema pubscens* (7.62) > *Lablab purpereus* black (5.85). The ability of forage legumes to fix N from the atmosphere or BNF is invaluable in soil fertility and significant in increasing crop yields. Dubeux *et al.* (2022) reported forage legumes in cropping systems are an alternative to replace N chemical fertilizers. Research has shown universal effects of legume green manuring on cereal yields and BNF N can substitute for 60 to 100 kg fertilizer N/ha (Fabunmi and Balogun, 2015).

CONCLUSION

In the experiment the forage species richest in % NPK composition were *Sesbania rostrata* > *Cajanus cajan* white > *Lablab purpereus* black > *Centrosema pubscens* > *Cajanus cajan* brown. The average NPK composition (7.0%) of forages was found to be 291% higher than that of Farmyard manure (1.79%). While the best 5 fixers of BNF – N (kg/ha), the most important criterion in green manure selection, were *Mucuna pruriens* (23.88) > *Sesbania rostrata* (14.27) > *Cajanus cajan* (13.78) > *Stylosanthesis guianensis* (9.18) > *Lablab purpereus* white (8.51).

REFERENCES

Adesoji, A.G., Abubakar, I.U. and Labe, D.A. (2014). Soil Properties as affected by Incorporated Legumes and Nitrogen in soil with maize in a Semi-arid Environment. International Journal in the Tropics and Sub-tropics. 102:2, pp 109-117.

Agroforestry.Net (2015). Carbon Sequestration, The Overstory#66. (http://www.agroforestry.net)

Bashir A.A. (2009). Effects of Spacing and time of application of Sesbania rostrata green Manure on soil chemical properties and growth of Sorghum bicolour. M.SC. Dissertations. Department of Soil Science, University of Maiduguri.

Bashir A.A. (2019). Influence of leguminous Green manures on soil chemical properties and the yields of Millet and Sorghum. PhD Thesis SS Department.

Caddel J., RedFearn D., Zhang H., Edwards J. and Deng S. (2017). Forage Legumes and Nitrogen Production. Okluhoma State University USA.

CIAT-International Centre for Agriculture in the Tropics (2019). Evaluation of Tropical Forages. Australia.

Debeux J., Queiroz L., Pereira Neto J. and Ruiz Moreno M. (2022). Grow your own Nitrogen fertilizer using forage legumes. University of Florida, USA.

Egbe O.M. and Aci A. (2006). Influence of soil incorporation of common food legume Stover on the yield of maize in moist savannah of Nigeria. Researchers. 2(8) 84-90

Food and Agriculture organization FAO (2011).Green manure/cover crops and crop rotation on small farms. Integrated crop management Vol. 12. 2010. FAO, Rome.

Forage Information Systems-FIS (2023). Define the utilization of legumes in forage-livestock systems. Oregon State Corvallis USA.

Iancheva A. and Naydenova G. (2021).Biological Nitrogen Fixation in legumes.Bulguria Legume Hub.https://www.legume-hub.eu

International Institute of Tropical Africa IITA (1983).Animal Report 1983 Ibadan.IITA (1999).Annual Report 1999 Ibadan.

Kebede E. (2021). Contribution, utilization and improvement of legume-Driven Biological Nitrogen Fixation in Agriculture Systems frontier Sustainable food system Vol. 5.

Kuepper G. (2003). Manures for organic Crop Production. ATTRA, National Centre for Appropriate Technology.

Kusvuran A., Parlak E.L. and Saglamtimur T. (2015). Biomass yield of Faba bean and its mixture with some grasses. Turkish Journal of Agricultural and Natural Sciences 2 (2): 178-184.

Ladtha J.K, Peoples M.B., Reddy P.M. and Biswas J.C. (2022). Biological nitrogen fixation and prospects for ecological intensification in cereal based cropping systems. Field crops Research Vol. 283.

Preston C. (2023).The difference between nutrient uptake and nutrient removal, eronocies.https://www.nutrient.com

Sullivan, P. (2023). Overview of Cover Crops and Green Manures. Fundamental of Sustainable Agriculture. ATTRA, USA.

Ting I.P. (1982). Plant Physiology. Addison-Wesley Publishing Company, California, USA.

Yakubu H., Ngula A.L. and Kwari J.D. (2007). Nitrogen Fixing potential of Tropical Forage Legumes in Sudano-Sahelian Zone of North-eastern Nigeria J. Arid Agric. 17: 65-68.

Table 1: Biomass Yield and Nutrient composition of some forage legumes.

Forage Legumes	Biomass yield (kg/ha)	Nutrient Composition (%)			
		N	P	K	NPK
Mucuma Pruriens **White Zaria (T2)**	820.0	3.06	0.12	2.46	5.64
Stylosanthesis Guinensis **Zaria (T3)**	242.5	4.30	0.07	2.18	6.55
Cajanus Cajan **Brown Zaria (T5)**	440.0	3.36	0.08	3.43	6.87
Cajanus Cajan Igbonbu **White (T7)**	364.0	4.13	0.09	4.11	8.33
Centrosema Pubescens **(T9)**	310.0	2.85	0.09	4.03	6.97
Lablab Purpereus **White (T11)**	368.5	2.64	0.09	3.80	6.63
Lablab Purpereus **Black (T12)**	145.2	4.03	0.09	3.05	7.17
Sesbania Rostrata Limanti **(T15)**	375.0	4.13	0.09	4.33	8.55
Millet Var. LCI (T19)	115.5	1.06			

Table 2: Nutrient Uptake in some forage legumes.

Forage Legumes	Nutrient Uptake (kg/ha)			
	N	P	K	NPK
Mucuma Pruriens **White Zaria (T2)**	25.1	1.0	20.2	46.2
Stylosanthesis Guinensis **Zaria (T3)**	10.4	0.20	5.30	15.9
Cajanus Cajan **Brown Zaria (T5)**	14.8	0.35	15.1	30.3
Cajanus Cajan Igbonbu **White (T7)**	15.0	0.33	15.0	30.3
Centrosema Pubescens **(T9)**	8.84	0.28	12.50	21.6
Lablab Purpereus **White (T11)**	9.73	0.33	14.0	24.1
Lablab Purpereus **Black (T12)**	5.85	0.13	4.43	10.4
Sesbania Rostrata Limanti **(T15)**	15.49	0.34	16.24	32.1
Millet Var. LCI (T19)	1.22			

Table 3: Biological Nitrogen Fixation in some forage legumes.

Forage Legumes	N-Uptake (kg/ha)	N-Fixed (kg/ha)	Ndfa (%)
Mucuma Pruriens **White Zaria (T2)**	25.1	23.88	95
Stylosanthesis Guinensis **Zaria (T3)**	10.4	9.18	88
Cajanus Cajan **Brown Zaria (T5)**	14.8	13.58	92
Cajanus Cajan Igbonbu **White (T7)**	15.0	13.78	92
Centrosema Pubescens **(T9)**	8.84	7.62	86
Lablab Purpereus **White (T11)**	9.73	8.51	87
Lablab Purpereus **Black (T12)**	5.85	4.63	79
Sesbania Rostrata Limanti **(T15)**	15.49	14.27	92
Millet Var. LCI (T19)	1.22		

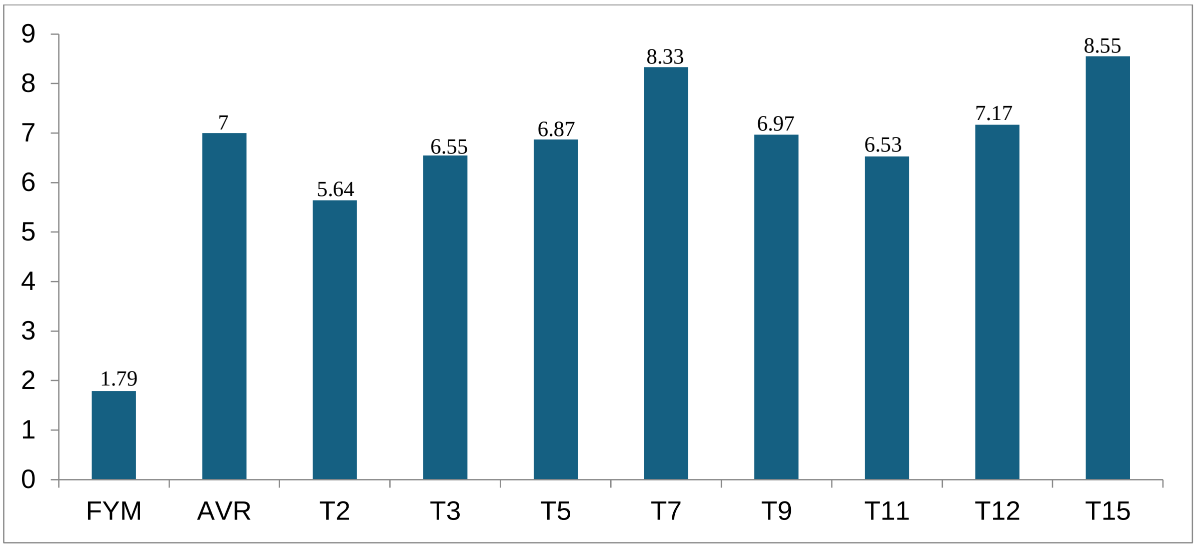

Fig. 1 Comparison of species % NPK with FYM (Key to T_1 to T_{17} see Table 1)

THE GERMINATION EFFECT OF POST-EMERGENCE AND PRE- EMERGENCE HERBICIDES ON SOME SELECTED OIL PALM INTERCROP AT NIFOR RAIN FOREST ZONE NIGERIA

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ABSTRACT

Despite all the agronomic practices carried out in oil palm establishment management both in the nursery and fields, the issue of planting distance encourages the flamboyant growth of weed in the intra and inter line of oil palm plantation. In view of this , farmers are desperately in use of herbicide either pre-emergence or post emergence or their combination in weed control measures and the length of time some of these herbicides remains active in the soil could be long and their effect may cause injury to succeeding crops on planting and as well affect their germination . In this vein an experiment was carried out in two stages: the field establishment and (ii) the bioassay study. Both experiments were laid out in a randomized complete block design (RCBD) with 3 replicates. A total of field measured 3240m^2 with each plot measured 12 m × 270 m. The experimental treatment consisted of the following: (1) Unwedded (as control), (2) Glyphosate as Roundup (1. 5 kg a.i ha^1) (3) Diuron (2. 0 kg a.i ha^1) + glyphosate (1. 5 kg a.i ha^1). (4)Glyphosate (1. 5 kg a. i ha^1) followed by indaziflam (0. 04 kg a.i ha^1) applied 10 days after glyphosate. (5) Glyphosate (1. 5 kg a.i ha^1) followed by indaziflam (0.05 kg a.i ha^1) applied 10 days after glyphosate. (6) (10 DAT of Glyph) Glyphosate at (1. 5 kg a.i ha^1) + indaziflam (0.05 kg a.i ha^1), (7) Glyphosate at (1. 5 kg a.i ha^1) + indaziflam (0.04 kg a.i ha^1), (8) Indaziflam at (0.05 kg a.i ha^1), (9) Indaziflam at (0.04 kg a. i ha^1) the result revels that germination of maize ;melon cucumber and tomato significantly increases as time of sowing was delayed for period of 4 , 8, 12 and 16 weeks respectively . In conclusion ‘it was revealed that indaziflam is not a choice herbicide of oil palm farmers intention is to intercrop immediately after indaziflam application that a period of 16 weeks will elapse before intercropping also tomato seedlings proved more sensitive to indaziflam herbicide for bioassay trials.
KEYWORD: Germination, Indaziflam and Residual activity.

INTRODUCTION

Oil Palm (*Elaeis guineensis* Jacq) is one of the most tree crop planted in West Africa and highly cultivated among the rainforest zone of Nigeria. It is a crop that all the component part is highly essential with high demand produces such as oil palm fruit, oil palm kernel and oil palm. In-order to get high quality of these produce there is an important emphasis on the general maintenance mostly at the establishment of oil palm both at the nursery stage and at field establishment. The general agronomic practices which include: timely establishment of nursery or field stages, frequent or timely application of appropriate fertilizer regime, proper weed management and general plantation sanitization cannot be over emphasized. Despite all these agronomic practice, the issues of planting distance of oil palm cultivation encourages the flamboyant growth of weed in the intra ant inter line of oil palm plantation. Among the oil palm owners the use of herbicides and manual method of mitigating weed is common. The use of post emergence or pre emergence herbicides or combination of both is common among the oil palm growers. The length of time some of these herbicides remain active in the soil could be long and their after effects may prove injurious to succeeding crops or plantings and as well affect their germination. Herbicides persistence is an important aspect to be considered in oil palm production because in oil palm cultivation, food crops (arable) are sometimes incorporated as intercrop and residues of applied herbicides can potentially injure sensitive crops grown as intercrop. Indaziflam a pre-emergence herbicide has the ability to persist in the soil for more six months in the soil and it is difficult to predict the amount of its residual effect on the germination of common intercrops usually grown within the palm rows at the early stage of field planting.

MATERIALS AND METHOD

The experiment was conducted in two stages: (i) the field establishment and (ii) the bioassay study. Both experiments were laid out in a randomized complete block design (RCBD) with 3 replicates. A total of field measured 3240m^2 with each plot measured 12 m × 270 m. The experimental treatment consisted of the following: (1) Unwedded (as control), (2) Glyphosate as Roundup (1. 5 kg a.i ha^{1}) (3) Diuron (2. 0 kg a.i ha^{1}) + glyphosate (1. 5 kg a.i ha^{1}). (4) Glyphosate (1. 5 kg a. i ha^{1}) followed by indaziflam (0. 04 kg a.i ha^{1}) applied 10 days after glyphosate. (5) Glyphosate (1. 5 kg a.i ha^{1}) followed by indaziflam (0.05 kg a.i ha^{1}) applied 10 days after glyphosate. (6) (10 DAT of Glyph) Glyphosate at (1. 5 kg a.i ha^{1}) + indaziflam (0.05 kg a.i ha^{1}), (7) Glyphosate at (1. 5 kg a.i ha^{1}) + indaziflam (0.04 kg a.i ha^{1}), (8) Indaziflam at (0.05 kg a.i ha^{1}) , (9) Indaziflam at (0.04 kg a. i ha^{1}) Glyphosate and diuron already in use in oil palm plantation were used selected herbicides. All herbicides treatments were applied post-emergence to actively re-growing weeds which were slashed back four weeks previously in the interrow and inter palm lines of seven palms spaced 9 m × 9m x 9m dimension. The herbicides were applied with a CP15 knapsack sprayer fitted with a 2.5 deflector nozzle which was used to deliver a volume of 240 L ha^{1} herbicide solution at oil palm interrow and inter palm on April for each year in 2016 and 2017. Before herbicide application 1.0-meter radius at the base of the palms was kept weed-free by hand weeding to provide a suitable condition for herbicide application. Soil samples were taken randomly at two depths (0 – 15cm and 15 – 30 cm) from the treated (sprayed with herbicides) and the untreated plots using 7.5 cm diameter auger in a diagonal transect. Four soil cores were taken per treatment plot at an interval of 0, 4, 8, and 16 weeks after application and were placed in polythene bags. The soil samples were air dry at room temperature for 48 hours and then screened through a 4 mm sieve. A plastic bioassay cups of 7cm width and 7cm depth, which was filled to 80% field capacity of soil that was replicated and laid out in a completely randomized design experiment. Each cup was sub-irrigated to field capacity and allowed to consolidate before sowing. Ten seeds of each test crops (maize, cucumber, melon and tomato) were sown at. Depth of 1cm and covered lightly which later thinned to five seeds. The cups were placed in the greenhouse located in the new laboratory complex in NIFOR for 21 days for further investigation.

Data collection and analysis

Seed germination of test crops was evaluated three days after sowing. Crop germination count was converted to percentage germination as follows:
The germination % test count was calculated thus = $\frac{No\ of germinated\ seeds}{Total\ no\ of seed\ planted}\ x\ \frac{100}{1}$
One week after sowing germinated seeds was thinned to five per test plant.

RESULTS

RESIDUAL EFFECT OF APPLIED INDAZIFLAM AND SOME REFERENCE HERBICIDES ON GERMINATION OF SOME SELECTED TEST CROPS WEEKS AFTER SOIL APPLICATION

Herbicides treatment significantly (± 0.05) affected maize germination in soil sampled from the two depths at various week of soil sampling after herbicides application. Percentage maize germination was 90 % in the control plot where indaziflam was not applied. Consequently, the rate of maize seed germination increased significantly as the time of sampling was delayed (Table.1). At 0 week of soil sampling (WSS) in herbicides treated plots within 0-15 cm maize germination was rate 65.95,%, 37.16%, 34.44%, 26.64%, 39.62%, 40.39% 36.24% and 38.65% respectively in the order of treatment arrangement while at 16 WSS maize germination rate increased significantly in this trend 90 %, 90%, 72.73%, 79.65% 83.95%, 81.15%, 73.40%, 71.95% and 67.40% respectively . Sampling soil treated with indaziflam within 15 -30 cm of soil depth results followed the same trend with the result of soil sampled at 0-15cm depth.

However, at 15 -30 cm of soil depth glyphosate use alone was significantly the same to the control plot with maize germination of 90 % each. Percentage maize germination increased significantly as the time of soil sampling within the treatment plots was delayed from 0 - 16 weeks at both soil depths (Table 1).

RESIDUAL EFFECT OF APPLIED INDAZIFLAM AND SOME REFERENCE HERBICIDES ON GERMINATION OF MELON

Germination of melon was significantly (± 0.05) affected by herbicides treatment and time of soil sampling (Table 2). Germination of melon increased significantly as the sampling time after herbicides application increased. In the control plots the germination of melon was 90 % irrespective of depth and sampling time. At 0-15cm, and 15-30cm, in plots that was treated with glyphosate at 1.5 kg a.i. ha^{-1} increased significantly as the time of sampling was delayed with 63.93%, 67.14 %, 67.22 % and 90 % and at 0- 15cm and 56.38 %, 60.91 %, 90.00%, 90.00% and 90.00% at 0-16WSS. Consequently, plot treated with glyphosate + diuron at 1.5 kg a.i ha^{-1} + 2.0 kg a.i ha^{-1}, glyphosate at 1.5 kg a.i ha^{-1}followed by indaziflam at 0.04kg a.i ha^{-1} ten days after glyphosate treatment, and other indaziflam combination, had lower germination rate irrespective of time of soil sampling. At 16WSS, melon germination rate was increased significantly in this order of treatment 90 %, 90 %, 76.18%, 75.18 %, 63.55 %, 78.57%, 70.30 %, 79.47 % and 78.18 % respectively. Similar trend was observed in all herbicides treatment plots sampled within 15cm -30cm depth (Table 2).

RESIDUAL EFFECT OF APPLIED INDAZIFLAM AND SOME REFERENCE HERBICIDES ON GERMINATION OF CUCUMBER

Percentage germination of cucumber seed increased significantly (± 0.05) as the time of soil sampling within the herbicides treated plot was delayed. Herbicide treatment significantly affected the rate of cucumber germination (Table 3). Cucumber germination was generally highest in the control plot at both depth and time of soil sampling than the other treatments except for soil treated with glyphosate at 1.5 kg a.i. ha^{-1} at 12 weeks and 16 weeks of soil sampling at both depths. (Table 3). In plots treated with tank mixture of diuron plus glyphosate, cucumber germination was significantly higher than in plots treated with glyphosate plus indaziflam, tank mixture of glyphosate plus indaziflam or indaziflam alone across sampling time and sampling depths. Cucumber germination in diuron plus glyphosate treated plot was 90 % and 70.88% respectively at 0 -15 cm and 15-30 cm depths and at 16 weeks of soil sampling after herbicide treatment (Table 3). Germination of cucumber in indaziflam treated plot as listed in the order of treatment was 71.95 %, 70.14 %, 53.76 %, 54.83 %, 57.86 % and 53.76 % respectively within 0 -15 cm of soil depth at 16 WSS. Similar trend in germination was followed within 15 cm-30 cm depth at 16 weeks of soil sampling after herbicides treatment (Table 3)

EFFECT OF INDAZIFLAM AND SOME REFERENCE HERBICIDES ON MEAN TOMATO GERMINATION (%) IN 2016 AND 2017

Herbicides treatment significantly (± 0.05) affected tomato germination irrespective of soil depth and weeks of soil sampling after the herbicides application. Germination of tomato increased significantly as the time of soil sampling after herbicide application was delayed (Table 4). At 12 and 16 weeks of soil sampling and within 0 – 15 cm, germination of tomato was significantly the same to the control plot with a value of 90 % each. While at 15- 30cm, germination of tomato was significantly similar at 8, 12 and 16 weeks with a value of 90% each respectively. Tomato germination was 90 % in the control plot and at 0 WSS (Table 4). Consequently, at 0WSS of 0-15 cm germination rate 44.81, %, 32.21%, 22.78%, 28.11%, 26.95%, 39.23%, 40.01% and 41.58 % respectively in plot treated with herbicides as listed in the order of treatment. In 15cm -30cm depth and at 0 WSS after herbicide application, the result follows the same trend as in the 0-15 cm of soil depth (Table 4.).

DISCUSSION

The residual effect of indaziflam and selected herbicides on maize, melon, cucumber and tomato germination

The initial observed reduction in the germination of the maize, melon, cucumber and tomato revealed that indaziflam has more negative effect on the test crops germination probably because of the soil activity of the herbicide and inhibition of crop seeds or seedlings emergence. The later increase in germination observed showed that the degradation and dissipation of indaziflam is a continuous process and introducing these crops within these observed period means that losses will be sustained. A previous report has indicated that when most herbicides is in contact with the soil, their redistribution and degradation process begin, which may be extremely short, in some simple and non-persistent herbicides molecules, or may persist for months for highly persistent compound (Filizola *et al*.,2002). This result indicated that residue of indaziflam persists in the soil up to sixteen weeks after application suggesting that 16 weeks must elapse before introducing any of these crops as intercrop. This result also indicated that indaziflam and other herbicides were significantly detected in soil of up to 30cm depth with long bioactivity that will cause damage to maize, melon, cucumber and tomato. The results will guide oil palm farmers on the appropriate time to introduce these crops as intercrops within the oil palm inter-rows which is the usual practice among small scale oil palm farmers. A previous study has also implicated atrazine plus alachlor for the reduction in wheat germination, which is cultivated alternatively with corn and after it (Anihita *et al.*, 2014). A similar result was obtained when the residue of sulfonylurea herbicide was tracked using sunflower, lettuce, lentil, corn and peas as test crop (Shanner and Henry, 2007). The residue of glyphosate has been shown to have affected the germination of faba bean and oat (Helander, 2019). A previous report indicated that diuron residue in the soil inhibited germination of bean, maize and soybean 70 days after application. This study indicated that indaziflam is not a choice herbicide if the intention of oil palm farmers is to intercrop these test crops along the palm inter-rows immediately after spraying of indaziflam for weed control.

REFERENCES

Anahita Y, Azizala A, Kamran F and Najaf A. (2014). The Residual/effect of herbicides on the germination and early growth of Shiraz wheat cultivar in the development of health agricultural crops. *American Eurasian Journal of Agriculture and Environmental Science*. 14(2): 161 – 164.

Filizola, H. F., Ferracini, V. L., Sans, L. M. A., Gomes, M. A. F and Ferreira C. J. A. (2002) Monitoramento e availacao do risca de contaminacao por pesticidas em agua superficial e subterranean na regao d Guaira . Pesqui. Agropecu. Bras. 37(5): 659-667.

Helander, M., Anna, P. Kari, S. and Irma, S. (2019). Glyphosate residues in soil affect crop plant germination and growth. w.w.w nature com/scientific reports.

Shaner, D. I. and Henry, W. B. (2007). Field history and dissipation of atrazine and metolachlor in Colorado. *Journal of Environment Quality*, 36: 128-134

Table 1: Residual effect of indaziflam on maize germination (%) in 2016 and 2017

		0–15					15–30				
		Weeks after treatment					Weeks after treatment				
Treatment	**Rate (kg a.i. /ha)**	**0**	**4**	**8**	**12**	**16**	**0**	**4**	**8**	**12**	**16**
Control	-	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Glyphosate	1.5	65.95	73.40	71.62	73.40	90.00	61.70	65.43	68.44	90.00	90.00
Diuron + glyphosate	2.0 + 1.5	37.16	52.34.	65.43	71.96	72.73	53.77	59.27	64.65	62.62	68.14
Glyphosate +indaziflam†	1.5 0.04	34.44	54.34	73.40	70.11	79.65	41.74	64.42	64.19	73.40	73.55
Glyphosate +indaziflam†	1.5 + 0.05	26.64	44.43	62.29	85.69	83.95	39.62	64.66	73.31	79.55	76.29
Glyphosate +indaziflam¥	1.5 + 0.05	39.62	65.09	44.81	67.40	81.15	44.00	65.96	66.23	67.24	90.00
Glyphosate +indaziflam¥	1.5 + 0.04	40.39	49.80	56.84	67.88	73.40	40.38	43.08	64.10	68.34	67.40
Indaziflam	0.05	36.24	47.88	64.70	70.11	71.95	36.86	53.06	61.19	73.48	68.85
Indaziflam	0.04	38.65	55.77	65.43	67.40	67.40	39.43	54.78	59.78	67.40	75.00
±SED	-			3.260					3.531		

† = Indaziflam applied 10 days after glyphosate; ¥ = Indaziflam applied same time as glyphosate
± Standard error of difference comparing dose rates and soil storage time after indaziflam application

Table 2: Residual effects of indaziflam on melon germination (%) in 2016 and 2017

		0 – 15					15 – 30				
		Weeks after treatment					Weeks after treatment				
Treatment	**Rate (kg a.i./ha)**	**0**	**4**	**8**	**12**	**16**	**0**	**4**	**8**	**12**	**16**
Control	-	90.00	88.08	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Glyphosate	1.5	63.93	67.14	67.22	71.62	83.78	56. 38	60.91	64.17	70.11	70.11
Diuron + glyphosate	2.0 + 1.5	30.22	41.74	51.82	56.80	76.18	45.00	51.96	53.96	55.76	59.62
Glyphosate +indaziflam†	1.5 + 0.04	22.78	42.71	48.45	63.12	75.18	40.00	48.46	51.37	54.78	55.82
Glyphosate +indaziflam†	1.5 + 0.05	26.56	43.85	56.79	67.40	63.55	33.20	51.95	56.80	60.08	58.26
Glyphosate +indaziflam¥	1.5 + 0.05	33.21	46.72	55.14	56.80	78.57	39.23	45.00	52.14	62.29	62.48
Glyphosate +indaziflam¥	1.5 + 0.04	40.56	52.53	58.06	63.12	70.30	36.24	36.83	40.59	44.04	53.76
Indaziflam	0.05	32.96	56.79	63.12	68.29	79.47	34.44	39.21	45.96	51.12	56.84
Indaziflam	0.04	39.10	51.95	63.55	67.40	78.18	37.46	37.61	49.80	52.86	62.48
±SED	-			3.285					1.985		

†= Indaziflam applied 10 days after glyphosate; ¥= Indaziflam applied same time as glyphosate
± Standard error of difference comparing dose rates and soil storage time after indaziflam application

Table 3: Residual effect of indaziflam on cucumber germination (%) in 2016 and 2017

Treatment	Rate (kg a.i/ha)	0 – 15 Weeks after treatment 0	4	8	12	16	15 – 30 Weeks after treatment 0	4	8	12	16
Control	-	86.17	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Glyphosate	1.5	68.67	74.34	88.08	90.00	90.00	64.70	64.70	71.95	71.57	87.30
Diuron + glyphosate	2.0 + 1.5	54.76	37.81	52.95	78.90	90.00	63.03	65.17	63.55	65.95	70.88
Glyphosate +indaziflam†	1.5 +0.04	21.96	38.24	51.76	67.40	71.95	24.05	54.37	55.82	57.76	58.93
Glyphosate +indaziflam†	1.5 +0.05	23.31	38.24	41.16	60.08	70.14	26.45	46.91	49.55	58.81	56.80
Glyphosate +indaziflam¥	1.5 +0.05	27.68	40.20	45.00	47.88	53.76	19.89	52.74	56.70	55.82	82.29
Glyphosate +indaziflam¥	1.5 +0.04	26.58	40.20	42.07	51.78	54.83	34.65	46.91	49.80	53.34	55.77
Indaziflam	0.05	29.82	38.12	51.76	55.86	57.86	26.46	51.76	55.08	55.55	56.84
Indaziflam	0.04	29.92	41.16	50.79	58.57	53.76	28.85	52.59	55.70	56.57	63.55
±SED	-				5.133				4.667		

†=Indaziflam applied 10 days after glyphosate; ¥= Indaziflam applied same time as glyphosate
± Standard error of difference comparing dose rates and soil storage time after indaziflam application

Table 4 : Residual effect of indaziflam on tomato germination in 2016 and 2017

Treatment	Rate (kg a.i/ha)	0 – 15 Weeks after treatment 0	4	8	12	16	15 – 30 Weeks after treatment 0	4	8	12	16
Control	-	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Glyphosate	1.5	44.81	50.00	64.70	75.79	77.71	57.86	56.74	71.56	73.40	90.00
Diuron + glyphosate	2.0 + 1.5	32.21	39.42	41.16	45.00	44.03	32.58	40.20	43.39	44.03	45.38
Glyphosate +indaziflam†	1.5 +0.04	22.78	42.12	39.75	43.09	44.57	30.00	40.59	42.12	42.12	45.57
Glyphosate +indaziflam†	1.5 +0.05	28.11	40.00	45.57	46.91	49.99	25.83	41.18	41.56	41.55	45.19
Glyphosate +indaziflam¥	1.5 +0.05	26.95	41.07	40.59	42.33	45.00	26.73	43.85	43.85	43.85	44.43
Glyphosate +indaziflam¥	1.5 +0.04	39.23	43.28	41.55	44.05	44.25	30.02	44.43	44.04	44.04	44.04
Indaziflam	0.05	40.01	40.97	41.20	42.90	44.05	34.23	42.53	43.28	45.52	44.62
Indaziflam	0.04	41.58	41.36	42.71	42.52	42.12	34.03	44.43	43.85	45.19	45.57
±SED	-			2.458						1.307	

†=Indaziflam applied 10 days after glyphosate; ¥=Indaziflam applied same time as glyphosate
± Standard error of difference comparing dose rates and soil storage time after indaziflam application

EFFECTS OF DIFFERENT WATERING REGIMES ON FLEA BEETLES INFESTATION AND PERFORMANCE OF OKRA (*Abelmoschus esculentus* L.) IN SOUTH WESTERN NIGERIA

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ABSTRACT

A field experiment was carried out to investigate the effects of watering regime on the growth, yield and insect infestation of okra at the Teaching and Research, Rufus Giwa Polytechnic, Owo. The experiment was laid out in Randomised Completely Block Design (RCBD) with three watering regimes (7, 10 and 12 days intervals) replicated three times. Data were collected on growth and yield parameters and subjected to analysis of variance and significant treatment means were separated using Ducan Multiple Range Test (DMRT) at 5% probability. The growth and yield attributes parameters obtained from all the treatment was significantly different ($p<0.05$) and this was as a result of different watering regimes. However, the study did not significantly influence insect pest infestation with the exception of slight high population observed okra with 7 days watering interval. The experiment suggests that irrigation every seven days characterized by best vegetative growth yield should by adopted by farmers in the study area to improve the supply of okra fruits during the dry season. Further study is recommended using different cultivar in field experiments.

Keywords:

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a traditional cheap and nutritious fruit vegetable crop in many tropical, subtropical, and warmer parts of the temperate region, grown for its immature pods (Unlukara and Cemek, 2019), which are consumed cooked either alone or in combination with other foods in several countries to fight against poverty and malnutrition due to its rich nutrient content with impressive health benefits (Gemede *et al*., 2015).

Notwithstanding the nutritional quality and great economic potential of the crop and the existing capacities for its high production in Nigeria, okra is generally cultivated by farmers in the country under a rain-fed condition, especially so in the south western Nigeria where there is two peak of rainfall which lasted for about two-third of the months of the year. However, rain-fed cultivation in Nigeria is subject to a high degree of variability, inadequacy and uncertainty due to climatic conditions (Tajudeen *et* al., 2022). Due to the economic importance of Okra in food security, it is crucial to understand how drought conditions or inadequate water supply potentially affect okra yield under climate change and to explore appropriate adaptation measures to maintain or increase okra production during the off season.

However, okra cultivation during the dry season is highly tasking and mainly dependent upon water availability as well as the challenge of insect pest infestation. Okra, despite having considerable drought resistance is a highwater consumptive crop (Nana *et al*., 2019). For high yields, an adequate water supply, relatively moist soils and insect pest management are required during the total growing period. Reduction in water supply during the growing period in general has an adverse effect on yield and the greatest reduction in yield occurs when there is a continuous water shortage until the time of first picking (Al-Harbi *et al*, 2008; Abd El-Kader *et al*., 2010).

Therefore, it is of importance to explore an alternative method of producing more of okra apart from rain fed production to supply moisture optimally. Thus, adopting irrigation is a crucial step in meeting the food demand of ever-increasing population of the world and has been a major boost for obtaining high okra yield during dry season farming due to the high prevalence of sunshine hours that promotes the metabolism reaction of photosynthesis (Adeogun, 2016). Unlike other tropical countries, there is dearth of empirical information on the production of okra under different irrigation management in Nigeria. Previous studies carried out on Okra are largely on response of okra to organic and inorganic source of fertilizers on growth, yield and economics (Akanbi *et al*., 2010 and Law-Ogbomo *et al.,* 2013). In response to this research gap, this study was carried out to evaluate the watering frequencies or intervals for optimal growth okra and flea beetle infestation in southern western Nigeria.

Experimental location

The experiment was carried out at the Teaching and Research Farms, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria. The research site is characterized by two rainy seasons: The major season which starts from May-July and the minor season which commences from September and runs through to the middle of November. The mean annual rainfall for the site is between 900 and 1000 mm.

Experimental design and field layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments and each treatment was replicated three times. Each treatment plot measured 5 m x 5 m with inter and intra-row spacing of 1 m x 0.5 m. A 2 m alley was allowed between the plots. The treatments were wetting after three Days (W3D), wetting after five Days (W5D) and wetting after seven Days (W7D).

Cultural Practices

V35 an improved variety of okra used for the experiment was sourced from Let Farm Agro Store, Akure, Nigeria. The seeds were placed in water for a about an hour before planting to stimulate germination, and then sown by placing two (2) seeds in each planting hole at an approximate depth of 3cm in each plot. After a week of seedling emergence, the seedlings were thinned, leaving only one (1) okra seedling per hole in each treatment. Manual weeding was done continuously throughout the study as the need arises. Each okra plant was uniformly irrigated with 50 cl of water at three wetting intervals as follows: 7, 10, and 12 days intervals. No fertilizer or insecticide application was carried out.

Sampling for Insect Pests

Sampling for insect pests was done weekly from 4 weeks after planting (WAP) between 07.00 – 09.00am through visual examination and counting when insect numbers were high and still inactive (Adesina, 2013). Sampling was done on five plants randomly selected from the three middle rows per plot.

Agronomic and Yield Data collection

Five plants per plot were selected for assessment of the following growth and yield parameters: number of leaves, plant height (cm), stem circumference (cm), number of pods/fruits per treatment, pod/fruit length (cm), pod/fruit diameter (cm), and pod weight per treatment (g) following standard procedure and weights obtained for each treatment were then extrapolated to kilograms per hectare (kg/ha).

Statistical analysis

The data collected from the parameters studied were subjected to One – Way Analysis of Variance (ANOVA, $P < 0.05$) using Statistical Package for Social Sciences (SPSS) version 15 (2009) computer software to determine effects of treatments. Duncan Multiple Range Test (DMRT) at 5% level was used as follow up the test to separate the means (El-Sahookie and Karyma, 1990).

RESULTS

Agronomic response of okra to different watering regime

The relationship between the growth parameters with respect to watering days interval in all the treatment are shown in Figure 1-3. watering intervals had a significant ($p<0.05$) effect on all growth parameters considered. The results showed reduction in the values of the parameters resulting from increasing watering intervals.

Watering every 10 days significantly increased mean number of leaves (5.07, 6.20 and 8.0) at 2, 4 and 6 weeks after sowing (WAS) respectively. While the number of leaves produced by okra plants watered at 7 and 12 days intervals were not significantly different when compared. However, okra watered at 7 days interval produced number of leaves closely to the plants water at 10 days interval and was significantly lower compared to the number of leaves produced by okra plants watered at 10 days interval (4.67, 5.7 and 6.93), with the lowest number of leaves produced by okra plants watered 12 days interval (4.27, 5.2 and 6.53) at 2, 4 and 6 WAS respectively (Figure 1).

Result in Figure 2 shows that watering regimes significantly influence okra plant height at 2, 4 and 6 WAS. At 2 and 4 WAS okra watered at 10 days interval had the tallest plant (12.53, 14.27cm), followed by 7 and 12 days interval regime (10.13cm and 10.73cm) respectively. At 6 WAS okra plants that was watered at 7 days interval produced the tallest plant (25.87cm) followed in decreasing order by 10 (21.73cm) and 12 days intervals (19.33cm) correspondingly (Figure 2).

Stem girth development was not significantly affected by the imposed watering regime on okra plants (Figure 3). Nevertheless, okra watered at 7 days interval had the thickest stem girth at 2, 4 and 6 WAS (1.17, 1.30 and 1.33cm), this was closely followed by 10 and 12 days interval in that order. At 6 WAS okra plant watered at 7 and 10 produced okra with same stem girth size and in all irrigation intervals okra watered at 12 days intervals produced the thinnest plants.

Effect of different watering regime on Flea beetle infestation

The effects of the different watering regime on flea beetle infestation of okra was presented in Table 1. At 2 WAS watering regimes did not significantly influence insect infestation of okra. While at 4 WAS, non-significant insect infestation was observed between 10 and 12-day watering intervals, but, a significant insect infestation was recorded in okra watered at 7- days intervals. At 6 WAS, a non-significant flea beetle infestation was observed in okra watered at 7 and 12 day intervals, while a significant infestation was recorded in okra watered at 10-days interval (Table 1).

Yield attributes of okra to different watering regime

Table 2 shows yield attributes of okra which included number of harvested fruits, fruit weight, fruit length and fruit diameter. Okra yield attributes were significantly affected by watering regimes. The highest number of pods (12.27) was recorded in okra harvested from plots watered at 10-days interval and the lowest number of fruits was obtained in 12 days interval plots (9.62). Statistically, no significant difference existed between 7 and 10 days interval watering regimes. The data in Table 1 indicate that of all the watering regimes, 10 days interval gave the highest okra weight (15.50g) and was significantly different from all the other treatments. Okra fruits harvested from okra planted in 7 days interval irrigated plots were second in terms of fruit weight (11.65g) and lowest weight was observed in okra harvested from 12 days interval (8.32g). Performance of the okra fruit in terms of length and diameter follow same trend, there was no significant difference comparing okra fruit length and diameter obtained from 10 and 12 days watering regimes (Table 2). However, longest okra fruit (5.48cm) and highest fruit diameter (4.53cm) was observed in 7 days interval plots and was significantly different from all other watering regimes.

DISCUSSION

Okra requires adequate water supply and relatively moist soil throughout the growing season in order to have high yield. The flowering and the fruiting stage of okra is considered to be the most sensitive stage in the entire growing season. Water shortage at this stage reduces the yield of okra. Therefore, to improve the yield of okra there is the need for controlled irrigation system. According to Al-Harbi *et al*. (2008), controlled irrigation is essential for high yields in okra cultivation, because the crop is sensitive to both over and under irrigation.

Onwugbuta-Enyi (1996) indicated that, okra plant height was significantly reduced by water stress. Generally, plants subjected to a low level of water stress (watered once a week) performed better than those moderately stressed (watered once every 2 weeks). The increase in the rate of growth will lead to increase in the hormones which increase the length of fruits (Hussein *et al*., 2011).

Irrigating okra plants at the right time will enhance the growth of vegetative parts, early flowering and fruit set, the okra crop need more water during growth and development (Matlob *et al*., 1989; Hassan, 1997). The influence of irrigation intervals of okra crop on different parameters may be due to stomata behaviour of plants which affected plants by these intervals. The opening and closing of the stomata have been affected by the intervals between the irrigation, especially the stomata in the upper layer of the leaf (Anant *et al*., 2009) and saving the plant from the drought. Abd-El-Kader *et al*. (2010) noticed that morphological characters of okra plants were reduced by increasing the intervals between irrigation and the plant would face a drought and less humidity which the plants needed for growth, flowering, and yield. From the experimental results, it is clear that all studied characters were improved by reducing the time between the irrigation, and hence increasing the humidity in the soil and increasing the mineral elements needed by the plants which dissolved by water inside the plant tissues (El-Sahookie *et al*., 2009). The results obtained from the study which showed the improved performances of okra under 7 days watering interval were similar to previous studies of Al-Ubaydi et al. (2017) and Ghannad *et al.* (2014a). It affirms the findings of and Habtamu *et al*. (2014) who reported that an increase in plant height as irrigation interval increases from 3 to 6 days and a gradual decrease after 6 days and a maximum number of leaves at 6 days irrigating frequency.

The water stress conditions under which the okra in this study was subjected to due to the watering regime intervals significantly influence the growth and yield of okra at the experimental site. According to Guiterrez-Boen and Thomas (1999), a decrease in soil water availability influences the velocity of diffusion of numerous plant nutrients, and thus their composition and concentration. Similarly, Schaff and Skogley (1982) found that the lack of water reduced the diffusive transport of numerous plant nutrients to the root system. A significant decrease in nutrient uptake has been recorded during periods of water stress (Marschner, 1995), due to decreased ion transport to the root. Abd-El-Kader et al. (2010) observed a reduction in the morphological characteristics of okra due to increasing irrigation intervals. The irrigation enables the mineral elements to be dissolved and conveyed to various plant parts and the water is highly imported into the photosynthetic apparatus, making water an important factor affecting plant growth (El-Sahookie *et al*. 2009).

The flea beetle infestation on the okra was significantly influenced by the watering interval. At 4 and 6 WAS okra watered at 7 days intervals recorded the significant highest insect infestation population compared to other treatments. The insect infestation on okra can be attributed to the water stressed suffered by the plants which leads to reduction in the leaves production, leaves size and their palatability to the insect being a foliage eater.

Conclusion

Due to the economic importance of Okra in food security, it is crucial to understand how drought conditions or inadequate water supply potentially affect okra yield under climate change and to explore appropriate adaptation measures to maintain or increase okra production. The study indicated that water shortage interferes with the normal function of vital processes of plants, thereby influencing their vigour and productivity. Also, the results have shown that a reduced watering regimes in the plant has an increasingly positive effect on the early growth, development, yield, and plant survival depending on the magnitude of excess or deficit of the water. The yield obtained from all the treatments was significantly different ($p<0.05$) and this was as a result of different watering regimes. However, the watering regimes did not significantly influence insect pest infestation with the exception of slight high population observed in okra with 7 days watering interval. This experiment suggests that watering every seven days characterized by best vegetative growth yield should by adopted by farmers in the study area to improve the supply of okra fruits during the dry season.

References

Abd El-Kader, A. A., Shaaban, S. M. and Abd El-Fattah, M. S. (2010). Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* L) grown in sandy calcareous soil. Agriculture and Biology Journal of North America 1: 225-231.

Adeogun, E. O. (2016). Yield response of okra to irrigation frequency and amount in a sprinkler irrigation system, *Continental Journal Agricultural Science,*10(2): 24-31.

Akanbi, W. B., A. O. Togun, J. A. Adediran, and Ilupeju, E. A. O. (2010). Growth, dry matter and fruit yields components of okra under organic and inorganic sources of nutrients. *American-Eurasian Journal of Sustainable Agriculture*, 4(1): 1-13.

Al-Harbi, A. R., Al-Orman, A. M. and El-Adgham, F. I. (2008). Effect of drip irrigation and emitters depth on okra (*Abelmoschus esculentus*) growth. *Journal of Applied Science*, 8(15): 2764-2769.

Al-Ubaidi, R. M., Al-Shakry, E. F., Al-Samara, M. A. and Al-Mohmadawy, S. M. (2017). Effect of irrigation intervals on growth, flowering and fruits quality of okra (*Abelmoschus esculentus* L. Monech), *African Journal of Agricultural Research*, 12 (23): 2036-2040.

Anant, B., Singh, K. P., Ashutosh, R. and Ajay, M. R. (2009). Physiological and Yield Response of okra (*Abelmoschus esculentus* L.) to irrigation scheduling and organic mulching. Indian Journal Agricultural Science, 79(1): 813-815.

El-Sahookie, M. M., Alfalahi, A. O. and Almehemidi, A. F. (2009). Crop and soil management and breeding for drought tolerance, *Journal Agricultural Science,* 40 (2), 1-28.

Gemede, H. F., Ratta, N., Haki, G. D., Woldegiorgis, A. Z. and Beyene, F. (2015). Nutritional quality and health benefits of okra (*Abelmoschus esculentus*): a review. *Journal of Food Process and Technol*ogy, 6(6): 458. Ghannad, M., Madani, H. and Darvishi, H. H. (2014). Effect of different sowing times, irrigation intervals and sowing methods on okra (*Abelmoschus esculentus* L. Moench). International Journal of Farming and Allied Science, 3(6):683 -689.

Gutierrez-Boem, F. H. and Thomas, G. W. (1999). Phosphorus nutrition and water deficits in field grown soya beans. Plant and Soil 207: 87-96.

Habtamu A, Ibrahim A, Hamza BT, Dagmawit D, Bogale A, Damene T (2014): Emergence and seedling growth of Corn (*Zea mays* L.) as influenced by irrigation schedules on Vertisol. International Research Journal of Plant Science, 5(1): 17-22.

Hassan, A. A. (1997). Fruiting Vegetable.2nd Ed. Al Dur Al Arabia for publishing and distribution. Egypt P. 300.

Hussein, H. A., Metwally, A. K., Farghuly, K. A., Baha, M. A. Wirth (2011). Effect of Irrigation Interval (water stree) on Vegetative growth and Yield in two Geno types of okra. Australian Journal of Basic Applied Science, 5(12):3024-3032.

Law-Ogbomo, K. E., Osaigbovo, A. U. and Ewansiha, S. U. (2013). Responses of okra (*Abelmoscus esculentus*) to various periods of weed interference in a humid tropical environment. *International Journal of Agriculture and Rural Development,* 16(1): 1368-1371. Marschner, H. (1995): Mineral Nutrition of Higher Plants. Academic Press International, San Diego, CA, USA.

Matlob, A. N., Ass Al-Dean, S. M. and Kareem, S. A. (1989). Vegetable production. Second Ed. Ministry of Higher Education and Science Research. P. 337.

Nana, R., Maiga, Y., Ouedraogo, R. F., Kabore, W. G. B., Badiel, B. and Tamini, Z. (2019). Effect of water quality on the germination of okra (*Abelmoschus esculentus*) seeds, *International Journal of Agronomy*, (6), 1-7.

Onwugbuta-Enyi, J. (1996). Effect of water on germination and growth of *Abelmoschus esculentus*. *Annals of Agricultural Research*, 17(4): 393-396.

Schaff, B. E. and Skogley, E. D. (1982). Diffusion of potassium, calcium and magnesium in Bozeman silt loam as influenced by temperature and moisture. Soil Science Society of American Journal, 46: 521-524.

Tajudeen, T. T., Omotayo, A., Ogundele, F. O. and Rathbun, L. C. (2022). The Effect of Climate Change on Food Crop Production in Lagos State. *Foods (Basel, Switzerland)*, *11*(24), 3987.

Unlukara, A. and Cemek, B. (2019). Response of okra to water stress. *MKU. Tar. Bil. Derg.* 24(Özel Sayı) :313-319.

Figure 1

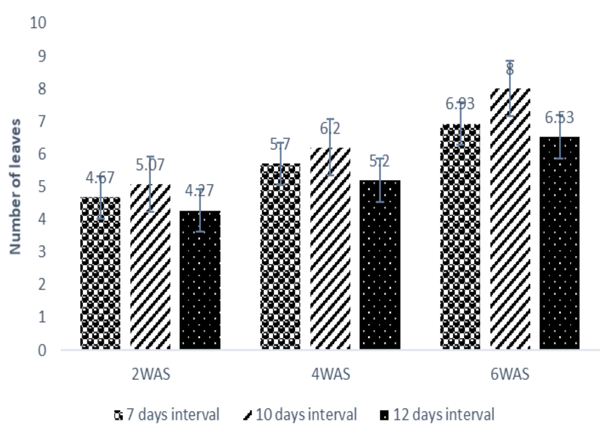

Figure 2

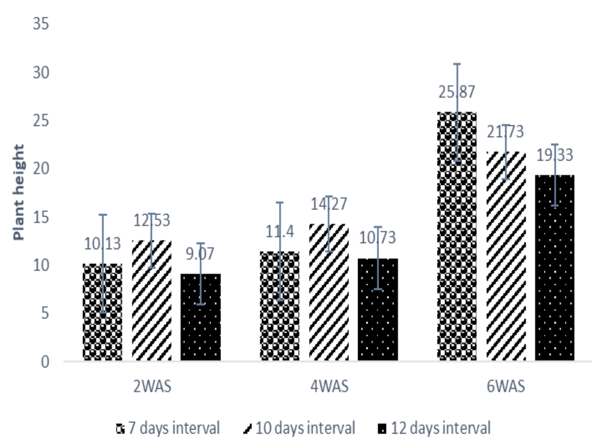

Figure 1: Effect of watering regime on number of okra leaves

Figure 2: Effect of watering regime on plant height of okra

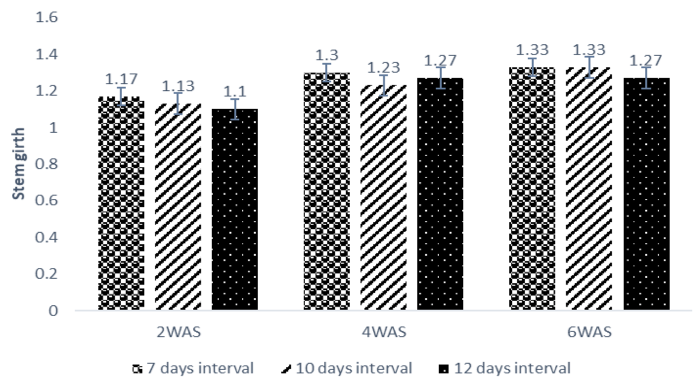

Figure 3: Effect of watering regime on okra stem girth development

Table 1: Effect of different watering regime on Flea beetle infestation

Watering regime	2 WAS	4 WAS	6 WAS
7 days interval	0.33a	1.67b	3.0a
10 days interval	0.33a	2.0a	2.0b
12 days interval	0.33a	2.0a	3.0a

Means followed by same letters in a column are not significantly different at 5% Probability level using DMRT

Table 2: Yield attributes of okra to different watering regime

Watering regime	No of fruits	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
7 days interval	12.09a	11.65b	5.48a	4.53a
10 days interval	12.27a	15.50a	4.71b	3.67b
12 days interval	9.62b	8.32c	4.36b	3.25b

Means followed by same letters in a column are not significantly different at 5% Probability level using DMRT

EFFICACY OF SOME BOTANICAL EXTRACTS AGAINST *Fusarium oxysporum* ASSOCIATED WITH POST-HARVEST LOSSES OF TOMATO (*Solanum lycopersicum* L.) AT SELECTED LOCATIONS IN KANO SATE.

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ABSTRACT

The demand for fresh tomato as important vegetable is high in Nigeria. However, post-harvest losses are threat to its production and storage. This study aims to isolate, identify fungi associated with post-harvest spoilage of tomato, and evaluate the efficacy of some botanicals against the post-harvest fungi. The study also aimed at determining whether cultivars have influence on post-harvest losses of tomatoes. Fungi associated with the post-harvest spoilage of tomato in this study were (*Fusarium oxysporum*, *Aspergillus niger*, *Rhizopous stolonifer*). Efficacy of botanicals at 100%, 75%, 50%, 0%, and check against mycelial growth of fungi were evaluated, results showed eucalyptus leaves extract, chili pepper and olive leaves extracts had significantly inhibited mycelial growth of the fungi and *Fusarium oxysporum* was the most inhibited. An *in vivo* experiment carried out where healthy riped tomato fruits from two cultivars (Makaho and UTC cultivars) were tested for the susceptibility to *F. oxysporum.* Results showed that chili pepper extract proved most effective botanical inhibiting the growth of all tested fungi compared to others. For the *in vivo* experiment, all the botanicals where found to be effective in controlling *F. oxysporum* associated with spoilage of tomato, but the efficacy vary among botanicals, and the concentrations. The level of susceptibility of two cultivars of tomato fruits to *F. oxysporum* varied with the cultivars. This proved that plant extracts of Chilli pepper, have the potential as a complementary and environment friendly bio-pesticide for inclusion in an Integrated Disease Management package for the management of fungal diseases.

Keyword: *Fussarium oxysporum*, Tomato, Botanical extracts, *In vitro*, and *In vivo* evaluation.

INTRODUCTION

Tomato is an annual crop from fruits and vegetables. Originating in South America, it was brought to Europe in the sixteenth century and then, in the early 1900s, to East Africa by colonial immigrants (Kenneth, 2016). Nearly all Nigerian homes cultivate tomato (Olanrewaju and Swamp, 1980). Diseases that develop before and after harvest, improper handling, and other factors can all reduce the quality and nutritional value of freshly harvested tomato fruits (Kader, 1986). The most significant and common disease-causing agents in tomato are, fungi infecting a variety of the host plants, causing havoc and financial loss in tomato production, whether in the field, during storage, or during transit (Sommer, 1985). Most important post-harvest disease causing organisms are fungi, Insects, and bacteria, causing a huge decrease in yield (Adamu, and Abhilasha, 2015). According to Kutama *et al.* (2007), these limitations are estimated to have caused a total loss of almost 60% in Nigeria.

Additionally, Opadokun (1987) reported that 20% of Nigeria's tomato production was lost to field rot and another 21% due to inadequate marketing, shipping, and storage practices. The tremendous loss has led to a hunt for easy, affordable, and efficient ways to manage pre- and postharvest illnesses as well as other losses in tomato fruits (Wilson and Wisniewski, 1989). The main reasons for tomato fruit deterioration after harvest and how to prevent it. Tomatoes are a very perishable crop; studies in tropical regions have revealed that up to 50% of the harvest is lost during the transition from rural to urban consumption (Oyeniran, 1988).

Tomato fruit has limited shelf life and is very susceptible to post-harvest microorganisms that cause deterioration. According to Oyekanmi (2007), There is the need for more fresh fruit to feed the expanding populations in emerging economies and/or nations.

However, postharvest losses prevention and technological solutions become crucial as more peris hable produce are transported from farms to consumption areas, and as more fresh tomato fruits are stored longer to achieve supply year round. Poor pre-harvest practices, poor production practice such as use of low-shelf-life cultivars, lack of balanced nutrient ion, insect pests and diseases, as well as abiotic stress, coupled with improper harvesting at the wrong stage, improper care during harvest, rough handling, moisture conditions leading to pathogen infestation. Alsopackaging in bulk without sorting leads to deteriorating produce, and improper transportation and storage are all main causes of post-harvest losses. This implies that only half of the output is ever used by consumers. Because of their high moisture content, fruits are easily attacked by pathogenic fungi that induce rots and create mycotoxins that render the fruits unsafe for human eating (Stinson *et al.,* 1981; Philips, 1984; Moss, 2002).

Tomatoes are necessary for human nutrition, but damage from post-harvest spoiling caused by fungi has been a major limiting factor. Fungal diseases that cause post-harvest tomato fruit deterioration are a major cause of crop losses and quality compromises. Because fungus may produce mycotoxins, which can lead to mycosis in humans, it is known that rotting tomatoes can provide health risk to both humans and animals. Since tomatoes contain a lot of fluid, mycotoxins in fruits are not just found in the affected area (Baker, 2006). The objectives of the study are to isolate, and morphologically identify fungi associated with the spoilage of tomato fruits and to evaluate the efficacy of some selected aqueous extracts on fungi associated with post-harvest spoilage of tomato fruits

MATERIALS AND METHODS

Collection of infected tomato fruit samples

Some Market centers in Kano State area were targeted for sample collection. Sampling vendors were randomly selected in the local markets which include Sheka market in Kumbotso Local Government, Janguza market in Tofa Local Government and Coke village market (BUK New Site) in Ungoggo Local Government, whereby physical examination was used to identify infected tomato fruits during samples collection. Infected tomato fruits were collected, placed in a paper envelopes and brought to the Laboratory of phytopathology, Department of Crop Protection, Bayero University Kano for identification.

Isolation of pathogen

Potato dextrose agar (PDA) was used in isolating the fungi from infected fruits. Infected tomato fruits samples were rinsed under tap first, dipped into 1 percent Sodium Hypochlorite for 20 seconds to surface sterilize, there after rinsed in three changes of sterile $_{dd}$Water. The tomatoes fruits were then blot dried using sterile tissue paper.

Direct plating method was applied for the isolation of fungi, where a scalpel was sterilized and used to cut a 3 mm x 3 mm sections between infection and healthy of tissue from tomato. Juice on the tissue pieces were dried with help of sterile tissue paper. The dried pieces of infected cute tissues lesion were directly plated on sterile PDA amended with streptomycin as anti-bacterial growth, then inoculated plates were incubated at room temperature (27°C) for 7 days.

Identification of Isolated Fungi.

Fungal identification was achieved using morphological characteristics of the isolates, compared with established keys as in Barnnet and Hunter. (1999). Microscopic examinations was conducted on each isolate, and their respective morphological features were observed, pictured and recorded. The fungi was identified based on their growth patterns, color of mycelia and microscopic examinations regarding their vegetative and reproductive structures (Robles-rion, 2016).

Preparation of plant crude extracts.

Olive leaves, chili fruits, and eucalyptus leaves were used to make the crude plant extracts. Leaves from eucalyptus and olive trees located across the campus were gathered and sent to the phytopathology laboratory, of the Department of Crop Protection Bayero University Kano. After being cleaned with tap water, the leaves and fruits were dried under shade, and rinsed three times using sterile distilled water. After which they were oven dried for 24 hours at 40°C. While chili fruits peppers were purchased at the Sheka market and transported to the same laboratory, where it was cleaned with tap water, rinsed three times using distilled water, and then oven dried for 24 hours at 40°C. The eucalyptus, olives leaves and chili pepper fruit were then ground to powder with help of a sterile blending machine so as to rapture open their tissues, and expose cellular structures to release their active constituents (de-Boe, 2022).

50g each of the respective powder was added to 250ml of distilled water in 1000ml capacity flat bottom flask, the suspension was allowed to stand overnight and the solution filtered using sterile muslin clotting and kept in a glass bottle until needed. The extracts at different concentrations were prepared by mixing 50ml, 25ml, of stock solution with distilled water to give final concentration of the extract at 50%, 75% and 100% respectively using $p_1v_1 = p_2v_2$.

Experimental design

The *in vitro* experiment was laid in Completely Randomized Design (CRD), consisting of 5 treatments, (treatment 1: eucalyptus leaves extract, treatment 2: olive leave extract, treatment 3: chili pepper fruit extract, treatment 4: control, and treatment 5: standard check). The treatments were replicated three times whereby the check and control were used for comparisons.

Data collected:

Efficacy of aqueous plant extracts against mycelial growth of *F. oxysporum*.

Effectiveness of the crude extracts in controlling growth of *F. oxysporum* was evaluated *in vitro*.

Five (5) mm fungal culture discs from five day old cultures of *F. oxysporum* was dropped at the center of each petri dish, replicated three times, and incubated at room temperature. Radial growth was measured after the second day from each treated culture, and same data was recorded at an interval of two days, up to the sixth day post inoculation. The mean growth of the fungi on the amended media was compared to the control.

In vitro testing of efficacy of the crude extracts for the inhibition of mycelial growth of *F. oxysporum* was conducted. Five-day-old *F. oxysporum* cultures were used; 5mm fungal culture discs were deposited at the center of each petri dish, duplicated three times, and incubated at room temperature. The second day after inoculation, radial development from each treatment was measured and then repeated every two days until the sixth day. The fungi's average growth on the modified media was contrasted with that of the control.

Data analysis

Data recorded were subjected to analysis of variance (ANOVA) using Genstat version 17th and means with significant difference were separated using LSD at 5% level of significance.

RESULTS

Isolation and identification of fungi associated with post-harvest tomato fruits rots:

Aworth *et al.* (1985) reported that bacteria and fungi are the major causal agents of post-harvest fruits tomatoes losses. The isolated fungi from this study were *Aspergillus niger, Fusarium oxysporum,* and *Rhizopus stolinifer*.

***Fusarium oxysporum*:**

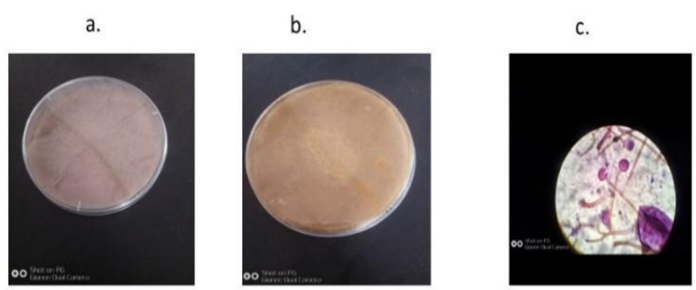
Fusarium oxysporum was identified as having fast growing colonies, having extensive mycelia, its cotton like in culture, with pink color at plate bottom, but whitish pink at the front. Conidiophores is known to be simple and slender, or stout, short and branching irregularly, or bearing spiral phialides, its sporodochia may be born singly, and its conidia (phialospores) are hyaline, variable, mostly hold in small heads. Macro-conidia are hyaline, bent at the pointed ends or slightly curved, several celled. While the micro-conidia are pyriform or fusiform to ovoid, hyaline, straight or curved. Majority of the features described above can be seen in plates below.

Top view of *F. oxysporum* Bottom view of *F. oxysporum* Microscopic view of *F. oxysporum* showing Macro and Micro conidia

Plate 1: a. Shows Top and Bottom view of isolated F. *oxysporum;*
b. Microscopic picture of isolated F. *oxysporum* showing macro and micro conidia.

Rhizophus stolonifer:

R. stolonifer is known to grow rapidly filling petri-culture with its dispersed white mycelia in two days. Colonies are whitish which turns gray-brown, this is due to yellow-brown sporangiophores and black to brown sporangia, as it get older bearing extensive mycelial growth. The mycelium is aseptate, while sporangiophores are large having striated walls, and irregular in shape. They may be colorless or dark brown with somewhat rough stolon opposing branched rhizoids. Its sporangia are sphere (i.e globose) or nearly sphere (i.e sub-globose) and blackish-brown color at maturity. Columella projects into the sporangium, sporangiophores and sporangiospores (i.e asexual spores bearing body) were irregular in shape and borned within pinhead like sporangium, which break to release the spores mature. And majority of the feature described above can be seen in the type culture below.



Plat 2 *R. stolonifer*; Top view *R. stolonifer*; Bottom view *R. stolonifer*; Microscopic view

Table 1 showed the effect of plant extract on mycelial growth of *F. oxysporum* causing post-harvest spoilage of tomato. At day two (D2) olive leave extract recorded the highest mycelial growth (10.98mm), followed by eucalyptus leaves extract (9.00mm), while chili pepper extract recorded the least mycelial growth (6.9mm) at D2. Hence, from the above data we can understand there is significance difference (p<0.05) between all the extracts at D2.

Moreover, at D4, the olive leaves extract recorded the highest mycelial growth (17.25mm), followed by eucalyptus leaves extract (15.39mm). While chili pepper extract was found to record the lowest mycelial growth (9.92mm) at D4 (Table 1). While at D6, olive leaves extract recorded highest mycelia growth (24.24mm), then eucalyptus leaves extract (19.18mm). Chili pepper extract recorded the least mycelial growth at D6 (12.63mm)(Table 1). This had indicated significant (p<0.05) difference among all the extracts at both D4 and D6 respectively. Nonetheless, the mycelial growth recorded an increase in mycelial growth from D2 to D6 among all the treatments, but olive leaves extract appeared to record the highest increase in mycelial growth (24.24mm) at D6, hence chili pepper was the lowest in mycelial growth (12.63mm) at D6. The above implies that chili pepper has the highest efficacy in inhibiting the growth of F. *oxysporum* (Table 1).

The effects of different concentrations of aqueous plant extracts on mycelial growth of *Fusarium oxysporum* Was significant (p<0.05) at different times of inoculation (Table 2). At D2 check recorded the lowest mycelial growth (5.00mm), followed by 100% concentration (7.64mm). While the control treatment recorded the highest mycelial growth of 14.50mm compared to all other treatments. Table 2 showed significant (p<0.05) difference among all the concentrations. More so, at D4, the check treatment recorded the least mycelial growth (5.00mm), followed by 100% concentration (10.12mm), while the control had the highest mycelial growth (28.80mm) with the check recorded the least mycelial growth (5.00mm) at D6, followed by 100% concentration (11.71mm). However, the control treatment recorded the highest mycelial growth (42.35mm). Furthermore, an increase in mycelial growth of *Fusarium oxysporum* from check to 100% concentration, followed by 75% then 50% and lastly the control. This implies that the check best inhibits mycelial growth of *F. oxysporum*, followed by 100%, then 75% concentration. An increase in mycelial growth of *F. oxysporum* was also observed from D2 to D4 then to D6 among all the concentrations except in the check (Table 2).

Table 3 presents the interaction effect between plant extracts and their various concentrations on mycelial growth of *Fusarium oxysporum* at two days post inoculation. Considering eucalyptus extract, we can observed that control recorded the highest mycelial growth (14.50mm), followed by 50% concentration (11.13mm), then 75% then 100%, while check recorded the lowest mycelial growth (5.00mm). Data in Table 3 result shows that the eucalyptus extract was significantly (p.0.05) different among all the concentrations, control, and check. .

Chili pepper fruit extract, control recorded the highest mycelial growth (14.50mm), while all concentrations recorded the same mycelial growth of (5.00mm) and check (Table 3). there was asignificant ($p<0.05$) difference between control and all other concentrations including check, hence there is no significance difference between all other concentrations including the check in chili pepper fruit extract at day two post inoculation.

In olive extract, control also recorded the highest mycelial growth (14.50mm) of *F. oxysporum* at day two post inoculation, followed by 50% concentration (11.90mm) mycelial growth, while check recorded the lowest mycelial growth (5.00mm) at two days post inoculation (Table 3). The result indicated significant ($p<0.05$) difference between control and 50% concentration. Hence no significant difference between 50% and 75% concentration, and also between 75% and 100% concentration in olive extract (Table 3). But there is significance difference between 100% and check (Table 3). The above indicated that the check inhibit the mycelial growth of *F. oxysporum* better, at 100% concentration, followed by 75%; while 50% concentration recorded the least inhibition (Table 3).

DISCUSSION

In vitro efficacy of aqueous botanicals extracts on the test fungi.

This study examined that the pathogenic fungi responded well to all the plant extracts and their concentrations, yet the effectiveness changed depending on the percent concentration used. Based on the findings, extracts from eucalyptus leaves, chili peppers, and olive leaves greatly reduced the mycelial development of the fungi that were examined, suggesting that they may have antifungal qualities. Out of all the plant extracts examined, *Fusarium oxysporum* proved to be most susceptible to the botanical extracts. Compared to the extracts from eucalyptus and olive leaves, the findings from this study indicates that the chili pepper extract appeared as the most successful aqueous extract in inhibiting the development of all the tested fungi, even at low concentrations.

The differences in the level of inhibition potentials among the aqueous botanical extracts might be due to varying level of reactions of the tested fungi to various doses of the extracts. Chili pepper showed the highest anti-fungal activity, and could be useful in managing post-harvest fungi in this study. Chili pepper extracts in all the concentrations tested had significantly reduced mycelial growth of both *Fusarium oxysporum*, and *Aspergillus niger*. Findings in this study agreed with shabnam *et al.* (2009), which reported antifungal properties of *Capsicum frutescens* extract against four main strains of (*Aspergillus niger, A. flavus, Rhizopous* spp.) related to groundnut storage. The minimum fungicidal concentration (MIC) of *Capsicum frutescens* extract was also evaluated and the chili aqueous extract proved to have antifungal activity against *A. niger* (88.33%), hence fruits treated with *Capsicum frutescens* fruit extract shows advance rate of antifungal activity.

The results are also consistent with the finding of *Singh et al.* (2008), who reported that 50% of chili pepper juice showed total inhibition of *Sphaerosis sapinae* and *Leptographium procerum* associated with wood discoloration.

According to Singh *et al.* (2004) the volatile oils such as piperine and piperoin and piperamid majorly obtain from acetone extract of chili pepper, were 100% effective in controlling mycelial growth of food borne fungi hence support findings in this work. While *Oyedeji et al.*, (1999), showed that all the concentrations of aqueous and alcoholic extract of *Eucalyptus camaldulensis* have inhibitory activities on *staphylococcus aureus* and *penicilium digitatum.* However, the inhibitory effect varied with concentration. Results from this study suggested that chili pepper, eucalyptus leaf extract, and olive leaf aqueous extracts, may have some anti-fungal compounds, which were able to retard both *in vitro* and *in vivo* growth of the tested fungal pathogens. Moreover, Katooli *et al.* (2011), revealed that *Eucalyptus camaldulensis* essential oil suppress the mycelial growth of post-harvest microorganism, (*Aspergillus flavus, Penicilluim digitatum, A. niger, C. gloesporiodes)* and soil pathogenic fungi (*R. solani,* and *Phythium ultimum).*

In Katooli *et al.* (2011), complete arrests of mycelial growth of *P. ultimum* and *R. solani* were achieved by four tested essential oil levels (25, 50, 75 and 100%) at 30 days post inoculation; hence, supports the findings in this study that aqueous extract of *Eucalyptus camaldulensis* significantly inhibits mycelial growth of *A. niger* and *F. oxysporum* at six days post inoculation. Nonetheless, the present study corroborates with Siramon *et al.* (2013), on the inhibitory activities of *Eucalyptus camaldulensis* extract against various types of kitchen and store molds, Fungi causing wood rots, and phyto-pathogenic fungi, such as *Chaetomium globosum, F. oxysporum, A. niger*, *Thenatephorus cucumeris* and *R. oryzae.* The extract caused 84-100% of the mycelial growth inhibition against *F. oxysporum, A. niger* and *Thenatephorus cucumeris* at 5mg/ml concentration, and caused 100% inhibition of *C. globosum* at 10mg/ml concentration (Siramon *et al.,* 2013).

Furthermore, this study agrees with the finding of Korukluoglu *et al.* (2007) who observed that aqueous leaf extract of olive have the highest antimicrobial activities against the following fungal strains; *Aspergillus niger, A. flavus, A. wentii, Fusarium oxysporum, P. echinulatum* when compared with acetone, methanol, and ethyl acetate extracts of the olive leaf. Likewise, with that where aqueous extracts of olive leaf at 15% killed *C. albicans* at 24hr after treatment (Markin *et al.,* 2003).

However, the this work is in contrast with that reported by Yasemin *et al.* (2006), that aqueous extract of olive leaf did not show any inhibitory activity on the following yeast speciecs (i.e *Sacchomyces cerevisiae*, *Candia oleophila*, *Kloeckera apiculata*). These differences are likely to occur because of the differences in olive cultivar used and possibly the yeast spacies resisted or tolerate the extracts used (Ranalli *et al.,* 2006).

REFERENCES

Adamu, S.H. and Abhilasha, A.L. (2015). In vitro efficacy of certain botanicals and their effect on some biochemical properties of Pectobacterium carotovora susp. carotovora inoculated tomato (*Lycopersicon esculentum* L.). *African Journ. F Bacteriology Research*. 7(7): 64-69: DOI: 10.5897/JBR2015.0172

Aworth, O. C. (1985). Preservation of perishable food commodities through processing. *Nigerian Food Journal*, 2:2.

Baker, S. (2006). *Aspergillus niger*, genomics; past, present and into the future. *Medical Mycology*. Vol. 44, No.1, S17-21. DOI: 10 .1080/13693780600921037.

Bernett, H. L. and Hunter, B. B. (1999). Illustrated Genera of Imperfect Fungi. Burgess Publishing Company Mineapolis, 246-249.

Hugo de Boer, Marcella, Orwick Rydmark, Brecht Verstraete, Barbara Gravendeel (2022). Molecular Identification of Plants: From Sequence to Species. https://doi.org/10.3897/ab.e98875

Kader, A.A. (1986). Effects of postharvest handling procedures on tomato quality. *Acta Hortic.* 190, 209-221.

Katooli, N. Maghsodlo, R. and Razavi, S. E. (2011). "Evaluation of eucalyptus essential oil against some plant pathogenic fungi," Journal of Plant Breeding and Crop Science, vol. 3, no. 2, pp. 41-43.

Kenneth, O. (2016). Agro-morphological and nutritional characterization of tomato landraces (*Lycopersicon species*) in Africa. Diss University of Nairobi, Kenya.

Korukluoglu, M., Ahan, Y., Yigit, A., Tumay Ozer, E. and Gucer, S. (2004). In-vitro Antibacterial *Activity of Olive Leaf (*Olea Europea *L.) Extracts and Their Chemical Characterization*, pp. 569–571, 4th Aegean Analytical Chemistry Days, Aydin, Turkey.

Kutama, A.S, Aliyu, B.S, and Mohammed, I. (2007). Fungal pathogens associated with tomato wicker baskets. *SWJ*. 2, 38-39.

Kutawa, A.B. and Tijjani, A. and Jibrin, S.M. (2020). Assessment of fungal species associated with tomato spoilage sold at Dutsin-ma Metropolis, Katsina Sate, Nigeria. *Inter. Journ. Of Agriculture, Forestry and Plantation.* Vol.10/2020. ISSN 2462-1757

Markin D., Duek L., Berdicevsky I. (2003). In vitro antimicrobial activity of olive leaves. *Mycoses*, 46: 132-136.

Moss, M. O. (2002). Mycotoxin Review Journal on *Aspergillus penicillium*. *Mycologist,* 16:116 119.

Olanrewaju, D. and Swamp, V. (1980). *Tomato cultivation and its potential in Nigeria.* National Horticulture Research Institute Bulletin. Ibadan, Nigeria, 20pp

Opadokun, J.S. (1987). *Reduction of postharvest losses in fruits and vegetables.* Lectures delivered at AERLS/NSPRI Joint National Crop protection workshop, Institute for Agricultural Research, Zaria, Nigeria. Pp. 3-26.

Oyedeji, A.O. Ekunday, O. Olawore O.N. Adeniyi, B.A. Koenig, W.A. (1999). Antimicrobial Activity of the Essential Oils of Five Eucalyptus Species Growing in Nigeria. *Fitoterapaia*, 70:526 528.

Oyekanmi, M. O. (2007). Determinants of post-harvest losses in tomato production: A case study of Imeko – Afon Local Government Area of Ogun State. Msc thesis, Dept of Agriculture,Babcock University. 60-90.

Oyeniran, J. O. (1988). Reports of the activities of nationally co-ordinated team on improved packaging and storage of fruits and vegetables in Nigeria. Proceedings of the workshop on improved packaging and storage systems for fruits and vegetables in Nigeria held in Ilorin, Nigeria.

Phillip, D. J. (1984). Mycotoxins as a post-harvest problem. In: Post-harvest pathology of fruits and vegetables; Post-harvest losses in perishable crops. Moline, H.E. (ed). Agricultural experimental station. University of California, Berkeley Publications, 50-54.

Ranalli A., Contento S., Lucera L., Di Febo M., Marchegiani D., Di Fonzo V. (2006). Factors affecting the contents of iridoid oleuropein in olive leaves (*Olea europaea* L.). *Jour. Agric. Food Chem.,* 54: 434-440.

Robles-CarriónI, A., Leiva-MoraII, M., Herrera-IslaIII, L., Sánchez-Rodríguez, A., Torres-Gutiérrez, R., (2016). Morphological and molecular identification of Fusarium species associated with vascular wilt of babaco (Vasconcellea heilbornii var. pentagona Badillo). Rev. Protección Veg. Vol. 31 No. 3 : 184-193

Samson, J. A. (1984).Tropical fruits. *Tropical Agricultural Series*, 20:64-118.

Shabnam, A. Shayesteh, N. (2009). Insecticidal Activity of black pepper and red pepper in powdered form on adult of Rhyzopertha dominica (F) and Sitophilus granaries (L.). *Pak. Entomol*; 31, 122–127.

Singh, G. Gupta, S. and Sharma, N. (2014). *In vitro* screening of selected plant extracts against *Alternaria alternata*. *Journal of Experimental Biology*, vol. 2, no. 3, pp. 344–351.

Singh, T., Chittenden, C., (2008). In-vitro antifungal activity of chili extracts in combination with Lactobacillus casei against common sapstain fungi. *International Biodeterioration & Biodegradation*, doi:10.1016/j.ibiod.2007.10.0093.

Siramon, P. Ohtani, Y. and Ichiura, H. (2013). "Chemical composition and antifungal property of *Eucalyptus camaldulensis* leaf oils fromThailand," *Records of Natural Products*, vol. 7, no. 1, pp. 49–53.

Sommer, N.F. (1985). Strategies for control of postharvest disease of selected commodities. In: *postharvest Technology of Horticultural Crops.* Univ. Calif. Spec. Pub. 3311, DANR, Oakland, CA. 83-98.

Stinson, E. E., Osman, S. F., Heisler, E. G., Sicihano, J. and Bill, D. D. (1981). Mycotoxin production in whole tomatoes, apples, oranges and lemons. *Journal of Agriculture and Food Chemistry*, 29:790-792.

Wilson, C.L. and Wisniewski, M.E. (1989). Biological control of postharvest diseases of fruits and vegetables: an emerging technology. *Annu. Rev. phytopathol*. 27: 425-441.

Yasemin Sahan, Aycan Yigit and Reyhan Karakas. (2006). Antifungal activity of Olive leaf extracts from the Trilye Region Turkey.

Table 1: Efficacy of aqueous plant extracts on mycelial growth of *Fusarium oxysporum*.

	Mycelial growth (mm)		
Extracts	D2	D4	D6
Eucalyptus leaves	9.00b	15.39b	19.18b
chili pepper	6.90c	9.92c	12.63c
Olive	10.98a	17.25a	24.24a
LSD	0.189	0.284	0.380

Where D2: Mycelial growth at day two post inoculation.
D4: Mycelial growth at day four post inoculation.
D6: Mycelial growth at day six post inoculation.

Table 2: Effect of concentrations of aqueous plant extracts on mycelial growth of *F. oxysporum*.

	Mycelial growth (mm)		
Concentration	D2	D4	D6
100%	7.64^{d}	10.12^{d}	11.71^{d}
75%	8.31^{c}	11.73^{c}	13.63^{c}
50%	9.34^{b}	15.28^{b}	20.71^{b}
Control	14.50^{a}	28.80^{a}	42.35^{a}
Check	5.00^{e}	5.00^{e}	5.00^{e}
L S D	0.244	0.367	0.443

Where: D2: Mycelial growth at day two after inoculation. D4: Mycelial growth at fourth day after inoculation. D6: Mycelial growth at sixth day after inoculation. Control: Un-amended petri dish (i.e. 0% extracts). Check: petri dish amended with fungicide.

Table 3: Interaction effect between extracts and its concentrations on mycelial growth of *F. oxysporum* at day two post inoculation.

	Mycelial growth (mm)		
Concentration	Eucalyptus	chili pepper	Olive
100%	6.17^{d}	7.78^{b}	11.77^{b}

75%	8.20c	8.82b	11.73b
50%	11.13b	8.80b	11.90b
Control	14.50a	14.50a	14.50a
Check	5.00e	5.00c	5.00c
L S D		0.423	

Control: Un-amended petri dish (i.e. 0% extracts). Check: petri dish amended with fungicide. Figures carrying same superscript within a column a statistically the same.

CROP-LIVESTOCK INTEGRATION: A STRATEGY FOR IMPROVED AGRICULTURAL PRODUCTION AND HEALTHY ENVIRONMENT SUSTAINABILITY

CROP-LIVESTOCK INTEGRATION: A STRATEGY FOR IMPROVED AGRICULTURAL PRODUCTION AND HEALTHY ENVIRONMENT SUSTAINABILITY

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ABSTRACT

Crop-livestock integration: Can be defined as the practices of combining the cultivation of one or more with at least one type of livestock. Have multiple benefits such as to improves soil fertility, soil physical structure from appropriate crop rotation using cover crop and organic compost, utilize marginal lands, recycles utilizes crop residues and livestock wastes, reduces weeds, insect pest and diseases through animal grazing and crop rotation, reduces animal feed costs, increase farm biodiversity. It strengthens farmer's autonomy (less reliance to external inputs- fertilizers, agrochemicals, feeds, energy, etc.). livestock integration provides the livelihoods of about 1-3 billion people of the world's food a substantial contribution to food security and nutrition, of humanity's protein intake. constraints and limitations are**:-** Overgrazing removes the soil cover, fostering soil erosion and reducing important soil functions such as climate regulation, inappropriate management of animal manure can lead to soil and water contamination, thus having a negative impact on the environment, can create higher risk of disease transmission and Certain diseases can easily spread from animals to crops and vice versa, leading to losses in productivity. Integrated livestock farming system, sustainability and economic impact.

Keywords: Crop- livestock, Integration, Benefits, Constraints and Sustainability.

INTRODUCTION

Crop-livestock integration: This refers to the practice of combining the cultivation of one or more crop with at least one type of livestock. This integration is designed to reduced reliance on external inputs, as the crops provide feed for the animals and the animals manure provides nutrients that faster crop production.

- ❖ Integrating crops and livestock into a multi-function operation have multiple benefits. If properly utilized it will improve the profitability of these kinds of operations. According to (Ilri *et al.*, 2020) stated that researchers at Iowa State University, the University of Minnesota and Rodale Institute conducted a four-year project, funded by the United State Department of Agriculture (USDA) Organic Research and Extension Initiative to evaluate the production, environmental and economic benefits of growing cash crops with forage crops for grazing, including small grains and hay crops for livestock feed.

The benefits of integrating crops and livestock can include:

- It improves soil fertility and soil physical structure from appropriate crop rotation and using cover crop and organic compost.
- It utilize marginal lands.
- It recycles and utilizes crop residues and livestock wastes.
- Reduce labour.
- It reduce machinery inputs.
- It reduce animal feed costs.
- Increase farm biodiversity
- It reduces weeds, insect pest and diseases through animal grazing and crop rotation.
- It strengthens farmer's autonomy (less reliance to external inputs- fertilizers, agrochemicals, feeds, energy, etc.).
- It allows higher net returns to land and labour re-sources of the farming family.
- It improves space utilization and increases productivity per unit area (FAO and TECA, 2019).

Components and conditions for the integration

A common features of crop and livestock integration is the combination of crop and livestock, including in some cases agro forestry and aquaculture. However, the modality of the combination strongly depend on local socio- economic and agro-ecological condition. For example, the selection of crops and animals are dependent on preferences based on family consumption, market, animals raised and availability of resources (Card, 2021). cash generated from crops providing incomes to buy animals or cash from selling the animals allowing investment in crop production. (FAO, 2020) reported that livestock integration provides the livelihoods of about 1-3 billion people of the world's food a substantial contribution to food security and nutrition, of humanity's protein intake.

Crop and livestock integration presented the following constraints and limitations:

- Overgrazing removes the soil cover, fostering soil erosion and reducing important soil functions such as climate regulation.

- Inappropriate management of animal manure can lead to soil and water contamination, thus having a negative impact on the environment.
- Can create higher risk of disease transmission.
- Certain diseases can easily spread from animals to crops and vice versa, leading to losses in productivity.
- Loss in the skills and knowledge.
- Can contaminate soil and water sources, which can subsequently affect crop growth.
- One of the challenges for farmers is to increase land productivity through a better use of livestock in mixed crop-livestock farming systems.

Critical aspects to be considered in crop- livestock integration.

The following criteria should be taken into account to achieve an effective crop and livestock integration (FAO and TECA, 2019).

- Suitability of the farm for integration crop and livestock. Before engaging in any crop and livestock integration there is need to assess farm suitability in terms of space for animal shedding and grazing, sufficient fodder or by products to feed, sufficient know-how on keeping, feeding and treating the specific kind of animals.
- Benefit of the integration, assess whether the integration allows the livestock to fulfill its input and output functions (utilization of animal manure, use of animal products for own consumption or sales).
- Access to livestock inputs. It is important to have sufficient labour available inside and outside the farming system enough fodder and water of good quality, veterinary support and suitable breeds of animals.
- Animal population. When defining the number of farm animals, keep in mind that the economic benefit will be higher when fewer animals are kept but fed well. Not only the amount, but also the quality of the available feed must be considered.
- Animal selection. The criteria of animal selection include feeding requirements, growth duration, production potential, adaptability to local conditions, use of livestock outputs for food and non-food benefits.

Agro-ecological principles for crop and livestock integration

- Adapt livestock production to the local ecosystem livestock production whose requirements are suitable for the resources available locally, breeding of suitable local species, respectful of local agro-ecological and social conditions.
- Promote livestock system that uses local resources production and use of animal feeds on the farming system, production of organic matters on the farm possibility of livestock and crop diversification.
- Integrate forage crops and trees in the farming systems.

Integrated livestock farming system; scope, limitations, sustainability and economic importance

Livestock plays a significant role in rural economic development by supplementing family income and generating gainful employment, especially for landless laborers, smallholders and marginal farmers, as well as for women. Historically, livestock rearing has been recognized as an integral part of the agricultural sector and has been observed that combining livestock with other farming systems such as fisheries, apiculture, horticulture, agro-forestry, etc can be more productive and sustainable than specialized and intensive systems. Which helps in efficient utilization of natural resources and wastes/organic residues and involve recycling of bio resources. For example paddy rice paddy straw a by-product from rice crop can be used as a valuable input for mushroom cultivation.

In integrated livestock farming "there is no waste and waste is only misplaced resource that can be transformed into another useful material for another purpose" it is a way of efficient waste utilization generated under different farming systems and assists the farmers in becoming self-sufficient and self-reliant. In agricultural operations the sowing and harvesting of crops are seasonally dependent and during other times of the year the farmers are free and under this scenario, integrated livestock sector with different farming systems can provides income and employment round the year and can meet the household's requirements of the farmers with small land holding.

Farming system are as follows:

- An appropriate mix of farm enterprises and the resources available to the farmers to raise them for profitability.

- It interacts adequately with environment without dislocating the ecological and socio-economic balance on one hand and attempt to meet the national goal on the other.
- In its real sense, it will help in lifting the economics of agriculture, livestock and standard of living of the farmers of the country as a whole.
- Farming system is a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of farmers livelihood while preserving resource base and maintaining a high level of environment quality (Lal and Miller, 2019).
- Farming system is a set of agro-economic activities that are interrelated and interact with themselves in a particular agrarian setting.
- It is a mix of farm enterprises to which farmers families allocate its resources in order to efficiently utilize the existing enterprises for increasing the productivity and profitability of the farm. These farm enterprises are crop, livestock, aquaculture, agro-forestry and agric-horticulture.

Specialized Vs Integrated Farming System

- Specialization involves the intensification of the agricultural activity aimed at maximization of the production/area/time.
- This involves improvement of operational efficiency and speed of operation/ execution at each step.
- The specialized farming system is focused on single cropping system or sequence of farming enterprise like animal breeding, dairying so as to achieve the highest degree of precision management with minimal diversion of resources to diverse crops or enterprises.

Mixed farming Vs Farming system

- Mixed farming consists of components such as crops and livestock that coexist independently from each other.
- In this farming integrating crops and livestock serves primarily to minimize the risk and not to recycle resources.
- Enterprises the integrated farming system are mutually supportive and depend on each other.
- In integrated farming system crops and livestock interact to create a synergy with recycling,

allowing the maximum use of available resources.

- Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility and reducing the use of chemical fertilizers.
- A high integration of crop and livestock is often considered as a step forward, but small farmers need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term (FAO, 2020).

Sustainability: The word "Sustain" from the Latin sustinere (Sus- from below and tenere to hold), to keep in existence or maintain, implies long-term support. As it pertains to Agriculture and Veterinary, sustainable describes farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely.

Sustainability of Integrated livestock farming system:-

- Sustainable production can be achieve through production of healthy animals and producing wholesome food, while wisely using environmental, social and financial resources.
- Cyclic: The farming system is essentially cyclic (organic resources, livestock and crops). Therefore, resources can be used more efficiently.
- Rationale using crop residues more rationally is an important route out of poverty. For resource poor farmers or less privilege farmers the correct management of crop residues together with an optional allocation of scarce resources leads to sustainable production.
- Ecologically sustainable, combining ecological sustainability and economic viability, the integrated livestock farming system maintain and improves agricultural productivity while also reducing negative environmental impacts.
- The maintenance of an integrated crop-livestock system is dependent on the availability of adequate nutrients to sustain animals, plants and to maintain fertility.
- Given their traditional knowledge and experience, local farmers are perfectly able to apply an integrated system.
- The animals are also checked from overgrazing of the grass lands and the overall products are more organic and eco-friendly and can be taken as a staple food without any consideration of

poisoning.

- In this system an inter-related set of enterprises used so that the "waste" from one component becomes an input for another part of the system, which reduces cost and improves production and/or income.

Economic impact of Integrated livestock farming system

- Although there is a gradual investment in agriculture by corporate investors, farms remain predominantly family owned and operated around the world.
- The need for diversity in income streams for family operations is high, single enterprise operations are venerable to both price and production fluctuations.
- These risks are often outside the control of the operator, in turn an integrated system creates a buffer against economical and biological risks.

Over the past decades, agriculture experience a huge and nearly universal specialization due to multiple drivers such as globalization, industrial development and liberalization of trade that calls for economies of scale (Garrett *et al*.,2020). Empowered by the great promises offered by inputs used in large quantities during the green revolution, crop and livestock production systems have been largely decoupled throughout the world in most developed regions (Mazoyer and Roudart, 2019). But this specialization was associated to serious negative societal and ecological outcomes, such as degraded water quality biodiversity loss, pesticide poisoning of humans and non-target species, soil erosion or green house gas emissions, droughts, heat waves, wildfires (Naylor *et al.*,2021).

To address these issues Integrated crop-livestock systems (ICLS) are increasingly proposed as key solutions to maintain high levels of food production while minimizing the agricultural impacts on the environment (Bonauo *et al.*, 2019). They rely on natural and long-established complementarities between crop and livestock, animals eat and convert forage and crop products, by products and residues that are inedible for humans (Garrett *et al.*,2020) which also stated that they contribute to maintain soil fertility throughout manure production and habitats for auxiliaries in the agro ecosystem through grazing land.

REFERENCES

Bonauro, J, Faith, T, Robbin, L and David, U. 2019). Critical review of the impacts of grazing intensity on soil organic carbon storage and other soil quality indicators in extensively managed grass land; *European Journal of Agriculture Ecosystem Environment 67: 453-460.*

Card, V.(2021). Competition between cattle, other species and people, cattle on the land; Environmental sensitivity. *Journal of Animal Science* 56; 432-438.

Food and Agricultural Organization (FAO, 2020).Evolution in crop-livestock integration systems that improve farm productivity and environmental performance in; *Australian Journal of Agronomy* 76: 232-239.

Garrett, N, Moraes, A, Aquilar, J, Martin, V and Wento, R.(2020).Evaluation of the soil-crop models STICS over 8 years against the "on farm" database of Bruyeres catchment. *European Journal of Agronomy* 67: 2111-218.

Ilri, S, Amos, G, Seth, K and Gabriel, D.(2020). Recent advances in Integrated farming systems by researchers Department of Agronomy, COA, CSK HPKV, Palampur 176062.

Lal, R and Miller, X. (2019). Integrated crop-livestock systems in the Brazilian subtropics; *European Journal of Agronomy* 43: 78-84.

Mazoyer, H and Roudart, P. (2019). System fertilization in integrated crop-livestock management favors microbial process, soil quality and production profitability; *Asian Journal of Agriculture, Ecosystems and Environment* 87: 321-328.

Naylor, F, Wen, J, Douglass, U and Bonaudo, T. (2021).Agro ecological principles for the redesign of integrated crop-livestock system; *African International Journal of Ani,mal Science Production* 87: 430-438.

VALUE CHAIN AND ADVISORY SERVICES THROUGH DIGITAL INNOVATIONS AND CLIMATE-SMART TECHNOLOGIES

PROFITABILITY OF ALOE VERA EXTRACT (*Aloe vera* [L] BURN. F) ON WEED CONTROL IN SORGHUM

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ABSTRACT

Traditional manual hoe weeding is labor-intensive in nature, costly and not always available at time of high demand. This study aimed to explore the cost effectiveness of *Aloe vera* extract (AVE) as a sustainable alternative to manual hoe weeding in sorghum production. The evaluation compared the effectiveness of AVE to a standard herbicide combination of pendimethalin followed by halosulfuron and manual hoe weeding, with a focus on economic viability measured by Benefit:Cost Ratio (BCR). A randomized complete block design was utilized to assess the efficacy of AVE at various concentrations and application timings, combined with supplementary hoe weeding (SHW) or halosulfuron, against a weedy check. Data generated on weed parameters were subjected to Analysis of Variance (ANAOVA) using JMP Pro v. 16.0 and significantly different means were compared using SNK at 5% level probability. The results indicated that all sequential AVE combination treatments resulted in better weed control than was achieved under the sole application of AVE. The combined use of 0.5% w/v AVE with halosulfuron at 0.25 kg a.i ha^{-1} significantly reduced weed count (by 44.7% and 34.7%) and weed biomass (by 41.67% and 54.23%) at BUK and Gaya, respectively, compared to the weedy check. The plots treated with 0.5% w/v AVE followed by hoe weeding at 6 weeks after sowing (WAS) showed the higher profitability at both locations (in BUK with each naira invested in weed management using 0.5% w/v AVE followed by hoe weeding at 6 WAS, there would be a return of ₦1.02 while for Gaya for each naira invested in using 0.5% w/v AVE followed by hoe weeding at 6 WAS there would be a return of ₦2.09). The findings suggested that AVE extract offers a promising and cost-effective alternative to manual hoe weeding in sorghum production. The integrated use of AVE with other weed control practices, may alleviate the labor burden on farmers, improve crop yields, and enhance economic efficiency and profitability in the Sudan savanna..
Key words: Bioherbicides, profitability, sorghum, weed control.

INTRODUCTION

With the growing need for sustainable and economically viable weed management strategies tailored for sorghum cultivation in arid and semi-arid regions, recent research has focused on addressing these challenges (Raza, 2022). Traditional weed control methods, such as manual hoe weeding, have proven to be labor-intensive and inadequate in effectively managing the diverse and resilient weed populations prevalent in these agroecological zones. Manual hoe weedings are common due to the high costs of herbicides and a lack of awareness about their use. Despite its prevalence, manual weeding is labor-intensive and often insufficient for comprehensive weed management (Naim *et al*., 2012). Studies indicate that while farmers continue to rely on manual weeding due to cost constraints, this method is inadequate for controlling diverse weed species, which can significantly reduce sorghum yields by up to 75% (Naim *et al*., 2012).

While manual methods remain culturally entrenched, research highlights the increasing resilience of weed populations, necessitating a shift towards more integrated approaches that combine manual and chemical methods for effective management. Integrated weed management practices, including the use of herbicides, have proven more effective in reducing weed biomass and enhancing crop productivity (Alhassan *et al*., 2015; Ajala *et al*., 2019). This has prompted the exploration of alternative, environmentally sustainable, and economically feasible strategies for weed control in the Sudan savanna.

Despite ongoing research into various weed management strategies, the potential of natural plant extracts, particularly Aloe vera, as an alternative to synthetic herbicides in sorghum weed control remains largely unexplored. Aloe vera (*Aloe vera* [L] Burn. f), a plant known for its diverse biological activities, may offer allelopathic properties that inhibit seed germination and plant growth through the release of phytochemicals (Agarwal and Haryana, 2011). However, comprehensive research into its application in sorghum production remains lacking, underscoring the need for a scientific assessment of Aloe vera extract (AVE) as a sustainable weed control option. This study will assess the efficacy of AVE in mitigating weed pressure, enhancing crop yields and widening the profit margin.

MATERIALS AND METHODS

Experimental site: The research was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Bayero University, Kano (11^{o} 58’56.82”N 008^{o} 26’05.10”E) and the Kano State University of Science and Technology Wudil located at Gaya (11^{o} 51’38.30”N 9^{o} 00’9.72”) both situated within the Sudan savannah ecology of Nigeria.

Treatments and Experimental Design:

The treatments consisted of Weedy check, *Aloe vera* at 0.75% (w/v) alone, *Aloe vera* extract at 1% (w/v) alone, *Aloe vera* at 0.5% (w/v) pre-emergence (PE) followed by (*fb*) 0.5% (w/v) *Aloe vera* post- emergence (POE), *Aloe vera* at 0.75% (w/v) PE *fb Aloe vera* at 0.75% (w/v) P0E, *Aloe vera* at 1% (w/v) PE *fb Aloe vera* at 1% (w/v) POE, *Aloe vera* at 0.5% (w/v) PE *fb* supplementary hoe weeding (SHW) at 6 weeks after sowing (WAS), *Aloe vera* at 0.75% (w/v) PE *fb* SHW at 6 WAS, *Aloe vera* at 1% (w/v) PE *fb* SHW at 6 WAS, *Aloe vera* at 0.5% (w/v) PE *fb* halosulfuron at 0.25 kg ha^{-1} (POE), pendimethalin at 3.0 kg active ingredient (a.i) ha^{-1} PE *fb* halosulfuron at 0.25 kg a.i ha^{-1} POE, hoe weeding at 3 and 6 WAS which were replicated three times using a randomized complete block design (RCBD).

***Aleo vera* Extract Preparation**:

A. vera leaves were harvested from the Faculty of Pharmaceutical Sciences, Bayero University, Kano. The waxy outer surface was peeled and the gel was placed in a round-bottom laboratory balloon. 50g of the gel was mixed with 500 ml of 96% methanol using a shaking water bath for 24h at room temperature. The extract was separated from the gel concentrate by filtering through the Whatman No. 1 filter paper. The remaining assay was re-extracted twice and the extracts were pooled. The solvent was removed under vacuum at 40°C using an oven. In order to detect the allelopathic effect of the *A. vera* leaf extracts, dilutions were made of the original extract to 50% w/v, 75% w/v and 100% w/v of the stock extract.

Data Collection: Data were collected on the following parameters:

Weed count: The number of weeds was determined from each net plot by randomly throwing a square meter quadrant and the number of weeds within it was recorded at the physiological maturity.

Weed control efficiency (WCE)*:* This was done using the formula described by Mani *et al.* (1976):

$$WCE = \frac{total\ dry\ weight\ in\ weedy\ check - total\ dry\ weight\ in\ treatment}{total\ dry\ weight\ in\ weedy\ check} \times 100 \ldots\ldots\ldots\ldots Equation\ 1$$

Grain Yield (kg ha^{-1})*:* Grain yield was determined by manually threshing, winnowing and measuring the weight of the sorghum grains obtained from the panicles harvested from the net plots using a sensitive weighting balance. The gross profit for each treatment combination was calculated by subtracting the total cost of cultivation from the return. The benefit-cost ratio for each treatment combination was calculated by dividing gross profit by total cost of cultivation.

RESULTS AND DISCUSSION

Weed Count: Weed management strategies significantly altered the weed population during the 2023 rainy season (Fig. 1). Results indicated that the weedy check consistently had the highest weed count compared with all other weed control treatments tested at both locations. Pendimethalin at the rate of 3.0 kg a.i ha^{-1} PE *fb* halosulfuron at the rate of 0.25 kg a.i ha^{-1} POE significantly recorded the lowest weed count at the BUK location while at the Gaya location hoe weeding at 3 and 6 WAS significantly recorded the lowest weed count compared to all other treatments.

Weed Control Efficiency: Fig. 2 shows the weed control efficiency (WCE) of different weed control treatments used in the experiment for the two locations. The application of pendimethalin *fb* halosulfuron achieved the highest WCE in both locations whereas the lowest WCE was observed with the control. The WCE at PE application of *A. vera* at 0.5% w/v to 1% w/v *fb* SHW at 6 WAS are statistically similar in both locations.

Yield: Sorghum grain yield was significantly influenced by weed control treatments at both locations (Fig. 3). The results indicated that pendimethalin *fb* halosulfuron consistently recorded higher grain yields than weedy check in both locations. The grain yield obtained from pendimethelin PE *fb* halosulfuron POE was statistically higher than that obtained from hoe weeding at 3 and 6 WAS in both locations. The grain yield obtained from hoe weeding at 3 and 6 WAS were statistically similar with that obtained from *A. vera* 0.5% w/v P.E *fb* halosulfuron at 0.25% a.i ha^{-1} at Gaya.

Analysis of Economic Benefits of Weed Control Treatments: Table 1 shows the economic feasibility of the opted weed control strategies during the study. At both locations, the control plots had the lowest BCR. *A. vera* 0.5% (w/v) *fb* SHW at 6 WAS had the highest BCR in both locations. Plots treated with pendimethalin *fb* halosulfurone had the highest revenue and profit in both locations. However, plots treated with 1% w/v AVE *fb* SHW at 6 WAS recorded the highest Total Variable Cost (TVC) at both locations. Consistently, the weedy check plots had the lowest total variable costs, profits, revenue and BCR at both locations.

The results obtained from this study provided valuable insights into the potentials of AVE to effectively control weed and provide economic sustainability to sorghum farmers at BUK and Gaya during the 2023 rainy season. Combining these weed control methods has not been trialled before in this region, and this approach is an innovative one to test new management options for farmers. The weedy check plots consistently exhibited the highest weed count at both locations, indicating significant weed pressure that reduced sorghum grain yields. This was also observed by the Weed Science Society of America's Weed Loss Committee which collected quantitative data from 10 individual experiments per calendar year over 10 years between 2007 and 2016, based on their summarized information, farmers from Arkansas, Kansas, Missouri, Nebraska, South Dakota and Texas would potentially lose an average of 37%, 38%, 30%, 56%, 61%, and 60% of their grain sorghum yield with no weed control. From our research, the application of pendimethalin PE *fb* halosulfuron POE demonstrated the most efficient weed control method across both locations. PE herbicides restrict the germination of weed seeds lying within 2-3 cm of the soil surface as they inhibit cell division during germination while POE effectively control sedges and all rhizome-propagated plants (Hossain *et al.,* 2020 and Mitra *et al.*, 2022). AVE applications at various concentrations showed promising results for weed control, and significantly reduced weed count compared to weedy checks at both locations. All sequential AVE combination treatments resulted in better weed control than was achieved under the sole application of AVE. This is the result of weed control over a longer period of time leading to lower weed counts in each of the sequential treatment combinations than in the sole applications. The inhibitory effect of AVE may be related to the presence of bioactive compounds, such as mucopolysaccharides, flavonoids, and anthraquinones, which exhibit antimicrobial properties that may enhance its allelopathic potential by suppressing the growth of competing flora (Kantam *et al*., 2016; Neelanchal *et al*., 2017). Furthermore, Aloe vera's leaves contain a gel rich in compounds like glucomannan, amino acids, lipids, sterols, and vitamins. The plant's latex also contains anthraquinones and polysaccharides, further contributing to its biological activities (Seong, 2023). Although the allelopathic effects of Aloe vera are not extensively documented, its phytochemical profile suggests a significant potential to influence plant growth dynamics in agroecosystems. These findings indicate the potential for AVE as an environmentally sustainable weed management tool, although its efficacy was noted to be lower than that of the chemical herbicide treatment, this could be due to a longer persistence of the chemical herbicides than the AVE under the conditions of the experimental sites as the AVE are known to have a brief environmental half-life and therefore undergo biotic (by microbes or by plant enzymes) and abiotic degradation (by sunlight or chemical degradation) faster than the chemical herbicides (Grayson *et al*., 2017), this is a key factor to reduced environmental pollution. Variations in treatment effectiveness between the two locations were observed, with the AVE exhibiting some location dependency. This highlights the need for further research to understand the factors influencing these variations such as agro-ecological influences that include soil composition, soil moisture and weed species dominance. Hoe weeding was found to be less efficient than standard herbicide application in controlling weeds. The limited effectiveness of hoe weeding could be attributed to the quick re-establishment of sedges due to the in-efficiency of the technique to completely destroy the corms.

A crucial factor in weed management is not just effectiveness but also cost-effectiveness, allowing farmers to maximize profits. The findings demonstrate a clear correlation between weed control and profitability. At both BUK and Gaya locations, the unweeded control plots had the lowest BCR, indicating lower profitability compared to TVC. This aligns with research by Udosor and Odigboh (2016) who reported significant yield losses and reduced economic returns in maize fields due to uncontrolled weeds. Implementing effective weed control measures translates to reduce weed competition, improved sorghum yields, and consequently, higher potential profits. The study highlights specific weed control strategies that emerged as economically favorable. At both locations, 0.5% w/v *A. vera* extract applied pre-emergence *fb* SHW at 6 WAS resulted in the highest BCR, indicating the highest relative profitability. This could be attributed to the lower cost associated with *Aloe vera* application with corresponding increase in yields compared to other treatments. These findings suggested that integrating hoe weeding with *A. vera* extracts might offer a cost-effective approach for weed suppression in sorghum fields. While the study identified promising results with *A. vera* and hoe weeding combinations, it's important to acknowledge the economic viability of standard herbicides observed in this experiment. Pendimethalin *fb* halosulfuron achieved high profitability (low BCR) at both locations. Herbicides can be a time-saving and efficient solution for weed control, particularly for large-scale farms. However, the long-term economic sustainability of relying solely on herbicides needs to be considered. Factors such as potential weed resistance development and the cost of herbicides themselves should be factored into the decision-making process.

CONCLUSION

This study investigated the effects of weed management strategies on weed population, weed control efficiency, sorghum grain yield, and economic benefits during the 2023 rainy season. The findings highlight the significant impact of weed control on sorghum production at both locations. Pendimethalin at the rate of 3.0 kg a.i ha^{-1} PE *fb* halosulfuron at the rate of 0.25 kg a.i ha^{-1} POE consistently outperformed other treatments in reducing weed populations and increasing grain yields. AVE treatments also showed promise, especially when combined with hoe weeding. While chemical herbicides generally yielded higher profits, AVE treatments offered a more cost-effective option, particularly when combined with hoe weeding. **The study demonstrated the potential of integrating Aloe vera in weed management approaches, combining chemical and biological methods, to enhance sorghum productivity and profitability in the region.** Future research should explore the long-term sustainability of AVE, including its impact on the environment and the potential for weed resistance development.

REFERENCES

Raza, Ullah., Zubair, Aslam., Houneida, Attia., Khawar, Sultan., Khalid, Alamer., Muhammad, Zeeshan, Mansha., Ashwaq, T., Althobaiti., Najla, Amin, T., Al, Kashgry., Badreyah, Algethami., Qamar, U., Zaman. (2022). Sorghum allelopathy: Alternative weed management strategy and its Impact on Mung Bean Productivity and Soil Rhizosphere Properties. *Reproductive and Developmental Biology*, doi: 10.3390/life12091359

Ahmed, M., El, Naim., Salheldeen, E., Ahmed., Abdelrhim, A., Jabereldar., Moayad, B., Zaied., Khlid, A., Ibrahim. (2012). Effect of weeds on calyx yield of *Hibiscus sabdariffa* L in traditional agricultural sector of Sudan. *Planta*, doi: 10.5923/J.PLANT.20120202.01

Ajala, A. A., Muhammad., A., Yakubu, A. I., H., Sanda, Y. (2019). Growth response of selected rice (*Oryza sativa* L.) varieties to integrated weed management in sudan Savanna of Nigeria. *Journal of Agriculture and Ecology Research International*, doi: 10.9734/JAERI/2019/V20I330106

Alhassan, J., Dadari, S. A., Babaji, B. A., Shebayan, J. A. Y. (2015). Weed control efficiency of management practices of lowland paddy production in Sudan Savanna ecology. *Journal of Biology, Agriculture and Healthcare*.

Shilpi, Agarwal., Karnal, Haryana. (2011).. Multiple biological activities of *Aloe barbadensis* (Aloe vera): An Overview.

Jyothsna, Chowdary, Kantam., Kavita, Rai., N, Nandan. (2016).. Aloe Vera – Nature's power. *Journal of Ayurveda and Integrated Medical Sciences*, doi: 10.21760/JAIMS.V1I2.3664

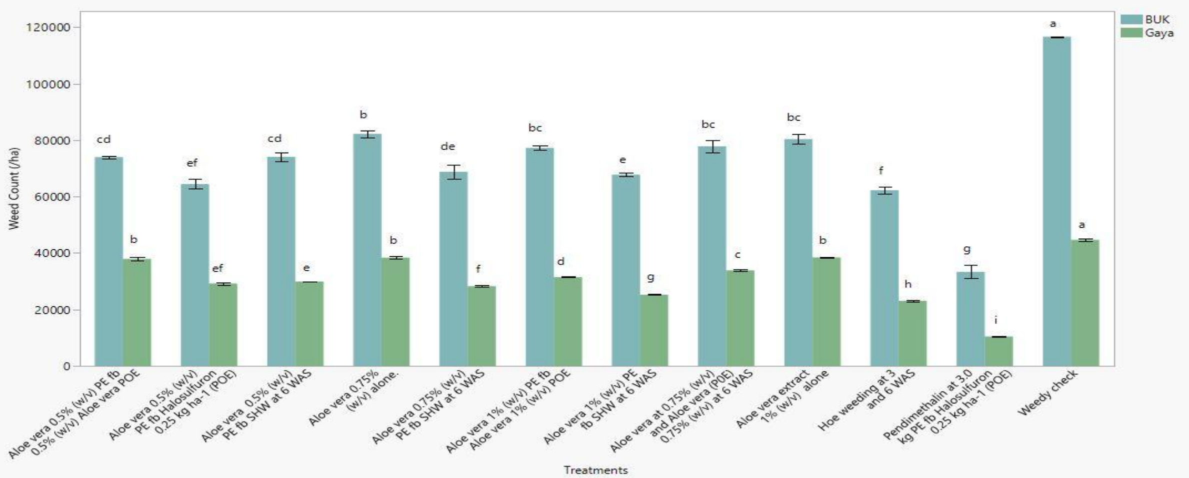
Trivedi, Neelanchal., Bhuvnesh, Kumar, Singh., Abhishek, Bharadwaj. (2017). Aloe Vera: An emerging herb.

Gupta, A., Swati, K., Rawat. (2017). 2. Clinical importance of aloe vera: Review. doi: 10.5958/2321-5844.2017.00004.8

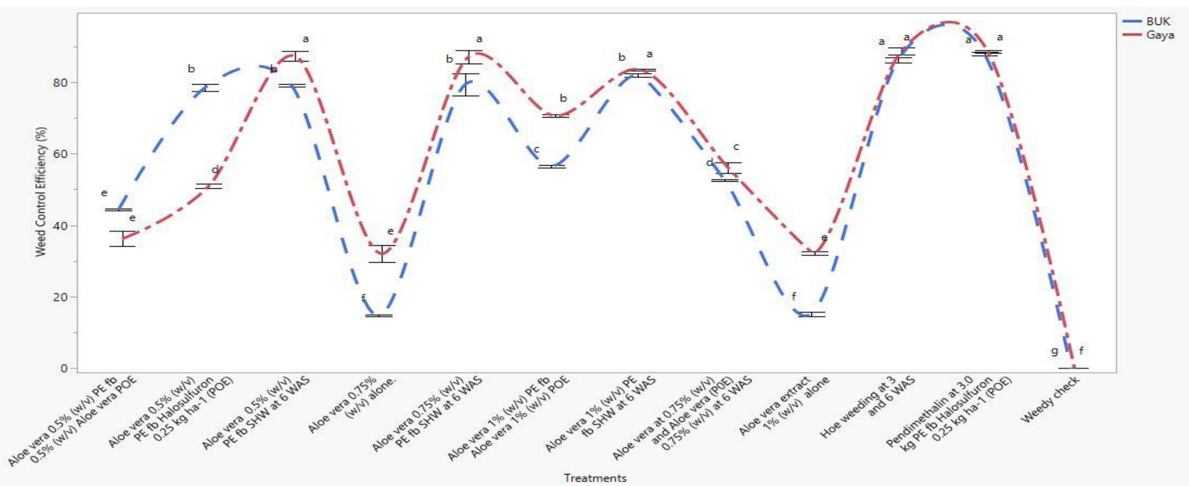
Seong, Seop, Han., In, Jung, Kim., Seong, Hun, Lee. (2023). Current research status and prospect of Aloe vera. 아열대농업생명과학연구지(2013), doi: 10.51711/jaab.2023.39.2.1

Gayatree, Mishra., Ashok, K., Mohapatra., Sweta, Rath. (2024). Precision weed management techniques for smart agriculture. doi: 10.58532/v3bcag10p2ch5

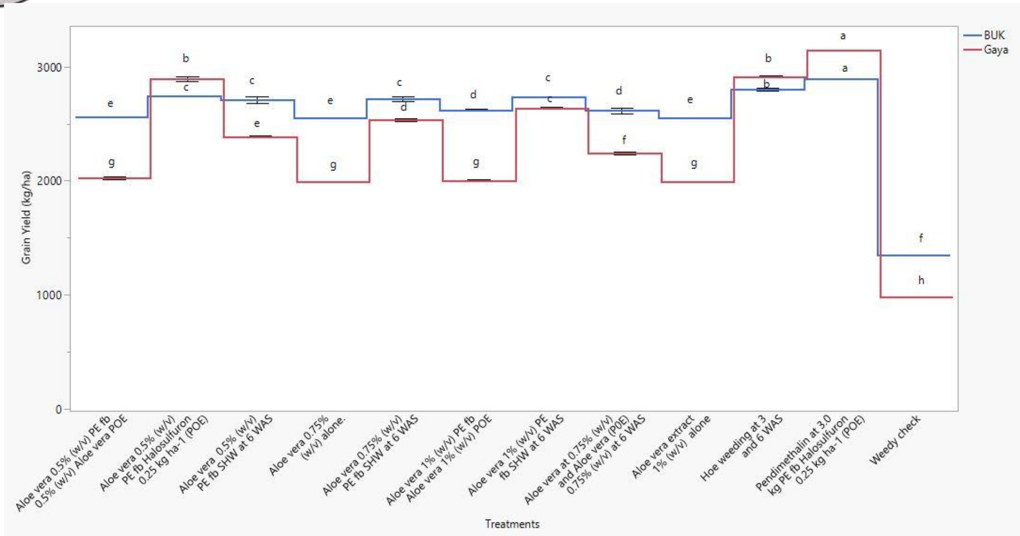
Mani, V.S.,Pandita, M.L, Gautam, K.C., & Bagwandas, B. (1973). Weed Killing Chemicals in potato cultivation. *Indian Farming*, 23, 7-13.



Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK.
Fog. 1: Effect of Weed Control Treatments on Weed Count (/ha) on a Sorghum Farm at BUK and Gaya during 2023 rainy season



Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK.
Fig. 2: Weed Control Efficiency of Weed Control Treatments on Sorghum Farms in BUK and Gaya During the 2023 Rainy Season



Means followed by the same letter(s) are not significantly different at 5% level of probability using SNK.
Fig. 3: Effects of Weed Control Treatments on Sorghum Grain Yields in BUK and Gaya During the 2023 Rainy Season

Table 1: Economic Analysis of Different Weed Control Treatments for Sorghum Production at BUK and Gaya during 2023 rainy season.
TVC= Total Variable Cost BCR: Benefit:Cost Ratio

Treatments	BUK			Gaya		
	Profit (₦ha^{-1})	Revenue (₦ha^{-1})	BCR	Profit (₦ha^{-1})	Revenue (₦ha^{-1})	BCR
Weedy check	1,020,119.8	1,901,064.3	0.26	406,304.1	1,374,025.9	0.38
Aloe vera 0.75% (w/v) alone.	1,022,593.9	1,915,508.7	0.86	573,685.6	1,492,663.3	1.60
Aloe vera extract 1% (w/v) alone	1,025,001.3	1,917,220.0	0.86	594,241.1	1,497,293.0	1.55
Aloe vera 0.5% (w/v) PE *fb* 0.5% (w/v) *Aloe vera* POE	1,043,330.9	1,927,360.6	0.86	614,793.0	1,507,848.5	1.67
Aloe vera at 0.75% (w/v) *fb Aloe vera* (P0E) 0.75% (w/v) at 6 WAS	1,057,960.6	1,960,693.9	0.86	620,811.5	1,532,385.6	1.58
Aloe vera 1% (w/v) PE *fb Aloe vera* 1% (w/v) POE	1,102,682.8	1,982,916.1	0.86	712,478.1	1,537,385.6	1.66
Aloe vera 0.5% (w/v) PE *fb* SHW at 6 WAS	1,128,056.9	2,031,527.2	1.02	840,630.0	1,706,737.4	2.09
Aloe vera 0.75% (w/v) PE *fb* SHW at 6 WAS	1,287,042.0	2,038,471.7	0.93	1,183,787.8	1,728,496.7	1.94
Aloe vera 1% (w/v) PE *fb* SHW at 6 WAS	1,322,412.4	2,039,397.6	0.93	1,286,707.4	1,812,015.2	1.96
Aloe vera 0.5% (w/v) PE *fb* Halosulfuron 0.25 kg ha^{-1} (POE)	1,363,793.9	2,066,712.4	0.79	940,718.9	1,840,811.5	1.63
Pendimethalin at 3.0 kg PE *fb* Halosulfuron 0.25 kg ha^{-1} (POE)	1,577,130.9	2,170,738.5	0.67	1,516,076.7	2,366,922.6	1.26
Hoe weeding at 3 and 6 WAS	1,540,953.1	2,103,749.4	0.34	1,337,369.3	2,018,496.7	0.58

ECONOMIC ANALYSIS OF SOYBEAN [*Glycine max* (L.) MERRILL] PRODUCTION USING PHOSPHORUS FERTILIZER AND INOCULANT IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT
The use of phosphorus fertilizer and inoculant in the production of soybean has been reported to increase yield. Economic appraisal was performed to study the profitability of producing soybean with phosphorus and inoculant. Field trials were conducted during 2021 rainy season at the Teaching and Research Farm of Aliko Dangote University of Science and Technology Wudil in Gaya and Teaching and Research Farm of Faculty of Agriculture Bayero University Kano in Sudan Savannah of Nigeria. The experiment was laid down in split plot design. The treatments consisted of four levels of phosphorus (0, 20, 30 and 40 kg ha-1), two rhizobium inoculation (inoculated and un-inoculated) and two varieties (TGX1447-2E and TGX1885-10E). Yield per hectare was used to assess the profitability using the current prices of commodities. The result of this study showed that the use of phosphorus and inoculant is beneficial in the production of soybean in the study areas.

Keywords: Benefit to cost ratio, soybean, phosphorus fertilizer, inoculant

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a grain legume crop in Sub-Saharan Africa with great potentials. It is a rich source of protein (~40%) and oil (20%) for human food as well as animal feed (Ibanda *et al.,* 2018). Soybean is one of the major sources of protein and oil (Wilcox *et al*., 2001). Nearly 400 different uses of soybean have been reported and it is the chief oil seed in the world at present, Soybean is used mainly for edible oil extraction (Large-scale solvent extraction) and meal production for livestock feed, (Javeheri and Bahdoin, 2011). In food industry, soybean is used for making flour, oil, cookies, candy, milk, vegetable cheese and many other products (Coskan *et al*., 2011).

In another development, soybean production faces so many challenges which includes among others abiotic and socio-economic factors accounting for production discrepancies across regions in sub-Saharan Africa (SSA). Inherent poor and declining soil fertility, soil acidity, poor management practices and low agricultural inputs use are the major causes of low soybean yields (Kanyanjua *et al*., 2002; Kimani *et al*., 2004; Okalebo *et al*., 2006; Njeru, 2009).

Soybeans obtain nitrogen requirements by either soil mineral nitrogen or symbiotic nitrogen fixation. One of the main causes in the decline of soybean production is unbalanced fertilization of nutrients (N, P and K). Such variables must be corrected as they are an integral part of the interaction of legume genotype, rhizobia strain, environment, and crop management which determine the performance of BNF, and legume productivity in general (Woomer *et al*., 2014; Keino *et al*., 2015; Thuita *et al*., 2018). Commercial production of soybean is concentrated in the Savanna ecology of Nigeria, particularly the southern Guinea Savanna (Akande *et al*., 2007; Ojo *et al*., 2010), where low levels of phosphorus militate against its optimal yield.

Previous studies on the evaluation of soybean in its traditional area of production in Nigeria (Southern Guinea Savanna ecology) have either excluded the application of phosphorus fertilizer (Akande *et al*., 2007) or used low levels of it (Aduloji *et al*., 2009; Ojo *et al*., 2013) in their experiments. Soybean can fix N from the atmosphere ranging from 0 – 450 kg N ha^{-1} (Giller, 2001; Unkovich and Pate, 2000). Under favorable environments for N fixation, over 60% to 70% of the N requirement of the soybean can be derived from BNF (Herridge *et al*., 2008), while the balance could be derived from the soil N stock. Conversely, Mapfumo (2011) reported that BNF could be as low as 5 kg N ha^{-1} in depleted soils, which are quite common in the smallholder farming systems in sub-Saharan Africa, which implied the reliance on nitrogen fertilizers even for legume crops. Utilization of soybean varieties with high biological nitrogen fixation potential and application of rhizobia inoculants would represent a cost-benefit option to reduce mineral N application (Bekere and Hailemariam, 2012; Thuita *et al*., 2012; Ronner *et al*., 2016). Therefore this study was carried out to analyze the effect of phosphorus on the performance of soybeans.

METHODOLOGY

Study sites

The experiment was conducted during 2021 cropping season at the University Teaching and Research Farm of Aliko Dangote University of Science and Technology Wudil in Gaya Latitude: 11.9331° N, Longitude: 8.5216° E and Bayero University Teaching and Research Farm, Kano at Latitude: 12.0027° N, Longitude: 8.5914° E with an elevation of 415m above sea level. Both locations are in Sudan savanna agro-ecological zone of Nigeria.

Treatments and experimental design

The treatment consisted of four levels of phosphorus (0 kg ha^{-1}, 20 kg ha^{-1}, 30 kg ha^{-1} and 40 kg ha^{-1}), two soybean varieties (TGX1447-2E and TGX1885-10E) and two levels of Rhizobium (un-inoculated and inoculated). The experiment was laid out in a split plot design with three replications. Phosphorus was allocated to the main plot while varieties and rhizobium were assigned to the sub plots respectively.

Seed rates

About 50–70 kg (20–28 standard mudus) are required to obtain a population of 444,444 plants/ha for most varieties. Since soybean seed sizes vary among varieties, it is essential to consider planting in terms of the quantity of seeds required/unit area (Omoigui et al., 2020)

Economic analysis

A profit appraisal was carried out to measure the effect of the project on individuals or participants based on the benefits derived. The economic analysis using the benefit to cost ratio was employed using the input cost and the financial gain in monetary value from the production system. The economic analysis of a project is a good tool in estimating the profit accruing to the project entity or to the project participants, because both feasibility and profitability of a crop are determined by their ultimate financial returns (Hayat *et al*., 2004).

Benefit Cost Ratio (BCR) was calculated as:

$$BCR = \frac{\text{Net income}}{\text{Total cost}}$$ (adapted from Sirajul Islam *et al*., 2012)

where:

Net income = gross income - cost of production.

The cost of production = cost of inputs

To estimate production cost and revenue in the production of soybean using phosphorous fertilizer and inoculant, the following assumptions were made based on the prevailing market prices. All data were subjected to analysis of benefit to cost ratio using Microsoft excel.

RESULTS AND DISCUSSION

Benefit to cost ratio of soybean production using different levels of phosphorus fertilizer and inoculant at Gaya.

Results for the benefit to cost ratio of soybean production at Aliko Dangote University Teaching and Research are presented in table 3. The highest benefit was obtained by the application of 30 kg P with inoculant on variety TGX 1448-2 E (N 3817720) followed by the application of 20 kg P without inoculant on same variety (N 2170420) and application of 20 kg P without inoculant on variety TGX 1885-10E. The least benefit was obtained by the application of 20 kg P with inoculant on variety TGX 1885-10E (N 525876). The highest BCR was obtained by the application of 30 kg P with inoculant on variety TGX 1448-2E (10.33) followed by the application of 20 kg P without inoculant on variety TGX 1448-2E (6.31), while the least BCR was obtained by the application of 20 kg P without inoculant on variety TGX 1885-10E (1.45).

Benefit to cost ratio of soybean production using different levels phosphorus fertilizer and inoculant at BUK Kano.

Results for the benefit to cost ratio of soybean production at BUK are presented in table 2. Highest benefit was obtained by the application of 20 kg P with inoculant on variety TGX 1448-2E (N 2879112) followed by the application of 40 kg P with inoculant on same variety (N 2298748) and application of 30 kg P with inoculant on variety TGX 1885-10E. The least benefit was obtained by the application of 40 kg P without inoculant on variety TGX 1885-10E (N 639178). The highest BCR was obtained by the application of 20 kg P with inoculant on variety TGX 1448-2E (7.96) followed by the application of 40 kg P with inoculant on variety TGX 1448-2E (6.09), while the least BCR was obtained by the application of 40 kg P without inoculant on variety TGX 1885-10E (1.77).

Benefits

Generally, the application of P with inoculant produced more profit in the study areas. This means application of phosphorus and inoculant improves the production of soybean in the study areas. Many researchers have reported improvement in production with addition of chemical fertilizers and inoculant (Hayat *et al*., 2004; Choudhary et al., 2007; Muhammad *et al*., 2018).

Benefit to cost ratio

Economics of production in the 2021 rainy season legume production was generally very high even without inoculant. However, profitability of such investments under normal conditions could be improved with the use of inoculant for both varieties in the two locations (Muhammad *et al*., 2018).

CONCLUSION

The study shows that soybean production with phosphorus fertilizer is a lucrative business in the study areas. The profitability of soybean cultivation also suggests that its production could add to aggregate food production and foreign exchange earnings. However, return to investment could be improved with the addition of inoculants.

REFERENCES

Aduloji, S. T., Osho, K., & Adejumo, O. (2009). Effect of phosphorus fertilizer on the growth and yield of soybean in a rainforest area of Nigeria. *African Crop Science Journal*, 17(2), 97-103.

Akande, M. O., Makinde, E. A., Oluwatoyinbo, F. I., & Adepoju, A. S. (2007). Effect of phosphorus fertilizer on soybean (Glycine max) yield and nutrient use efficiency in Nigeria. *African Journal of Biotechnology*, 6(3), 1200-1206.

Bekere, W., & Hailemariam, A. (2012). Influence of inoculation methods and phosphorus levels on growth and yield of soybean. *International Journal of Agriculture*, 2(1), 59-66.

Choudhary, A. K., Thakur, R.C., and Kumar, N. (2007) Effects of organic manures and chemical fertilizers on productivity and profitability in wheat – rice cropping sequence. *Oryza* Vol. 44. No.3, 2007 (239-242)

Coskan, A., Dogan, K., & Kapucu, S. (2011). Effects of inoculation with Rhizobium on yield and nutrient uptake in soybean cultivars. *Turkish Journal of Agriculture and Forestry*, 35(3), 113-122.

Giller, K. E. (2001). Nitrogen fixation in tropical cropping systems. CABI Publishing, Wallingford, UK.

Hayat, R., Safdar, A. and Faisal, S. K. (2004). Effect of nitrogen and *rhizobium* inoculation on yield, N- uptake and economics of mungbean. *International Journal of Agriculture and Biology*, (3), pp.547–551.

Herridge, D. F., Peoples, M. B., & Boddey, R. M. (2008). Global inputs of biological nitrogen fixation in agricultural systems. *Plant and Soil*, 311(1-2), 1-18.

Ibanda, A., Kyamanywa, S., Mukasa, S. B., & Adipala, E. (2018). Growth and yield of soybean as affected by Bradyrhizobium japonicum inoculation and phosphorus application. *African Crop Science Journal*, 26(3), 405-420.

Javeheri, A., & Bahdoin, P. (2011). Industrial applications of soybean products. *Journal of Agricultural and Food Chemistry*, 59(12), 6661-6666.

Kanyanjua, S. M., Ireri, L., Wambua, S., & NanDry weighta, S. M. (2002). Acid soils in Kenya: Constraints and remedial options. KARI Technical Note, 11, 24-32.

Keino, L., Vanlauwe, B., Sanginga, N., & Chianu, J. (2015). Phosphorus response of soybean in a tropical soil of western Kenya. *African Journal of Biotechnology*, 14(21), 1817-1823.

Kimani, S. K., Obura, P. A., & Mutsotso, B. (2004). Effect of liming and manure on maize and soybean yields in acidic soils of Mucwa, Embu District, Kenya. East African Agricultural and Forestry Journal, 70(1), 1-8.

Mapfumo, P. (2011). Soil fertility management strategies and practices by smallholder farmers in semi-arid areas of Zimbabwe. Soil Fertility Consortium for Southern Africa (SOFECSA).

Muhammad, A. Sarkodie-Addo, J and Ewusi-Mensah, N. (2018). Cost Benefit Analysis of Grain Legume Production and Maize Yield under Legume Haulms and NPK Fertilizer in Semi-Deciduous Forest Zone of Ghana. Wudil Journal of Science and Technology. Volume 1, Issue 1. Pp. 39-47

Njeru, J. M. (2009). Crop production in smallholder farms in sub-Saharan Africa. *World Development*, 37(6), 1072-1085.

Ojo, A. A., Ogunlela, V. B., & Lawal, B. A. (2013). Phosphorus use efficiency and yield of soybean in Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 9(1), 56-62.

Ojo, D. K., Falusi, A. O., & Bello, L. L. (2010). Comparative study of yield and yield components of soybean varieties in Nigeria. *Journal of Agricultural Science and Environment*, 10(1), 70-74.

Okalebo, J. R., Gathua, K. W., & Woomer, P. L. (2006). Laboratory methods of soil and plant analysis: A working manual. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.

Ronner, E., Franke, A. C., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., & Giller, K. E. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. *Field Crops Research*, 186, 133-145.

Sirajul Islam, M. D., Ahmad, A., Mahmud, S., Tusher, T. R. and Khanom, S. (2012). Effects of organic fertilizer on the growth and yield of lettuce (*Lactuca sativa* L .) used as vegetable. *International Journal of Agricultural Science*, *2*(3), 116–128

Thuita, M., Pypers, P., Herrmann, L., Okalebo, R., & Lesueur, D. (2018). Farm management practices and their impact on soil fertility in smallholder farms in Kenya. *Agronomy Journal*, 110(4), 1375-1386.

Thuita, M., Pypers, P., Herrmann, L., Okalebo, R., & Lesueur, D. (2012). Farm management practices and their impact on soil fertility in smallholder farms in Kenya. *Agronomy Journal*, 110(4), 1375-1386.

Unkovich, M. J., & Pate, J. S. (2000). An appraisal of recent field measurements of symbiotic N2 fixation by annual legumes. *Field Crops Research*, 65(2), 211-228.

Woomer, P. L., Singleton, P. W., & Bohlool, B. B. (2014). Ecological indicators of N2-fixation. *Field Crops Research*, 26(1), 27-35.

Table 1. Estimated input and output (N) based on prevailing market prices of the study area

Input and output	Equivalent monetary
Single Super Phosphate fertilizer (36%P_2O_5)	N 40000/50 kg
Cost of inoculant (NoduMax inoculant) (100 g/10 kg of seeds)	N 2500/100 g
Cost of inoculant per hectare	N 17500/ha
Cost of land preparation	N 180000/ha
Cost of general labour	N 120000/ha
Cost of soybean seeds (70 kg/ha)(400/kg)	N 28000/ha
Cost of soybean (Market price)	N 20000/ 100 kg

Table 2. Benefit to cost ratio of soybean production with phosphorus and inoculant in 2021 rainy season at Aliko Dangote University, Teaching and Research in Gaya.

P levels	Variety	Inoculum	Net benefit (N)	Benefit to cost ratio
0	TGX 1448-2E	Non-inoculated	716836	2.19
0	TGX 1448-2E	Inoculated	1696022	4.91
0	TGX 1885-10E	Non-inoculated	1026744	3.13
0	TGX 1885-10E	Inoculated	1045366	3.03
20	TGX 1448-2E	Non-inoculated	2170420	13.17
20	TGX 1448-2E	Inoculated	1334598	3.69
20	TGX 1885-10E	Non-inoculated	2038560	13.37
20	TGX 1885-10E	Inoculated	525876	1.45
30	TGX 1448-2E	Non-inoculated	542744	1.54
30	TGX 1448-2E	Inoculated	3817720	10.33
30	TGX 1885-10E	Non-inoculated	1120164	3.18
30	TGX 1885-10E	Inoculated	1045800	2.83
40	TGX 1448-2E	Non-inoculated	810360	2.25
40	TGX 1448-2E	Inoculated	1872742	4.96
40	TGX 1885-10E	Non-inoculated	830822	2.31
40	TGX 1885-10E	Inoculated	1681456	4.45

Table 3. Benefit to cost ratio of soybean production with phosphorus and inoculant in 2021 rainy season at BUK Kano.

P levels	Variety	Inoculum	Net benefit (N)	Benefit to cost ratio
0	TGX 1448-2E	Non-inoculated	729712	2.22
0	TGX 1448-2E	Inoculated	1378000	3.99
0	TGX 1885-10E	Non-inoculated	889918	2.71
0	TGX 1885-10E	Inoculated	1522022	4.41
20	TGX 1448-2E	Non-inoculated	1071148	3.11
20	TGX 1448-2E	Inoculated	2879112	7.96
20	TGX 1885-10E	Non-inoculated	1722438	5.01
20	TGX 1885-10E	Inoculated	881688	2.44
30	TGX 1448-2E	Non-inoculated	1587214	4.51
30	TGX 1448-2E	Inoculated	727888	1.97
30	TGX 1885-10E	Non-inoculated	943162	2.68
30	TGX 1885-10E	Inoculated	1844186	4.99
40	TGX 1448-2E	Non-inoculated	1691852	4.70
40	TGX 1448-2E	Inoculated	2298748	6.09
40	TGX 1885-10E	Non-inoculated	639178	1.78
40	TGX 1885-10E	Inoculated	900792	2.39

DATE PALM (*Phoenix dactylifera* L.) VALUE CHAIN STUDY IN JIGAWA STATE

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ABSTRACT

Date palm (*Phoenix dactylifera* L.) is a high energy value crop, with a good nutritional value. It is a long-lived monocotyledon cultivated for food, fuel, shelter and fibre. It was introduced to Nigeria by pilgrims who travel to Mecca and Medina many years ago. It is one of the major sources of income to farmers. Date fruits mature in the dry season when other sources of income are few. This increases year-round employment and market value, reducing the need for young men to leave their homes in search of dry season work. Besides its economic importance the crop has numerous advantages to the people living in the arid and semi- arid regions such as; it helps control desertification, it provides high calorific value with a long storage life, date palm does not only produce dates but also increases other crop development by creating a favorable micro –climate for their growth and consequently improves their productivity.

INTRODUCTION

Date palm (*Phoenix dactylifera*) is a soft edible fruit. Date fruits are popular among the people of northern Nigeria. The plant is dioecious in nature and a slow growing tree. It is originated from the Middle East and North Africa (Wrigley, 1995; Sanderson, 2001). According to McCurrah, (1960), date palm belongs to the family Palmaceae (Arecaceae) which contains several other cultivated palms such as coconut palm (*Cocos nucifera L.*) and oil palm (*Elaeis guineesis* Jacq).

Date palm also has religious importance. In Christianity, the palm leaves are used for celebration of Easter Sunday. In Islam, dates are mentioned several times in the Quran. They are used usually to break the long fasting days in the month of Ramadan. According to Zaid and de Wet, the availability of high amount of sugar makes the fruit one of the most nutritious foods available to the people in arid and semiarid areas of the world. Moreover, the fruits contain 15–30% water depending on the variety and maturity stage (L. M. Butler *et al*, 2007).

Date palm not only provided concentrated energy food, which could easily transport and carried out a long journey across many areas, it also creates a good habitat for the people to live in by providing a suitable environment and protection from harsh conditions of arid and semi-arid areas.

The date palm belt in Nigeria lies within the marginal area for date palm production (from 12^0 - 9^0N) considering the effect of rainfall and humidity on date ripening and preservation. Within that belt, the rainy season (June-October) is preceded by 2-3 months of humid season. During the rains, date palm produces fruits which are harvested at khalal and Rutab ripening stages. These fruits are usually consumed fresh and because they do not attract good price in the market, serious losses are incurred because the fruits easily deteriorate due to fungal and microbial attack (*Al shaickley et al 1996*). The fruit is used in confectioneries, syrup and baker's yeast production. The leaves are used for making bags, baskets, calf muzzles and hats, while the trunks are used as buoyancy blocks for boats, windows, door frame and ladders.

DISTRIBUTION

In Nigeria the date palm thrives extensively in the Sudan, Sahel, and guinea savannah regions of the country principally between latitude 10^o-14^oN and longitude 4^o-12^oE which falls within the marginal area of world production of latitude 15^o-35^oN Osuhor (1991) and Omamor (2000a). The date palm growing belt in Nigeria includes Kano, Jigawa, Bauchi, Yobe, Borno, Katsina, Sokoto, Zamfara, Gombe, Kebbi, Adamawa, Taraba, Plateau and Kaduna States covering an estimated area of over 30,000 sq.km of arid and semi-arid land with climatic condition suitable for date palm cultivation. Climatic conditions have a positive effect on relative growth rate and fruiting on many date palm varieties (Al- Banna, 2019). Date palm requires long hot dry spells for successful flowering, pollination and fruit development (Umoti and Okolo, 2000). It grows well at temperatures of higher than 30^oC but will also tolerate a fall temperature to 0^oC provided the soil is free draining. The date palm grows on moist soils being tolerant to both saline ad alkaline conditions (Al-Mansoori *et al*; 2007).

RESEARCH AND DEVELOPMENT

Date palm research in Nigeria is at infancy stage, due to the fact the crop was neglected upon all the numerous benefits that we derived from it. Special research grant should be allocated to the crop due to it is importance which includes; industrial, environmental, religious, economic, ornamental and medicinal values. Little research was carried out on the crop since it is introduction many years ago.

PRODUCTION

In 1941, the British colonial authorities in Nigeria established a 10 ha, observational plot of Date Palm in Fika Yobe State. This was abandoned a few years later with the result that only a few stands of palm can be presently seen at the site. Despite over the 400 years of its introduction into Nigeria, cultivation of Date Palm has remained restricted to homesteads, small and medium holder farms where it is intercropped with arable crops like cowpea, millet, sorghum and groundnut. Due to subsistence cultivation, the total area put into Date Palm was about 1446.8ha (FAO, 2022). Nigeria is thus not recognized as a date producing country in the international market. Thus, production in Nigeria falls short of demand especially during Ramadan period and date fruits are imported from date producing countries like Algeria, Niger and Morocco. Because of the economic importance of the products of Date Palm to the people of date growing region of Nigeria in particular and the country in general, the Nigerian Institute for Oil Palm Research (NIFOR) initiated research on the Date Palm in 1981. The effort began with the establishment of Date Palm germplasm in Nigeria. A sub-station of NIFOR was established at Dutse, Jigawa State in 1980.

DATE PRODUCTION BY VARIETY

In Nigeria there are several date palm varieties depending upon the areas with good market value, fruit size, yield and good storability more than the international varieties. But very unfortunate Nigeria was not recognized as a date palm producing country upon several years of introduction of the crop**.** The good and selected varieties in Nigeria do not have names as like international varieties like Medjool, Deglet noor etc. Even, though we have varieties with good features like fruit size, sweetness, taste etc, but being our country was not recognized as date palm producing country in the world the varieties too were not considered.

VARIETAL TYPES

Varietal types are classified as:

1.Sugar cane varieties they contain mainly sucrose, these includes Deglet noor, Sukhari and Thoory.

2.Invert Sugar varieties containing mainly invert sugar which are glucose and fructose, these includes barhi, Saidy, Khadrawy, Halawy and Sayer.

3.Medicinal; Ajwah.

HARVESTING, POST-HARVEST AND HANDLING

In some local farms attempt are being made to harvest the fruits by shaking the trunk of the palm in order to avoid having to climb it, it is important to reach the top of the palm to harvest the fruit. Harvesting is normally done manually with a sharp knife by carefully cutting the base of the bunch stalk and tight with a rope for careful collection in a clean container. Where available mechanical harvesting can be done crane with a clean container are also used instead of climbing this applies only in large plantations. Harvesting is carried out in the month of February to May for dry season fruits, while the wet season fruits harvesting is carried out around June and July. Harvesting must be done faultless and should be clean, since this will affect the rest of process such as packaging and marketing.

STORAGE

Date palm fruits were one of the few fruits among all other fruits that have good storability without being damage by storage pests. Date can be stored up to a decade without being damage by pests. Before storing the fruit, the store should be clean, well ventilated and fumigated to avoid storage pests and diseases. The fruit good storability is the dry season fruit due to its low moisture content; the wet season fruit has high moisture content so it cannot be stored for a long period of time. After harvesting the bunches should be hang as they were harvested from the mother tree. The loose fruits can be consumed immediately.

FACTORS TO CONSIDER IN STORAGE

1. During storage the fruits shall be free from bruises.
2. Free from pests and diseases
3. The fruits most be botanically matured
4. Only fruits with calyx should be stored to prevent entry of pests
5. Do not store wet season fruits due to their high moisture content
6. Do not store unpollinated fruits

PROCESSING

Date fruits can be processed into several ways depending upon the varieties and regions.

The fruits can be processed into several ways which are as follows:

- ✓ Animal feed
- ✓ Panel board

- ✓ Pharmaceutical use
- ✓ Bakery products
- ✓ Organic acids
- ✓ Confectionery

MARKETING AND SALES

Nigeria been the most populated country in Africa, and one of the few nations that have wet and dry fruits that is rainy and dry season fruits, can produce just 20% of all the date fruit consumed despite the good climatic factor, the two fruiting seasons with enough rainfall the country have. All the balance is coming from North Africa countries. Date fruit consumption during fasting is very high, that is why whenever fasting is approaching the price skyrocketed. We also use date fruit in Muslim festivals like naming ceremony, marriage ceremony at the extent that, date is competing with Kolanut. The fruits and other date palm products were sold locally in our markets and most of the fruits are consumed locally without any values addition. But the import fruits were packaged neatly and hygienically and were sold at exorbitant prices.

VALUE ADDED PRODUCTS FROM DATE PALM

1. Liquid sugars
2. Sweeteners
3. Jam
4. Syrup
5. Date palm juice
6. Date palm coffee

CONSTRAINTS TO DATE PALM PRODUCTION

The major constraints to date palm production in Nigeria are itemized as follows:

Date palm is a dioecious species and consequently, half of the progeny will be males and half will be females, with no certain way to determine at an early stage the sex of the progeny, nor fruit or pollen quality prior to flowering, which could after seven years of establishment or more.

1. Female plants originating from seedlings usually produce late-maturing fruits of variable and generally inferior quality compared to established clonal palms. In a seedling plantation, it is rare that more than 10% of the palms produce fruit of the palms produce date fruit of satisfactory quality.

2. Date palms are heterozygous, and thus there will be many variations within the progeny, and desirable characteristics of the parent palm may be lost. In other words, it is not true to type propagation and no two seedlings are alike.
3. Seedlings differ considerably with regard to production potential, fruiting quality, and harvesting time, making them very difficult to market as one harvest.
4. The above reasons result in a waste of time, space, and money.
5. Pest and diseases, such as Oryctes, termites, birds, and animals cause considerable damage to the fruits and the trees in general. Graphiola and Bayoud diseases are the important diseases that lead to the death of the tree.
6. Lack of perennial water source.
7. Lack of good fencing materials.

CONCLUSION

Date palm cultivation in Nigeria has long history. The production was carried out mostly by peasant farmers, the agronomic practices of date palm production which includes irrigation methods, traditional sex identification methods, plant spacing, varieties used, were all inherited from generation to generation. The varieties used were local and they give low yield. Moreover. nearly all the fruits harvested were consumed locally without value addition.

RECOMMENDATIONS

Based on the outcome of this study, the following recommendations were made:

1. Private companies and individuals should encourage in the establishment of date palm plantation to diversify the economy of our country, and to create job opportunity to the masses.
2. Government should bring high quality, high yielding and early maturing varieties so as to in order to increase yield and have a bumper harvest.
3. More research should be carried out so that diecious problem in date palm can hinder the production of the crop.
4. Continuous training, and extension services, research, and developmental interventions in the cultivation and management of date palm trees as well as handling of date fruits by the responsible stakeholders are recommended to improve the incomes and livelihoods of the farmers.

REFERENCES

Al – Banna, M.F (2019). The effect of climatic condition and geographical distribution on the success of Date Palm varieties (*phoenix dactylifera L.*) in the Gaza Strip. Proceedings. 3rd International Conference on Date Palm. Acta Hort. 736. Pp 59-63.

B. Glasner, A. Botes, A. Zaid, and A. Emmens. (2002). “Date harvesting packinghouse management and marketing aspects,” in Date palm cultivation, FAO Plant Production and Protection Paper 156.

D. V. Johnson, J. M. Al-Khayri, and S. M. Jain. (2015). Date Production Status and Prospects in Africa and the Americas, J. M. Al-Khayri, S. M. Jain, and D. V. Johnson, Eds., Springer, Dordrecht, Netherlands.

D. Zohary, M. Hopf, and E. Weiss (2012). “Domestication of Plants in the Old World: The origin and spread of domesticated plants in Southwest Asia, Europe, and the Mediterranean Basin,” Domestication of Plants in the Old World: The Origin and Spread of Domesticated Plants in Southwest Asia, Europe, and the Mediterranean Basin, pp. 1–264.

FAO, (2022). Date palm Cultivation. FAO Plant Production and Protection. Paper 156. Rome,2002.

G. Bekele, F. Demeke, and Z. Ali. (2019). “Livelihood-based drought response in Afar: Impact assessment of livestock feeding program implemented in Amibara, Teru and Abala Districts.

H. Hussen. (2010). “Potential of date palm plantation in afar region, Ethiopia and its market,” Acta Horticulturae, vol. 882, pp.

L. M. Butler and R. E. Mazur. (2007). “Principles and processes for enhancing sustainable rural livelihoods: Collaborative learning in Uganda,” International Journal of Sustainable Development & World Ecology, vol. 14, no. 6, pp. 604–617.

M. Demeli, (2013). Date palm research in Wererar Agricultural Research Center (WARC), Ethiopian Institute of Agricultural Research, Addis Ababa: Ethiopia.

McCurrah, J. C. (1960). Palms of the world. Harper and Brothers, New York.

Omoti, U. and E. C. Okolo. (2000). Date palm Research in Nigeria, progress and priorities. In: Proceedings of Date palm international symposium, Windhoek, Namibia, February,2000. PP. 237.

Osuhor, E.O (1983). Estimates of genetic parameters of fruit traits among some Date palms (*Phoenix dactylifera L.)* types grown in Nigeria and their implication in selection. M.Sc. thesis, ABU, Zaria. Pp. 1-35.

Sanderson, G. (2001). Natural history of date palm. Phoenix *dactylifera L.*, http:/enhy.4t.

V. H. W. Dowson. (1982). "Date production and protection with special reference to North Africa and the Near East," in FAO Plant Production and Protection Paper 35. Retrieved from, URL http, //trove.nla.gov.au/version/

Wrigley, G. (1995*)*. Date palm. In: Smart, J., Simmnods, N.W. (eds) Evolution of crop plants, second edition, Longman Group, Essex, England.PP.399-403.

Zaid and P. F. de Wet (2002). "Date palm cultivation (chapter VIII)," in FAO Plant Production and Protection Paper 156.

Figure 1: First Date palm plantation in Nigeria established at Fika 1941.

Table 1. Statistics of Date Palm Production in Nigeria, 2021.

S/n	States	Yield (tonnes)	Hectares	Number of Palms
1	Adamawa	785.4	77	15616
2	Bauchi	3182.4	312	63711
3	Benue	N.A.	N.A.	N.A.
4	Borno	26101.8	2559	522,233
5	Fct Abuja	316.2	31	6217
6	Gombe	372.3	36.5	7455
7	Jigawa	4896	480	97853
8	Kaduna	2825.4	277	56586
9	Kano	714	70	14214
10	Katsina	375	35	7190
11	Kebbi	1009.8	99	20100
12	Kogi	40.8	4	801
13	Kwara	673.2	66	13550
14	Nasarawa	71.4	7	1350
15	Niger	285.6	28	5630
16	Plateau	81.6	8	1580
17	Sokoto	306	30	6130
18	Taraba	1224	120	24450

19	Yobe	173.4	17	3530
20	Zamfara	2407.2	236	48150
	Total	**45,823.5**	**2,189.4**	**916,344**

Source: Magaji, 2021.

Table 2. Characteristics of different varieties of date palm.

S/n	Variety	Colour	Shape	Texture	Origin	Characteristics
1	Ajwah	Black	Oval	Semi-dry	Saudi Arabia	The most important date palm variety, highly sacred, with high economic value.
2	Medjool	Amber	Long	Semi-soft	Morocco	Has a high fruit quality (large size and attractive). It outshines other varieties. With regard to fruit quality and size. It is of high commercial value and it is considered best for export.
3	Barhee	Yellow	Round	Soft	Iraq	Barhee (barhi) (from Arabic *barh*, a hot wind)— it is nearly cylindrical, light amber to dark brown when ripe; soft, with thick flesh and rich flavour. One of the few varieties which are good in the *khalal* stage when they are yellow (like a fresh grape as opposed to dry, like a raisin).
4	Deglet noor	Dark brown	Oblong	Dry	Algeria	Arabic, "translucent" or "date of light"); so, named because the center appears light or golden when held up to the sun. It is semi-dry and very sweet. Is one of the most popular varieties.
5	Sukhri	Brown	Oval	Soft	Saudi Arabia	This is one of the sweetest varieties of date palm, with good taste and market value, it is suitable for making syrup and jam**.**
6	Dan Mali	Dark brown	Long	Soft	Mali	This date is long, big and cylindrical, dry golden brown and is not sugary, with high economic returns due to its size. One of the best varieties in terms of commercial value.

7	Sub station	Brown	Oblong	Soft	Nigeria	The fruit is soft, with thin skin and thick flesh; of superior quality was grown abundantly in the station.
8	Tirgal	Light brown	Medium	Dry	Tunisia	This is an exotic variety semi white, high yielding with good market value.

Source; Field Survey 2020

Table 3. Major Date palm Markets

S/n	Markets	Retailers	Local govt.	Production & Marketing
1	Babaldu	53	Gwaram	Production area
2	Shuwarin	50	Kiyawa	Production area
3	Maigatari	28	Maigatari	Marketing
4	Gumel	30	Gumel	Marketing
5	Hadejia	30	Hadejia	Marketing
6	Kazaure	20	Kazaure	Marketing
7	Sara	10	Gwaram	Production area
	Total	261	-	

Source; Field Survey, 2023

IMPROVED HANDLING PRACTICES FOR REDUCTION OF POSTHARVEST LOSSES

EFFECT OF SOLAR ENERGY ON COLORED POLYPROPYLENE SHEETS IN TRAPPING SOLAR HEAT AND MAINTAINING QUALITY OF MAIZE SEED INFESTED WITH *Sitophilous zemais*

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ABSTRACT

The maize weevil (*Sitophilus zeamais* Motsch; Coleoptera; Curculionidae) is one the most important storage pests of maize in Africa. The objective of the study was to evaluate the effect of solar energy on colored polypropylene sheets in maintaining maize seed quality infested with *Sitophilus zemais***.** Polypropylene sheets (black, blue, orange and transparent) containing 100g of maize seeds with control (open seeds) were exposed to solar energy for 2, 4, 6 and 8 hours with each treatment replicated three times. Temperature inside the sheets was measured and recorded in the field, 30mins and 24hours after exposure for each treatment and replicates. Consequently, further experiment was conducted to investigate the effects of solar heat trapped by the polypropylene sheets against the quality of maize seed. Data were collected on germination percentage, shoot and root length. Data collected was subjected to analysis of variance using python 3.9 Computer Software. Results of the study show significant difference in the temperature trapped by the varying-colored polypropylene sheets at different exposure periods. Black polypropylene sheets recorded the highest amount of temperature trapped (59 °C) among the colors evaluated. Moreover, seed germination was not affected by exposure of maize seed to solar heat. Furthermore, little seed damage and weight losses was observed in maize seed stored for three (3) months after exposure to solar heat for 2,4,6 and 8hours. Based on the findings of this study exposing maize seeds in black polypropylene sheet for 2hours can be used to manage maize weevil *(S. zemais)*.and has no detrimental effect on maize seed quality.

Keywords: Absorption, Retention, Maize seed, Germination

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals crops in the world both as food for man and feed for animals FOA, (2020). *Sitophilus zeamais* is one of the destructive pests of maize account for 5-10% of damage to maize grain Arex, (2004). Under severe infestation, maize weevil can cause up to 90% loss of stored grain. In Nigeria, the management of storage pests of maize has mainly included use of chemical insecticides such as malathion 2%, pirimiphos methyl + permethrin dust and deltamethrin among others. However, the pesticides are grossly misused by the largely farmers, mainly through application of wrong dosages resulting from poor interpretation of recommended application rates. Pesticides are also adulterated by unscrupulous traders which have resulted in insecticide resistance by several species of storage insects in Nigeria and elsewhere (Hamacher *et al.,* 2002; Pereira *et al.,* (2008). However, there is a widespread worry regarding environmental risks, chemical residues on food, the emergence of pesticide resistance, and related expenses Chiam *et al.,* (2019). Currently, other management techniques /tactics such as bio pesticides, and green energy as grain protectors are receiving attention. Heating grains in polymers as solar heat collectors tend to rise the temperature of the seeds to a lethal level enough to eliminate the weevils (Gbaye, 2011). Therefore, this study was revealed to evaluate the solar heat trapping and retention ability of polypropylene sheets for managing maize and maintaining maize seed quality.

MATERIALS AND METHODS

The experiment was conducted in the vicinity of the Department of Crop Protection and Entomology laboratory of the Faculty of Agriculture, Bayero University Kano on sunny clear sky days during the month of October, 2023.

The treatments consist of colored (Black, blue, orange and transparent) polypropylene sheet and four (4) exposure periods (2, 4, 6, and 8 hours), with checks (unexposed seeds) were laid out in a completely randomized design with each treatment being replicated three (3) times (Peter and Sule, 2019).

Evaluation of solar heat trapping and retention ability of different colored polypropylene sheets exposed to solar heat

One hundred (100) gram of maize seeds was placed in different colored polypropylene bags. The bag containing the seeds were laid out on a platform (carton) as an insulating material to reduce heat loss to the ground, and exposed to solar energy for 2, 4, 6, and 8 hours between 9.00 AM to 5.00 PM. A little opening was created to enable taking of temperature reading during the exposure periods. Temperature of the environment and inside the bags containing the maize seeds was measured using thermometer and recorded at the field for trapping, 30mins and 24hrs after the exposure for retention for each treatment and replicates using a thermometer (Intech Micro 2100-A16).

Germination test

Ten (10) seeds from the different Polypropylene bag (exposed and unexposed) were randomly selected and placed on a moistened Whatman filter paper in 9 cm Petri dishes and left on laboratory benches at room temperature and relative humidity for seven days (ISTA, 1996). First germination count was performed 3 days after planting and then at 7th day after planting (i.e day 3 and 7). Germination was evaluated as percentage of seeds that produced normal seedlings (ISTA, 2006). Germination percentage of the maize seeds was calculated from germination data according to Awoke *et al.,* (2014) as follows:

Germination percentage (G %)

$$G\% = \frac{\text{Number of emerged seedlings at the final count}}{\text{Total number of seeds planted}} \times \frac{100}{1}$$

Shoot and Root Length

Shoot and root lengths of the germinated seed was measured using meter rule Silva *et al.,* (2019)

RESULTS

Solar heat trapping and retention ability of different polypropylene sheets exposed to solar heat.

Table 1 presents the results of solar heat trapped by different colored polypropylene sheets and their ability to retain the heat at 30 minutes and 24 hours after exposure. Significant differences ($P \leq 0.05$) were observed in the temperature trapped by different colored polypropylene sheets and different exposure time. High temperature was recorded in black sheet and was significantly different from the temperature recorded in the remaining color sheets. However, the least temperature was recorded in the control (un-exposed) and was significantly different from the other treatments.

Furthermore, two-hour exposure time absorbed significant higher temperature compared to the remaining exposure time but was not statistically different from the temperature absorbed in four hour exposure time. Least temperature was absorbed in eight hours exposure time, which was different statistically from the temperature absorbed in the other exposure time (Table 1). When temperature retention is been considered, at 30 minutes after exposure high temperature was retained in black color polypropylene sheet compared to the remaining sheets, although was not different from temperature retained in orange color polypropylene sheet. Next to black colored polypropylene sheet was blue color polypropylene sheet. Low temperature was retained in control treatment compared to the other colored polypropylene sheets.

Moreover, high temperature was retained at four hours exposure time and was not significantly different from temperature retained at six hours exposure time. Least temperature was retained in two hours exposure time which is statistically different from the temperature retained in the remaining exposure time.

At 24 hours after exposure, black color polypropylene sheets recorded the high temperature retained but is not significantly different from temperature retained in blue and orange color polypropylene sheets. Least temperature was obtained from transparent polypropylene sheets which are statistically similar with the temperature retained in the control. Moreover, high temperature retained was recorded from two hours exposure time, next to it is six hours exposure time which is not statistically different from four hours exposure time, the least temperature retained is obtain from eight hours exposure time which is significantly different from the temperatures retained from other treatments (Table 1).

The effect of different colored polypropylene sheets and different exposure time on maize seed germination at 3 and 7days is shown in table 2. At 3 days after planting black colored polypropylene sheet recorded significantly higher number of maize seeds germination, which was not different statistically from the number of maize seed germination recorded in blue colored polypropylene sheet and control treatment. The least number of maize seeds germination was recorded in orange polypropylene sheet, which was difference statistically compared to the remaining colored polypropylene sheet and control. Furthermore, at 3 days after planting high number of maize seed germination was recorded at six hour exposure time but was not different statistically from the number of maize seed germination recorded in the other exposure time.

Similarly, when 7 days after planting is been considered, significantly higher number of maize seed germination was recorded in black polypropylene sheet which was not different statistically from the number of maize seed germination recorded in the control treatment and the least number of maize seed germination was recorded in orange polypropylene sheet was not different statistically from the number of maize seed germination recorded in transparent polypropylene sheet. Moreover, at 7 days after planting the result reveals that, significantly higher number of maize seed germination was recorded in eight hours exposure time compared to the remaining exposure times.

The effect of different colored polypropylene sheets and different exposure time on maize seed germination percentage is shown in Table 3. Significantly higher maize seed germination percentage was recorded in black colored polypropylene sheet compared to the remaining treatments. Next to it is the control treatment which was not statistically different blue colored polypropylene sheet. The least maize seed germination percentage was recorded in the orange polypropylene sheet but is not statistically different from transparent polypropylene sheet. Also, the result reveals that, significantly higher maize seed germination percentage was recorded in eight hours exposure time compared to the remaining exposure time.

Effect of different colored polypropylene sheets and different exposure time on shoot and root length of maize seed at 7 days after planting is presented in Table 5. Significantly longer maize shoot length was recorded in the control (unexposed seeds) treatment and is not statistically different from maize shoot length recorded in black and blue polypropylene sheets. While the shortest maize shoot length was recorded in orange and transparent polypropylene sheets which are statistically same with maize shoot length recorded in blue and black polypropylene sheets. Furthermore, the results reveal that, 8 hour exposure produce longest maize shoot but was not different statistically ($P \leq 0.05$) from the maize shoot length produce by the remaining exposure periods.

Similarly, significantly longer maize root length was recorded in the control (unexposed seeds) treatment compared to the remaining treatments. Next to control, is maize root length recorded in black polypropylene sheet which is statistically the same with maize root length recorded blue polypropylene sheets. Nevertheless, the shortest maize root length was recorded in orange polypropylene sheet which is statistically the same with maize root length recorded in transparent polypropylene sheets. When exposure time is been considered, significantly longer maize root length was recorded in eight hours exposure time but is statistically the same with maize root length recorded in four- and six-hour exposure time. The shortest maize root length was recorded in two hours exposure time compared to the remaining exposure times.

DISCUSSION

Evaluation of solar heat absorption and retention ability of different colored polypropylene sheets exposed to solar heat

The Earth receives energy radiated from the sun, which amounts to about 1,000 (Ren, 2011). Energy is radiant light and heat from the Sun that is harnessed using a range of technologies such as solar power to generate electricity, solar thermal energy (including solar water heating), and solar architecture solar energy perspective.

The results of this study revealed that black colored polypropylene sheets had the highest temperature absorbed and retained compared to the remaining colors evaluated for their ability to absorb and retain solar heat. This corresponds with the results obtained by Kang *et al.,* (2020) who reported that black or dark colored materials and objects radiate (give off) and absorb heat This study is also in line with the findings of Peter and Sule (2019), which reported that black colored polypropylene sheets, absorbs more energy than other colors. Moreover, these findings further support the idea of Murmson (2017), who highlighted that every material absorb and reflect some solar energy. The amount of solar energy a material absorbs or reflects depends on a number of physical properties. The color and coating of a material for instance affect the amount of solar energy that an object can absorb or reflect. Black materials absorb a large amount of visible light. Therefore, darker materials will absorb more solar energy than lighter materials.

Evaluation of solar heat absorbed by different colored polypropylene sheets on quality of maize seed

The results of this study shows that despite being exposed to solar energy on different colored polypropylene sheets and different exposure time the maize seeds are viable, all seeds germinate with a good germination rate. All the seeds evaluated for germination germinated 7days after planting. Similar observations were made by Kaaya (2010), who stated that, exposing maize seeds to solar radiation did not significantly reduce germination potential. Also Agona (2018) reported that, grain dried using the natural solar convection dryer technology is also good for seed production. The results of this study also corresponds to the findings of Fong, (2015) which itemized that Seed germination in outside bean and maize seeds (exposed to solar energy) was not significantly affected in comparison to the control, with a decrease of around 5.6%. The inside bean and maize seeds showed no effect from the radiation. This indicates exposure to radiation does not significantly affect the germination success of bean and maize seeds. The results also support the findings of Bamazan, (2016) which showed that irradiated seeds had increased seed germination percentage, seedling and root lengths, seedling fresh weight, seedling dry matter content and total chlorophyll content in the leaves of seedlings. The short and root lengths are in good rate

CONCLUSION

It was observed that there was rapid increase in the temperature trapped and retained by different polypropylene color sheets exposed to solar heat at different time intervals as exposure time progresses. However black polypropylene sheets recorded the highest temperature trapped among the colors evaluated for their ability to trap and retain solar heat. The high temperatures achieved (59°C) were suitable for heat treatment of stored-product insects which significantly suppressed the population of *S.zemais.* Our results concluded that effect of solar energy has no significant effect on germination of the seeds, and shoot and root length. Therefore, it was recommended that this technique if adopted will have great potential for the management of *S.zemais* in the Nigerian Savanna regions without affecting the viability of the seeds considering its low cost, safety to the environment, grain handlers and consumers and maintenance of grain cleanliness.

REFERENCE

Agona, J.A. and Nahdy, S.M. (2018) Effect of Solar Drying Period of Beans and maize on Seed Viability, Cooking Time and Injuriousness of Acanthoscelides obtectus Say. *African Crop Science Journal,* 6, 417-421.https://doi.org/10.4314/acsj.v6i4.27793

AREX. 2004. An overview of Zimbabwe's agriculture, *Ministry of Lands and Agriculture*. Government Printers, Harare.

Awoke, Y., Assets, G., Melaku, G., Derbies, M., Kerri, S. and Raja, N. (2014). Evaluation of c ertain Plant Leaf Powders and Aqueous Extracts against Maize Weevil, Sitiphilus zeamais Kitsch. (Coleoptera: Curculionidae*). Asian Journal of Agricultural Science,* 6(3): 83-88.

Bamazan (2016)Ahi Evran University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Bağbaşı, Kırşehir, Turkey10, 967-974.

Chiam WanYee; Huang Yan; Chen ShaoXing; Ho ShuitHung, 2019. Toxic and antifeedant effects of allyl disulfide on Tribolium castaneum (Coleoptera: Tenebrionidae) and Sitophilus zeamais (Coleoptera: Curculionidae*). Journal of Economic Entomology*, 92(1):239-245; 31 ref

Fong, B. N.; Newhouse, K. V.; Huss, M. J.; Roberts, E.; Kennon, J. T.; and Ali, H. (2015) "Investigating the Effect of Stratospheric Radiation on Seed Germination and Growth," *Journal of the Arkansas Academy of Science*: Vol. 69, Article 9. DOI: 10.54119/jaas.2015.6903

Food and Agriculture Organizations FOA (2020). Statistics FAOSTAT. *http://www.fao.org/faostat*

Gbaye, O.A., J.C. Millard and G.J. Holloway, 2011. Legume type and temperature effects on the toxicity of insecticide to the genus Callosobruchus (Coleoptera: Bruchidae). *Journal of Stored Products. Research*., 47: 8-12.

Hamacher, L.S., Faroni, L.R.D.A., Guedes, R.N.C. and Queiroz, M.E.L.R.2002. Persistence and activity towards S. zeamais (Coleoptera: Curculionidae) of pirimiphos-methyl sprayed at different temperatures on maize. *Journal of Stored Products Research* 38(2):167- 175

ISTA (1996). *Handbook of Vigour Test Methods* (2nd Edn). International Seed Testing Association, Zurich, Switzerland, Pp 28-37.

ISTA (2006). International Rules for Seed Testing. International Seed Testing Association, Zurich, 33pp.

Kaaya, A.N. and Kyamuhangire, W. (2010) Drying Maize in Using Biomass-Heated Natural Convection Dryer to Improve Grain Quality during Storage. *Journal of Applied Sciences*,

Kang. Y, J. Lyu and P. Wang, The influence of different heating rates on mortality of Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae), Sitophilus zemais (fab) Grain & Oil Science and Technology (2020), https://doi.org/10.1016/j.gaost.2020.03.001

Murmsom, S., 2017. Materials that absorb and reflect solar energy. pp: 2. https://sciencing.com/materials-absorb-reflect-solar-energy-8878.html.

Pereira, C.J., Pereira, E.J.G., Cordeiro, E.M.G., Della Lucia, T.M.C., Guedes, R.N.C. and Totola, M.R. 2008. Organophosphate resistance in the maize weevil Sitophilus zeamais: Magnitude and behaviour. *Crop protection* 28(2):168-173.

Peter Emmanuel and Sule Hassan, 2019. Potentials of polypropylene sheets in trapping solar heat for the management of Callosobruchus maculatus (fab.) Infestation**.** *Journal of Applied Science,* 19: 349-354.

REN.,2011. Global status report by renewable energy policy network for 21st century (REN21). pp: 4-9. http://www.ren21.net/.

Silva, L.J.; de Medeiros, A.D.; Oliveira, A.M.S. Seed Calc, a new automated R software tool for germination and seedling length data processing. *Journal of seed science* 2019, 41, 250–257.

Table1: Effect of different colored polypropylene bags and exposure times on solar heat trapping and retention at 30 minute and 24 hours after exposed

		Temp retained after exposure	
Color	Temp absorbed	30 minutes	24 hours
Black	48.92[a]	35.83[a]	26.08[a]
Blue	46.92[b]	35.17[b]	25.67[a]
Orange	46.25[b]	35.75[a]	26.17[a]
Transparent	46.08[b]	33.67[c]	23.75[b]
Control	25.0[c]	25.0[d]	24.25[b]
Exposure time			
2hours	47.13[a]	31.27[c]	26.13[a]
4hours	47.07[a]	33.40[ab]	25.03[b]
6hours	38.93[b]	34.00[a]	25.07[b]
8hours	37.40[c]	33.40[b]	24.27[c]
SE±	0.48		

Temp; Temperature, SE; standard error, Means followed by same letter(s) within same column are not significantly different a P≤ 0.05 according to LSD test

Table 2: Effect of different colored polypropylene sheets and different exposure time on maize seed germination at 3 and 7days after planting

	Germination	
Treatment	**3days after planting**	**7days after planting**
Color (C)		
Black	5.41[a]	5.75[a]
Blue	4.91[ab]	5.25[b]
Orange	3.58[c]	4.41[c]
Transparent	4.58[b]	4.75[c]
Control	4.83[ab]	5.41[ab]
LSD (P≤0.05)	0.63	0.47
Exposure time (T)		
2hours	4.46[a]	5.00[b]
4hours	4.73[a]	5.00[b]
6hours	4.86[a]	5.00[b]
8hours	4.60[a]	5.41[a]
LSD (P≤0.05)	0.56	0.42
Interaction (C × T)	Ns	Ns

Means in each column bearing the same letter(s) are not significantly different at 5% level of probability (P≤ 0.05) by LSD test, Ns= Non significant

Table 3: Interaction effect of different colored polypropylene bags and different exposure time on percentage maize seed germination

Treatment	**Germination %**
Color (C)	
Black	95.75[a]
Blue	87.25[bc]
Orange	73.25[d]

Transparent	80.15^{cd}
Control	90.08^{ab}
LSD (P≤0.05)	7.44
Exposure time (T)	
2hours	83.00^{b}
4hours	83.00^{b}
6hours	83.13^{b}
6hours	92.06^{a}
LSD (P≤0.05)	6.65
Interaction (C × T)	*

Means in each column bearing the same letter(s) are not significantly different at 5% level of probability (P≤0.05) by LSD test.

Table 4: Interaction effects of different colored polypropylene sheets and different exposure time on germination percentage of maize seeds

Treatment	**2hours**	**4hours**	**6hours**	**8hours**
Color (c)				
Black	100.00^{a}	94.33^{ab}	100.00^{a}	88.67^{abc}
Blue	71.67^{de}	83.00^{bcd}	100.00^{a}	94.33 ^{ab}
Orange	77.33^{cde}	66.00^{cde}	55.33^{f}	94.33 ^{ab}
Transparent	71.67^{de}	77.33^{cde}	77.33^{cde}	94.33 ^{ab}
Control	94.33^{ab}	94.33^{ab}	83.00^{bcd}	88.67 ^{abc}
LSD (P≤0.05)		14.88		

Means within a superscript of same letter(s) within a column are statistically similar at 5% level of significant (P≤ 0.05) using LSD test

Table 5: Effect of different colored polypropylene bags and different exposure times on maize seed shoot and root length 7 days after planting

Treatment	Shoot length	Root length
Color (C)		
Black	1.96^{ab}	4.56^{b}
Blue	2.15^{ab}	4.60^{b}
Orange	1.69^{b}	3.57^{c}
Transparent	1.69^{b}	3.85^{c}
Control	2.34^{a}	5.53^{a}
LSD (P≤0.05)	0.47	0.98
Exposure time (T)		
2hours	1.94 ^{a}	3.52^{b}
4hours	1.94^{a}	4.47^{a}
6hours	1.84^{a}	4.83^{a}
8hours	2.16^{a}	4.88^{a}
LSD (P≤0.05)	0.42	0.88
Interaction (C ×T)	*	*

Means within a superscript of same letter(s) within a column are statistically similar at 5% level of significant (P≤ 0.05) using LSD test, *=significant different

Table 6: Interaction effects of different colored polypropylene sheets and different exposure time on shoot length of maize seed 7days after sowing

Treatment	**2hours**	**4hours**	**6hours**	**8hours**
Color (C)				
Black	2.66ab	1.66cdef	1.66cdef	1.90abcdef
Blue	2.03bccdef	1.76bcdef	2.56bc	2.26bcde
Orange	1.60def	1.90abcdef	1.40ef	1.86bcdef
Transparent	1.66cdef	1.86bcdef	1.26f	1.96abcdef
Control	1.73bcdef	2.50bcd	2.30bcde	2.83a
LSD (P≤0.05)		0.95		

Means within each column followed by the same letter(s) are not significantly different using LSD test (P≤0.05)

Table 7: Interaction effects of different colored polypropylene sheets and different exposure time on root length of maize seeds 7days after sowing

Treatment	**2hours**	**4hours**	**6hours**	**8hours**
Color(C)				
Black	4.90abcde	4.60abcdef	4.70abcdef	4.06cdef
Blue	2.10fg	4.53abcde	6.36ab	5.43abcd
Orange	2.43fg	3.73def	3.46def	4.66abcde
Transparent	3.73def	3.03ef	3.80def	4.83abcde
Control	4.43bcde	6.46a	5.83abc	5.40abcd
LSD (p≤0.05)		1.97		

Means within each column followed by the same letter(s) are not significantly different using LSD test (P≤0.05)

SOCIO-ECONOMIC FACTORS INFLUENCING THE USE OF RURAL INNOVATIONS AMONG SMALL-HOLDER FARMERS IN KANO STATE, NIGERIA

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ABSTRACT
The study assessed the socio-economic factors influencing the use of rural innovations among small-holder farmers in Kano State, Nigeria. Three (3) Rural-Based Local Government Areas (LGAs) were selected from each of the three agricultural zones in the State. From each of the LGAs, two communities were randomly selected to form six communities. Data were collected using structured questionnaires from 133 respondents as sample size. Data collected were analysed using descriptive and inferential (Logit regression) statistics. Findings from this study revealed that majority of the small holder farmers were arable crop farmers, within active years, with a mean age of 45 years, married with an average household size of 9 members, had contact with extension workers and had vast knowledge in rural innovations. Two major rural innovations were identified, sourced, and shared amongst them with family, neighbors, opinion leaders and farmer groups with formal ones. The findings indicated that variables such as age, household size, farming experience and high number of innovations used. Intensively used innovations include fertilizer and organic manure applications, improved planting techniques, hedging, produce drying, tie ridging among others. Major constraints militating against the use of rural innovations include: inadequate land and resources, poor documentation and soil variability. The study recommended that rural youths should make good use of both formal and effective informal innovation practices to boost their yields.
Keywords: Socio-economic factors, rural innovations, smallholder farmers,

INTRODUCTION
In Nigeria about 70 % of the population lives in the rural areas. Their knowledge and culture that constitute their social and livelihood systems are closely attuned to the natural ecosystem (NBS, 2022). The development of rural innovation systems, covering all aspect of natural environment has been a matter of survival to the people who generated these systems (Tella, 2007). The agricultural sector has the highest poverty incidence in the country and to reduce poverty, it is critical for households to earn more from their income generating activities (Phillip *et al.*, 2009). The World Development Report (WDR, 2008) emphasized the importance of agriculture for poverty reduction and growth in Africa. Improving the agricultural sector in Nigeria is vital to

increasing food security and reducing poverty, especially in rural areas. Most farming in the country is still done at the subsistence level with minimal commercialization. An innovation refers to a new idea which solves the specific challenge(s) to achieve the goals and objectives as designed by OECD, (2005) and (2016). The view that innovation is critical to the growth and sustainability of agriculture (and other businesses), government, education and industry is present everywhere and this cut across discipline areas as diverse as Management, Education, Design and Economics (OECD, (2005 & 2016).

Nigeria has a valuably and largely untapped reservoir of indigenous knowledge in agricultural and natural resources experiences. The need on rural innovation for national development has come timely to reinforce the emphasis on structural adjustment due to economic issues which this country has been vigorously pursuing since last decade. Looking at the simple definitions of rural innovation and development process, the development planners and policy makers are beginning to recognize the need to understand the existing knowledge systems and decision-making process as they focus their attention on small scale agricultural producers (OECD, 2005 and 2016). In an attempt to raise productivity, smallholder farmers for not been engaged at planning and decision-making stages, they seemed not being encouraged to adopt different production technologies to move on to the anticipated higher levels of profitability through improved land management and sustainable practices. It is more auspicious now in the wake of a looming "global food crisis" and rural poverty that threatens to reduce state's food production by as much. The farmers were at the receiving end and now need to be incorporated in the planning, decision, technology formulation and execution processes of any program that affect them. It is due to this fact that; they are the masters (in terms of knowledge) of their environment, economy, culture and technologies better than anyone else.

Objectives of the Study

i. describe the socio-economic characteristics of the rural farmers in the study area,

ii. determine the socio- economic factors influencing food security the use of rural innovation among the smallholder farmers in the study area, and

iii. identify major constraints that limits the use of rural innovations in promoting food security in the study area.

METHODOLOGY

Description of the Study Area

Kano State has a total of 44 local government areas. It is partly situated in guinea, Sudan and to some extent Sahel savannas within latitudes 13.53^{0}N and 10.25^{0}N and longitudes 7.40^{0}E and 10.53^{0}E equivalent to a landmass of 20,680km^2 area (NPC., 2006) with a population density of over 748 people per square kilometer making the city alone as number 108th world's most populous, 14th Africa's most populous and 2nd most populous state in Nigeria (Population Stat.). According to NPC, (2006), the State had a population of 9.4million out of which, 4,947,952 males and 4,453,336 females. It has an annual growth rate of 3.2% which gives a projected figure of 15,462,200 populations in the year 2022. There are two distinct seasons; wet season (May-September) with average rainfall of 600mm- 1000mm annually and dry season (October - April). The maximum temperature ranges between 21^{0}C - 39^{o}C (KNSG, 2006). Kano State Agricultural and Rural Development Authority (KNARDA) serve as the technical and management unit responsible for Agricultural extension service of the State Government. KNARDA is divided into three Agro-ecological zones including, Zone I, Zone II and Zone III with their respective Local Governments Areas (LGAs) as follows: Zone I with 15 number of LGAs has its Headquarter at Rano LGA; Zone II has 14 has number LGAs with Headquarter at Danbatta LGA and Zone III has 16 number of LGAs with head quarter at Gaya LGA (KNARDA, 1998).

Sampling and Sampling Techniques

Multistage random sampling was employed in this work as follow:

- ✓ First stage involved random selection of one rural Local Government Area (LGA) in each of the three agricultural zones in Kano state. LGAs from each zone was segregated into urban, semi- urban and rural LGAs based on the following parameters: Land size, population, population density, major occupations/ businesses and availability of modern infrastructures. Land size is seen as a determinant of farmland availability; population. The rural Local Government Areas were segregated due to their peculiarity as contained in the segregation (table 1) with: High land mass, Low population density, Low availability of infra-structures and farming as the main occupation in the area.

The followings are randomly selected for this research purpose, they include:

- Kibiya (out of 8 rural LGAs in zone I),
- Makoda (out of 9 LGAs in zone II) and
- Ajingi (out of 8 LGAs in zone III).

✓ The second stage, considered random selection of two communities from each of the LGAs chosen.

✓ Third stage, quota sampling was employed where: 10% of the respondents were randomly selected from each of the selected villages to give a sample size of 113 rural farmers in Kano state.

Data Collection

Primary data was collected using Structured- questionnaire to elicit information from respondents on their socio-economic characteristics, identifying formal and informal innovations, roles of RIs to realization of food security in the area as well as major constraints limiting the use of rural innovations.

Tools of Analysis

Analytical tools such as simple descriptive statistics would be used to achieve objective I and III. While Logit regressions was used to achieve objective II. For this objective, socio- economic variables (age, education, household size, farm size (ha), farming experience (yrs), and extension contact (number of contacts/ year) would be used in determining the influence that rural innovations have on household food security.

Model Specifications

Logit Model on factors influencing the use of innovation practices in the study area.

$Y = X_n \beta_n + u$ --- (i)

Y = Innovation Use otherwise 0

Where;

Y= Innovation Use (Innovation Use otherwise 0)

β = Intercept.

X= Vector of Independent Variables.

u = Error term.

n = Number of observation.

Explicit model:-

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + u$ …………. (ii)

Where:

X_1 = Age (yrs)
X_2 = Educational status (yrs)
X_3 = Household size (No.)
X_4 = Farm size (Ha.)
X_5 = Farming experience (yrs)
X_6 = Extension contact
β_0 = Constant
β_1------ β_7 = Regression coefficients of X variables from X_1 - X_6.
u= Stochastic error term

RESULTS AND DISCUSSION

Socio-economic characteristics usually assist in getting clear understanding of their behaviors as well as providing hint towards explaining their disposition that could be used to improve their productivity (Ayinde, *et al.*, 2007). The analysis is important in order to highlight the socio-demographic set up in the course of earning their livelihoods. For this study, socio- economic characteristics considered: age; gender; marital status; household size; farming experience; educational status; primary occupation among others. Socio-economic characteristics of the farming households analysed by this research is presented on table 2.

The results in Table 2 above revealed that the age of the farmers ranged from 25- 67 yrs with mean age of 45 yrs; majority of them 23.9% are between 42- 49 yrs, 23% were between 50- 58 yrs, 20.4% of them were between 34- 41 yrs, those between 25- 33yrs were 18.6% and 14.2% were between 49- 67yrs respectively. The standard deviation of 10.437 (is smaller than the mean age) implying that the farmers in the study area were relatively young hence were able to learn and share new ideas, information, techniques, technologies (innovations) amongst them and have more strength to address farm labour challenges involving the utilization of innovation practices.

Farmers in the study area were all male (100%), signified that males are mostly involved in farming in the study area. This result could be attributed to the enhanced status of farming as a source of income. Thus, most males who by virtue of being head of the family and people with access to land resources engage most in rural innovation initiation, transformation, adoption, use and dissemination.

From Table 2, the result showed that, the farming household sizes ranged from 1- 24 person(s). It also revealed that, 48.7% had the highest household size with 6- 10 members followed by 23% with 11- 15 members, then 20.4% with 1- 5 household members followed by 5.3% with 16- 20 members and 2.7% with 21- 25 members. Thus 69.1% of the farmers have an average household size of 9 persons. The household size has mean household size of 9 persons and standard deviation of 4.347. This outcome happened to be in line with Debora, (2011), who reported that majority of farmers in Kano state whose (52.5%) had 1- 9 household size. Thus, majority of the farmers in the study area had family responsibilities attributed to the culture of the area making them to have a medium household size. This highlighted that family labour appears readily available for farm activities which involve the use of innovation practices, this is also in line with the work of Udo, (1999): in Emodi (2009) who said that farmers who had a fairly large household could probably supply farm labour households characterized by high number of members with high dependency ratio in Nigeria.

The table also showed that respondents' farm size with 1- 2 ha carried the highest percentage with 34.5%, followed by 3- 4 and 5- 6 ha with 20.4% each, then 8- 10 ha with 16.8% and 11- 13 ha with 8%. The result showed the mean farm size of the farming household as 5 ha and standard deviation of 3.381. Thus, majority of the respondents 75.3% had a mean farm size of 5 ha therefore, majority of the farmers were small scale farmers. This is in line with the work of Ubale, (2014) who reported that Nigerian farms are classified into small scale; medium scale and large scale as judged by international standards whereby small farms with less than 10 hectares are classified as small scale farms.

Results presented in Table 2 showed that, farming experience in the study area ranged from 5- 42 yrs; a greater proportion (29.2%) of the farmers had 22- 29 years of farming experience as seen in Table 2. About 23% of them each had 5- 13 and 14- 21 years of farming experience, while 19% had 30- 37 yrs, and 8% had between 38- 42 years of farming experience respectively. Their mean farming experience was 22 years and standard deviation of 9.695. This finding implies that most of the farmers had been in the farming livelihood for quite a long time. Long period is an important advantage in farm productivity since it encourages faster adoption of farm innovations (Obinne, 1991 in: Nwalieji 2005).

The result shows that married people engaged in farming activities are in the most majority. The couple and the children complement one another's efforts thereby reducing the stress that could have been in individual working alone. The cost of labour is reduced too. This possibly culminated into having an early marriage that helps in building strong farming population, which is in line with the assertion from Morale, (1990) in: Sani, (2014) who stated that, young people in rural areas get married earlier than their urban counterparts.

The investigation revealed in Table 3 that about 35.4% of the respondents had (informal) Qur'anic education followed by those with primary education (27.4%), then secondary and tertiary education (15%) each and only 7.1% with adult education, thus most of the farmers were literate. This implied that majority (74.5%) of the farmers have had one form of education or another at different levels. It also showed that, the engagement of educated people in farming is an asset to technological adoption and sustained use. Education polishes an individual, develops the intellect and makes him a wide user of vast resources. This is in line with the work of Obinne, (1991) who opined that, it is generally considered that, education is an important variable option that could enhance farmers' adoption of new technology.

Result from table 3 further revealed that most of the respondents (99.1%) had crop production as primary occupation while only 0.9% were animal rearers. Thus, most of the respondents were crop farmers who grew crops for both home consumption, animal feeding and surplus used to cater for other obligations.

This relates to the number of time farmers received a visit, call or mail from an extension agent regarding technological guides that boost their farm production. The table (3) shows that lower proportion of the farmers (2.7%) were not visited regularly by extension agents, while higher proportion (97.3%) has received the visit of an extension agent. This implied that extension visit is okay in the area with an optimal number of extension personnel.

Innovation Practices in the Area

The result revealed that majority 76% (22) of the innovation practices in that study area were informal while 24% (7) were the formal ones. Thus, all the forms of innovation practices were put into practice in the study area to boost their production or economy as a whole and in the face of increasing global challenges, rural farmers are becoming more innovative (Sanginga *et al.*, 2009). They engage in informal experimentation, develop new technologies and modify or adapt external innovations to suit their local environments (Reij and Waters-Bayer, 2001). Farmer innovation processes are claimed to be relatively inexpensive, easily accessible, locally appropriate and highly disseminated (Waters-Bayer and Bayer, 2009). Thus, farmer innovation could complement the highly promoted external innovations in addressing increasing challenges in agriculture, and also contribute to sustainable intensification efforts.

Socio- economic Factors Influencing the use of Innovation Practices

The factors considered to be the dependent variable are the rural innovation practices while age, education, household size, farm size, farming experience and extension contact were considered as independent variables. Table 4 presents the result is as follows:

Table 4 above, revealed that, the coefficient of age was positive and significant at 5% probability level. This showed that, the higher the age of a farming household head the more likely higher number of innovations are employed leading to realization of higher yield. The coefficient of household size was negative but also found significant at 5% level of probability. This could be discerned that, the higher the household size the more likely to be food insecure. Thus, additional measures are needed to be food secure. Also, the coefficient of farming experience was found to be negative but significant at 10% probability level showed that, they mostly engage more rural innovation practices as compared to formal innovations. Indigenous knowledge systems are tuned to the needs of local people based on the quality and quantity of available resources (Chikaire and Nnadi, 2011). And, also Phillip *et. al,* (2009) depicted that, despite its importance, the agricultural sector in Nigeria is far from reaching its full potential. Phillip *et al.*, (2009) in their work further highlighted that, the agricultural sector has the highest poverty incidence in the country where they, recommended that; to reduce poverty, it is critical for households to earn more from their income generating activities.

CONCLUSION

This study revealed that rural innovation constituted 76% of the total innovations identified. Most of these innovations were sourced endogenously from family and neighbours, farmer groups and opinion leaders. Majority of the respondents had Qur'anic education with low level of western education and characterized by reasonably small sized farms. Variables such as age, household size and farming experience as well as number of innovations used resulted in achieving food security status through realization of monthly food expenditure above the food security line. Constraints that militated against use of rural innovations include; inadequate land, poor documentation, single initiatorship, longevity/ time demanding, soil variability and obsoleteness. Best and tested rural innovation practices could be used alone or augmented with exogenous /formal ones to achieve better food security status.

RECOMMENDATIONS

Base on the findings of this study, it is recommended that:

- Rural farmers should endeavor to allow their families especially wives and female children get into farming as business so as to allow them benefit from various governmental and non- governmental interventions in boosting household food security.
- Larger rural households should diversify their means of earning by using multiple ways of earning livelihoods from up- streams and downstream agricultural activities and other non-agricultural sectors.
- Rural farming should endeavor to make good use of both formal and effective informal innovation practices in order to boost their yields.

REFERENCES

Ayinde, I. A., Okuneye P.A., Momoh, S. and Alomolaran, A.B. (2007). Socio- economic factors affecting insecticide use in cowpea production in Kano state. In: Haruna, U., Jibrin, S.A., Mancha, Y.P. and Nasiru, M. (eds). Consolidation of Growth and Development for Agricultural sector, Proceeding of the 9th annual national conference of the Nigerian Association of Agricultural Economists (Vol.2), 5th- 8th Nov., 2007 held at Tafawa Balewa University Bauchi, Nigeria pp 449.

Dauda R. S. (2006), "**Food Security: A Critical Variable in Nigeria's Quest for Economic Empowerment and Development**," in: Akano, O. and Familoni, K. (eds.), The National Economic Empowerment and Development Strategy: Philosophy, Opportunities and Challenges, Lagos: University Press.

Debora, S.S. (2011). Commodity chain analysis of Benni seed along Kano and Jigawa State axis. An M.Sc. Thesis submitted to the Department of Agric. Economics and Extension, BUK (Unpublished).

Emodi, A.I. (2009). Analysis of rice innovation system in southeast Nigeria, a PhD. Research findings seminar presented at the department of Agricultural extension, University of Nigeria Nsukka.

Ifeoma, J. Irohibe and Agwu, E.A. (2014). Assessment of food security situation among farming households in rural areas of Kano state, Nigeria. Journal of Central European Agriculture 2014, 15(1) p.94-157

NPC (2006). Nigeria census figure. National population commission, Abuja.

Obinne, C.P. (1991). Adoption of improved cassava production technologies by small- scale farmers in Bendel state. *Journal of Agriculture, Science and Technology, 1(1):12- 15.*

OECD (2005) Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition, The Measurement of Scientific and Technological Activities, OECD Publishing. Statistical Office of the European Communities, Luxembourg.

Phillip, D., Nkonya, E., Pender, J., and Omobowale, A. O., (2009). “Constraints to Increasing

Agricultural Productivity in Nigeria: A Review.” Background Paper No. NSSP 006for the Nigeria Strategy Support Program (NSSP).

Reij, C. and Waters-Bayer, A. (eds.), (2001) Farmer innovation in Africa: a source of inspiration for agricultural development. Earthscan, London

Sanginga, P., Waters Bayer, A., Kaaria, S., Njuki, J. and Wettasinha, C. (eds.), (2009) Innovation Africa: enriching farmers' livelihoods. London: Earthscan

Sani, U. (2014). Evaluation of Sasakawa Global (SG) 2000 stakeholder Needs Assessment for Enhanced Crop Productivity in Gombe and Jigawa States, Nigeria. An M.Sc. Thesis submitted to the Department of Agric. Economics and Extension, BUK (Unpublished).

Tella, R. D. (2007). Towards Promotion and Dissemination of Indigenous Knowledge. A Case of NIRD. The International Information and Library Review 39, P. 185.

Table 1: Showing Multistage Random Sampling Technique Employed.

Zone	LGA	Village	No. of Groups	Respondents
1	Kibiya	Tarai	14	34
		Sayasaya	6	16
2	Makoda	Galoru	4	11
		Koren Tabo	3	8
3	Ajingi	Gulya	9	23
		Ung/ Bai	8	21
Total	**3**	**6**	**44**	**113**

Field work, 2016.

Table 2: Age, Household Size, Farm Size and Farming Experience of the Farmers

Variable	Frequency	Percentage	Min	Max	Mean	S.D
Age (Yrs)			25	67	45	10.437
25 – 33	21	18.6				
34 – 41	23	20.4				
42 – 49	27	23.9				
50 – 58	26	23.0				
59 - 67	16	14.2				
Total	113	100				
Household size			1	24	9	4.347
1 – 5	23	20.4				
6 - 10	55	48.7				
11 - 15	26	23				
16 - 20	6	5.3				
21 - 25	3	2.7				
Total	113	100				
Farm size			1	13	5	3.381
1 - 2	39	34.5				
3 – 4	23	20.4				
5 – 6	23	20.4				
8 - 10	19	16.8				
11 - 13	9	8.0				
Total	113	100				
Farming experience			9.695	5	42	22
5 - 13	26	23				
14 - 21	26	23				
22 - 29	33	29.2				
30 - 37	19	16.8				
38 - 42	9	8				
Total	113	100				

Source: Field survey 2016

Table 3: Marital Status, Education Level, Primary Occupation and Extension Contact of the Farmers in Kano State.

Variable	Frequency	Percentage
Marital status		
Married	111	98.2
Single	2	1.8
Education		
Primary education	31	27.4
Secondary education	17	15
Tertiary education	17	15
Qur'anic education	40	35.4
Adult education (others)	8	7.1
Primary occupation		
Crops farming	112	99.1
Animal rearing	1	0.9
Extension contact		
There is contact	110	97.3
No contact	3	2.7
Total	113	100

Source: Field survey 2016

Table 4: Socio economic Factors Influencing Innovation Practices among Farmers in Kano State.

Variables	Coefficient	S.E	Wald	Df	Sign.	Exp(B)
Constant	-25.49	2.0904	0.00	1	0.999	0
Age	0.145	0.062	5.529	1	0.019**	1.156
Education	0.147	0.171	0.737	1	0.391	1.158
Household size	-0.149	0.064	5.471	1	0.019**	0.861
Farm size	0.084	0.067	1.56	1	0.212	1.087
Farming experience	-0.117	0.065	3.295	1	0.069*	0.889
Extension contact	22.637	2.0904	0.00	1	0.999	6.7809
Summary statistics						
2log-likelihood	135.454					
Chi-square	16.483					

Source: Field survey 2016.

ROLE OF SOCIOECONOMIC PARAMETERS IN THE USE AND CATEGORISATION OF RURAL INNOVATION AMONG FARMERS IN KANO STATE, NIGERIA

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ABSTRACT
The study assessed the use and categorization of rural innovations among small-holder farmers in Kano State, Nigeria. Three (3) Rural-Based Local Government Areas (LGAs) were selected from each of the three agricultural zones in the State. From each of the LGAs, two communities were randomly selected to form six communities. Data were collected using structured questionnaires from 133 respondents as sample size. Data collected were analysed using descriptive statistics. Findings from this study revealed that majority of the small holder farmers had vast knowledge in rural innovations. Two major categories of rural innovations (Informal and Formal) were identified, sourced, and shared amongst them with family, neighbors, opinion leaders and farmer groups with formal ones from KNARDA, IITA, SAA etc. The findings also indicated that variables such as age, household size, farming experience and high number of innovations are used. Intensively used innovations include fertilizer and organic manure applications, improved planting techniques, hedging, produce drying, tie ridging among others. Major constraints militating the use of rural innovations include: inadequate land and resources, poor documentation, single initiatorship and soil variability. The study recommended that rural farmers should make good use of both formal and effective informal innovation practices to boost their yields.
Keywords: Rural innovations, Innovation categorization, smallholder farmers

INTRODUCTION

Rural innovations (RIs) constitute an area with vast potentialities needed for agricultural sustainability and development goals to be realized. The traditional knowledge under the United Nations Permanent Forum on Indigenous Issues (UNPRII, 2019) which forms the identities and practices of indigenous and local communities are recognized under the United Nation Convention (UNC). The convention also highlighted by Odoemelam and Ajuka, (2015) was based on biological diversity that contains ways of life relevant for conservation and sustainable use of ecosystems; and by others as generated by the purposeful interaction of physical and intellectual materials embedded in place based on cultures and identities.

Prolinnova-Ethiopia (2006), presented the various aspects of farmer innovation. It showed that a farmer as innovator, is someone who: conducts informal experiments based on his own ideas; tests various indigenous and or external ideas, skills, information or practices; modifies and adapt technologies brought from outside to local conditions; improves or adds value to external and local practices to solve problems; or develop a novel product such as new technologies or better ways of carrying out farming activities.

Nigeria has a valuably untapped reservoir of indigenous knowledge in agricultural and natural resources experiences. The need on rural innovation for national development has come timely to reinforce the emphasis on structural adjustment due to economic constraints which this country has been vigorously pursuing since last decades. Looking at the simple definitions of rural innovation and development process, the development planners and policy makers are beginning to recognize the need to understand the existing knowledge systems and decision making process as key to focus their attention on small scale agricultural producers (OECD, 2005 & 2016).

It is due to this fact that they are the masters (in terms of knowledge) of their environment, economy, culture and technologies better than anyone else. Their felt needs must be considered, RIs recognized, environment and climate also considered for new and sustainable ways of growing their crops to avoid the imminent displacement and marginalization that is bound to take place in this dynamic world.

Objectives of the Study

i. describe the socioeconomic characteristics of the farmers in the study area;
ii. identify the rural innovation practices in the study area;
iii. categorize the identified innovation practices and their sources and
iv. describe the major constraints militating the use of the innovations in the study area.

METHODOLOGY

Description of the Study Area

Kano State has a total of 44 local government areas. It is partly situated in guinea, Sudan and to some extent Sahel savannas within latitudes 13.53^{0}N and 10.25^{0}N and longitudes 7.40^{0}E and 10.53^{0}E equivalent to a landmass of 20,680km^2 area (NPC., 2006) with a population density of over 748 people per square kilometer making the city alone as number 108th world's most populous, 14th Africa's most populous and 2nd most populous state in Nigeria (Population Stat.). According to NPC, (2006), the State had a population of 9.4million out of which, 4,947,952 males and 4,453,336 females. It has an annual growth rate of 3.2% which gives a projected figure of 15,462,200 populations in the year 2022. There are two distinct seasons; wet season (May-September) with average rainfall of 600mm- 1000mm annually and dry season (October - April). The maximum temperature ranges between 21^{0}C - 39^{o}C (KNSG, 2006). Kano State Agricultural and Rural Development Authority (KNARDA) serve as the technical and management unit responsible for Agricultural extension service of the State Government. KNARDA is divided into three Agro-ecological zones including, Zone I, Zone II and Zone III with their respective Local Governments Areas (LGAs) as follows: Zone I with 15 number of LGAs has its Headquarter at Rano LGA; Zone II has 14 LGAs with Headquarter at Danbatta and Zone III has 16 number of LGAs with head quarter at Gaya (KNARDA, 1998).

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- Makoda (out of 9 LGAs in zone II) and
- Ajingi (out of 8 LGAs in zone III).

- ✓ The second stage considered random selection of two communities from each of the
- ✓ LGAs chosen.
- ✓ Third stage, quota sampling was employed where: 10% of the respondents were randomly selected from each of the selected villages to give a sample size of 113 rural farmers in Kano state.

Data Collection

Primary data was collected using Structured- questionnaire to elicit information from respondents on their socio-economic characteristics, identifying formal and informal innovations, roles of RIs to realization of food security in the area as well as major constraints limiting the use of rural innovations.

Tools of Analysis: Analytical tools such as simple descriptive statistics was used to achieve objectives I, II and III. Tools such as frequency counts presented in tables and charts were employed to present the data; where variables such as age (yrs), household size (no.), education (yrs), experience (yrs) were subjected to Quantitative analyses involving Minimum, Maximum, Mean and Standard Error. While Qualitative data: sex (male or female), marital status (married, single, divorce, widow), and occupation) were subjected to frequencies and percentages.

RESULTS AND DISCUSSION

Age of the Farmers

The results in table 2 above, revealed that, the age of the farmers ranged from 25- 67 yrs with mean age of 45 yrs; majority of them 23.9% are between 42- 49 yrs, 23% were between 50- 58 yrs, 20.4% of them were between 34- 41 yrs, those between 25- 33yrs were 18.6% and 14.2% were between 49- 67yrs respectively. The mean age was 45 years, implied that the farmers in the study area were relatively young hence could be able to learn and share new ideas, information, techniques, technologies (innovations) amongst themselves and have more strength to address labour challenges involving the utilization of innovation practices.

The Sex denotes the set of characteristics that determine whether an individual is male or female. The farmers in the study area were all male (100%), signified that males are mostly involved in farming in the study area. This result could be attributed to the enhanced status of farming as a source of income. Thus, most males who by virtue of being head of the family and people with access to land resources engage most in rural innovation initiation, transformation, adoption, use and dissemination.

Household size

From Table 2, the result showed that, the farming household sizes ranged from 1- 24 person(s). It also revealed that, 48.7% had the highest household size with 6- 10 members followed by 23% with 11- 15 members, then 20.4% with 1- 5 household members followed by 5.3% with 16- 20 members and 2.7% with 21- 25 members. Thus 69.1% of the farmers have an average household size of 9 persons. The household size has mean household size of 9 persons and standard deviation of 4.347. This outcome happened to be in line with Debora, (2011), who reported that majority of farmers in Kano state (52.5%) had 1- 9 household size. Thus, majority of the farmers in the study area had family responsibilities attributed to the culture of the area making them to have a medium household size. This highlighted that family labour appears readily available for farm activities which involve the use of innovation practices, this is also in line with the work of Udo, (1999): in Emodi (2009) who said that farmers who had a fairly large household could probably supply farm labour households characterized by high number of members with high dependency ratio in Nigeria.

Farm Size

Farm size refers to the share farm land owned by a person. It is regarded as one of the ways of earning a living in agrarian communities. Farm size ranged from 1- 13 ha. The Table also showed that respondent's farm size with 1- 2 ha carried the highest percentage with 34.5%, followed by 3-4 and 5- 6 ha with 20.4% each, then 8- 10 ha with 16.8% and 11- 13 ha with 8%. The result showed the mean farm size of the farming household as 5 ha and standard deviation of 3.381. Thus, majority of the respondents 75.3% had a mean farm size of 5 ha therefore, majority of the farmers were small scale farmers. This is in line with the work of Ubale, (2014) who reported that Nigerian farms are classified into small scale; medium scale and large scale as judged by international standards whereby small farms with less than 10 hectares and hence classified as small-scale farms.

Farming Experience

While farming experience is regarded as the period of time (in years) a person took in farming activities or business. It warrants initiation, use and adoption of innovations. The results are presented in Table 2 showed that, farming experience in the study area ranged from 5- 42 yrs; a greater proportion (29.2%) of the farmers had 22- 29 years of farming experience as seen in Table 2. About 23% of them each had 5- 13 and 14- 21 years of farming experience, while 19% had 30-37 yrs, and 8% had between 38- 42 years of farming experience respectively. Their mean farming experience was 22 years and standard deviation of 9.695. This finding implied that most of the farmers had been in the farming livelihood for quite a long time. Long period is an important advantage in farm productivity since it encourages faster adoption of farm innovations (Obinne, 1991 in: Nwalieji 2005).

Marital Status

It is evident from table 3 above, that greater proportions (98.2%) of the respondents were married while only 1.8% of them were single. The result shows that married people engaged in farming activities are in the most majority. The couple and the children complement one another's efforts thereby reducing the stress that could have been in individual working alone. The cost of labour is reduced too. In the same manner, more information on rural innovation initiation, transforming and adoption are most likely to trickle in as each member of the farming is a prospective source of receiving information on innovative farming practices. This agreed with United Nations (UN) (2008) findings which reported that, different ethno- religious groups continue to attach prestige to marriage as an indicator to social responsibility, trust and achievement.

Educational Level

Educational status allows respondents to easily comprehend, modify and make use of new practices or innovations. The investigation revealed in Table 3 that about 35.4% of the respondents had (informal) Qur'anic education followed by those with primary education with 27.4%, then secondary and tertiary education had 15% each and only 7.1% with adult education, thus most of the farmers were literate. This implied that majority (74.5%) of the farmers have had one form of education or another at different levels. It also showed that, the engagement of educated people in farming is an asset to technological adoption and sustained use.

Primary Occupation in the Area

Result from table 3 further revealed that, most of the respondents (99.1%) had crop production as primary occupation while only 0.9% were animal rearers. Thus, most of the respondents were crop farmers who grew crops for both home consumption, animal feeding and surplus used to cater for other obligations.

Extension Visits

Table 3 shows that lower proportion of the farmers (2.7%) were not visited regularly by extension agents, while higher proportion (97.3%) has received the visit of extension agents. This implied that extension visit was okay in the area with an optimal number of extension personnel.

Types of Innovation Practices in the Area

The result from table 4 revealed that 76% of the innovation practices in that study area were informal while 24% were the formal ones. Thus, all the forms of innovation practices were put into practice in the study area to boost their production as a whole and in the face of increasing global challenges, rural farmers are becoming more innovative (Sanginga *et al.*, 2009). They engage in informal experimentation, develop new technologies and modify or adapt external innovations to suit their local environments (Reij and Waters-Bayer, 2001). Farmer innovation processes are claimed to be relatively inexpensive, easily accessible, locally appropriate and highly disseminated (Waters-Bayer and Bayer, 2009). Thus, farmer innovation could complement the highly promoted external innovations in addressing increasing challenges in agriculture and contribute to sustainable intensification efforts.

Result from table 5 revealed that almost all the farmers practiced formal innovation in one way or the other. This was evident in the application of fertilizer where 100% used inorganic fertilizer, 91.2% of the farmers applied improved planting practices; chemical weeding practices (86.7%), pests/ diseases control practices (86.7%), seed dressing practice (81.4%). Therefore, most of the farmers also practiced formal innovations using improved technologies.

Also, the results in tables 4 and 5 witnessed two categories of innovation been practice in the study area viz: informal innovation carried majority of the innovations in place with 76% followed by its formal counterpart with 24%. This implied that: majority of innovations in use by the farmers (76%) are from informal sources (family and neighbours, farmer groups and opinion leaders) while 24% were rooted from formal sources (KNARDA, SASAKAWA, IITA etc.). It is opined that the more the local people experiment with external technologies, the more they strengthen their indigenous knowledge and practices (Lemma and Hoffman, 2005). External knowledge is a key component in improving small-scale agricultural production and linking increased production to remunerative markets, thus leading to food security and national economics (Asaba *et al*, 2006). The above findings are also in line with Chikaire and Nnadi, (2011) who posited that indigenous knowledge provides the basis for problem solving strategies for local communities especially the poor. Thus, Farmers invent new practices, modify existing technologies, or experiment with new ideas to adapt to changes in their environment (Millar, 1994; Bentley, 2006). They often use locally available resources and generate low-cost innovation in many farming domains, including soil fertility, crop varieties, animal husbandry and marketing (Reij and Waters-Bayer, 2001).

Constraints Militating the Use of Rural Innovations improved livelihood in the study area

This refers to the problems that hinder development, experimenting, adoption and continual use of rural innovations. Table 14 presents the constraints as follows. Table 6 revealed the respondents' problems as follow: majority 60% reported on inadequate land, 82.3% reported to have inadequate land, 50% poor documentation of the innovations, 46% single initiatorship (as one man invention), 44.3% complained its time demanding, 40% focus their problem on soil variability (intra and inter-farm) and 27.4% considered obsoleteness as problem militating the use of rural innovation in the study area. Thus, these constraints hinder the use and effectiveness of innovations in agriculture and food security. Rural innovations are mainly preserved in the memories of elders whose knowledge disappear when they die of old ages, and thus rural innovation has been lost at a high rate. At the same time, there is still a low rate of adoption of external technology despite the fact that it receives most of the attention (Ngendello, *et al.*, 2003) due to weak linkage between research extension and farmers. Hence, farmers neither adapt the new technologies, nor manage their knowledge systems for improved farming operations.

CONCLUSION

This study revealed that rural innovation constituted 76% of the total innovations identified. Most of these innovations were sourced endogenously and locally from family and neighbours, farmer groups and opinion leaders. Constraints that militated against use of rural innovations include; inadequate land, poor documentation, single initiatorship, longevity/ time demanding, soil variability and obsoleteness. Best and tested rural innovation practices could be used alone or augmented with exogenous /formal ones to achieve better food security status.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that:

i. Rural farming should endeavor to make good use of both formal and effective informal innovation practices in order to boost their production.
ii. Farmers with limited lands are encouraged to make use of improved, early maturing and high return technologies that could be produced twice a season in order to checkmate the limitation attached to their land sizes.

REFERENCES

Asaba, E.B. (2006). Bridging the information and knowledge gap between urban and rural communities through rural knowledge centre: Cases studies from Kenga and Uganda. International Association of Agricultural Information Specialists (IAALD) *Quarterly Bullentin,* 51 (3-4).

Ayinde, I. A., Okuneye P.A., Momoh, S. and Alomolaran, A.B. (2007). Socio- economic factors affecting insecticide use in cowpea production in Kano state. In: Haruna, U., Jibrin, S.A., Mancha, Y.P. and Nasiru, M. (eds). Consolidation of Growth and Development for Agricultural sector, Proceedings of the 9th annual national conference of the Nigerian association of Agricultural economists (Vol.2), 5th- 8th Nov., 2007 held at Tafawa Balewa University Bauchi, Nigeria pp 449.

Bentley, J.W., (2006). Folk Experiment. Agriculture and Human Values 23:451-462. Google Scholar

Debora, S.S. (2011). Commodity chain analysis of Benni seed along Kano and Jigawa State axis. An M.Sc. Thesis submitted to the Department of Agric. Economics and Extension, BUK (Unpublished).

Emodi, A.I. (2009). Analysis of rice innovation system in southeast Nigeria, a PhD. Research findings seminar presented at the department of Agricultural extension, University of Nigeria Nsukka.

Miller, D., (1994) what Happens after Success: The Peril of Excellence. *Journal of Management Studies vol.31p325-358.* https//doi.org/10.1111/j.1467-6486.1994.tb00621.x

NPC (2006). Nigeria census figure. National population commission, Abuja.

Ngendello, A M., Byabachwezi, M.S.R. and Schrader,T. (2003). Dissemination of agricultural technology: Narrowing the gap between research, extension and farmers. In proceedings of the National Workshop on Client Oriented Research.

Obinne, C.P. (1991). Adoption of improved cassava production technologies by small- scale farmers in Bendel state. *Journal of Agriculture, Science and Technology, 1(1):12 - 15.*

Odoemelam, L. E. and Ajuka, P. N., (2015). Indigenous Farm Management Practices among Rural Farmers: Implications for Sustainable Environment in South-East Agro-Ecological Zone, Nigeria. Discourse *Journal of Agriculture and Food Sciences 3(1): 7- 14*, January, 2015

OECD (2005) Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition, The Measurement of Scientific and Technological Activities, OECD Publishing. Statistical Office of the European Communities, Luxembourg.

Phillip, D., Nkonya, E., Pender, J., and Omobowale, A. O., (2009). “Constraints to Increasing Agricultural Productivity in Nigeria: A Review.” Background Paper No. NSSP 006for the Nigeria Strategy Support Program (NSSP).

Prolinnova-Ethiopia (2006) Progress report. Unpublished report

Reij, C. and Waters-Bayer, A. (eds.), (2001) Farmer innovation in Africa: a source of inspiration for agricultural development. Earthscan, London

Sanginga, P., Waters Bayer, A., Kaaria, S., Njuki, J. and Wettasinha, C. (eds.), (2009) Innovation Africa: enriching farmers' livelihoods. London: Earthscan

Sani, U. (2014). Evaluation of Sasakawa Global (SG) 2000 stakeholder Needs Assessment for Enhanced Crop Productivity in Gombe and Jigawa States, Nigeria. An M.Sc. Thesis submitted to the Department of Agric. Economics and Extension, BUK (Unpublished).

Tella, R. D. (2007). Towards Promotion and Dissemination of Indigenous Knowledge. A Case of NIRD. The International Information and Library Review 39, P. 185.

United Nation (UN) (2008). The Challenges of climate and bio-energy. *Paper presentation at the high level conference on world food security. Rome.*

Reig Waters-Bayer, A. and Bayer, W. (2001) Enhancing local innovation to improve water productivity in crop–livestock systems. *The Rangeland Journal 31:231–235*

Reig Waters-Bayer, A., van Veldhuizen, L., Wongtschowski, M. and Wettasinha, C. (2009) Recognizing and enhancing processes of local innovation. In: Sanginga *et al.* (eds.), Innovation Africa: enriching farmers' livelihoods. London: Earthscan.

Table 1: Showing Multistage Random Sampling Technique Employed.

Zone	LGA	Village	No. of Groups	Respondents
1	Kibiya	Tarai	14	34
		Sayasaya	6	16
2	Makoda	Galoru	4	11
		Koren Tabo	3	8
3	Ajingi	Gulya	9	23
		Ung/ Bai	8	21
Total	**3**	**6**	**44**	**113**

Field work, 2016.

Table 2: Age, Household Size, Farm Size and Farming Experience of the Farmers

Variable	Frequency	Percentage	Min	Max	Mean	S.D
Age (Yrs)			25	67	45	10.437
25 – 33	21	18.6				
34 – 41	23	20.4				
42 – 49	27	23.9				
50 – 58	26	23.0				
59 - 67	16	14.2				
Total	113	100				
Household size			1	24	9	4.347
1 – 5	23	20.4				
6 - 10	55	48.7				
11 - 15	26	23				
16 - 20	6	5.3				
21 - 25	3	2.7				
Total	113	100				
Farm size			1	13	5	3.381

1 - 2	39	34.5				
3 – 4	23	20.4				
5 – 6	23	20.4				
8 - 10	19	16.8				
11 - 13	9	8.0				
Total	113	100				
Farming experience			9.695	5	42	22
5 - 13	26	23				
14 - 21	26	23				
22 - 29	33	29.2				
30 - 37	19	16.8				
38 - 42	9	8				
Total	113	100				

Source: Field survey 2016

Table 3: Marital Status, Education Level, Primary Occupation and Extension Contact of the Farmers in Kano State.

Variable	Frequency	Percentage
Marital status		
Married	111	98.2
Single	2	1.8
Education		
Primary education	31	27.4
Secondary education	17	15
Tertiary education	17	15
Qur’anic education	40	35.4
Adult education (others)	8	7.1
Primary occupation		
Crops farming	112	99.1
Animal rearing	1	0.9
Extension contact		
There is contact	110	97.3
No contact	3	2.7
Total	113	100

Source: Field survey 2016

Table 4: Distribution of Informal Innovation Practices Identified in the Study Area**.**

Informal innovation	**Frequency**	**Percentage**	**Ranking**
Organic manuring	107	94.7	1st
Manual weeding	106	93.8	2nd
Manual land preparation	98	86.7	3rd

Hedging	85	75.2	4th
Sun drying	84	74.3	5th
Tie ridging	82	72.6	6th
local seed preparation/selection	80	70.8	7th
Mulching	80	70.8	7th
Early harvesting	79	69.9	9th
Farm boundary mounding	75	66.4	10th
Furrow/ furrow planting	70	61.9	11th
Wider space planting	63	55.8	12th
Minimum tillage	55	48.7	13th
Local storage using insect repellent plants	55	48.7	13th
Local storage structure	52	46.0	15th
Local pest/disease control	47	41.6	16th
Mono cropping	11	9.7	17th
Bush fallow	10	8.8	18th
Shifting cultivation	8	7.1	19th
Local storage using Hot spices	4	3.5	20th

Source: Field survey 2016.

Table 5: Distribution of Formal Innovation Practices Identified in the Study Area.

Formal innovation	**Frequency**	**Percentage**	**Ranking**
Fertilizer	113	100.0	1st
Planting	103	91.2	2nd
Chemical Weeding	98	86.7	3rd
Chemical Pest/Diseases Control	98	86.7	3rd
Seed Dressing	92	81.4	5th
Triple Bagging	70	61.9	6th
Land Preparation (mechanical)	67	59.3	7th
Harvesting (mechanical)	34	30.1	8th

Source: Field work 2016.

Table 6: Constraints Militating the Use of Rural Innovations in the Study Area

Constraints	Frequency	Percentage
Inadequate land	68	60
Inadequate of capital	93	82.3
Poor of documentation	56	50
Single initiatorship	52	46
Time demanding	50	44.3
Soil variability	45	40
Obsoleteness/ outdating	31	27.4

Source: Field survey, 2016 *Multiple responses

EFFECT OF FARO 58 RICE PRODUCTION PACKAGE AND CHALLENGES FACED BY THE FARMERS IN KATSINA STATE

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ABSTRACT

Rice production plays a crucial role in the agricultural landscape of Katsina State, Nigeria, with smallholder farmers forming the backbone of this sector. This study focuses on evaluating the impact of the FARO 58 Rice Production Package, a comprehensive set of agricultural technologies and practices designed to enhance rice cultivation. This research aid to determine the effect of FARO 58 Rice Production Package and Challenges Faced by the Farmers in Katsina State. The methodology involves a combination of quantitative and qualitative approaches. A structured survey is conducted to collect data on the adoption rates of FARO 58 technologies among farmers, their socio-economic characteristics, and the perceived benefits and challenges associated with its implementation. Additionally, in-depth interviews and focus group discussions were employed to gather qualitative investigation into the farmers' experiences and perspectives. This research contributes to the ongoing discourse on the effectiveness of agricultural innovations in addressing food security and rural development challenges in Nigeria.

Key words: FARO 58 Rice; production package; Farmers Challenges

INTRODUCTION

Nigeria has a diverse climate from tropical of the coast to the arid zone of the north make it possible to produce virtually all agricultural products that can be grown in the tropical and sub-tropical areas of the world (Nigerian forum, 2007). Research records therefore indicated that about 33% of Nigeria land area is under rice cultivation (Komawa and Akande, 2004). As a result, the Federal Government of Nigeria has launched the Anchor Borrower Agricultural Program in the year 2015 and the program was introduced in some state including Katsina State. The Anchor Borrowers Program in the state has created millions of jobs for the rice farmers especially those who adopted improved (FARO 58) varieties and has aided in eradicating indolence and redundancy, especially among youths (KATARDA, 2017). Most of the factors which influence the adoption of improved rice package by the small-scale farmers in Katsina state will include; Socio-economic factors, Institutional factor, Technologies related, and Environmental factors (KATARDA, 2017). According to Nigeria Federal Ministry of Agriculture and Rural Development- FMARD (2015), rice sub-sector generates about ₦ 4, 706 billion to the Nigerian economy and over the last three years of rice transformation program, rice had added ₦ 3, 206 billion to the nation's economy. Federal ministry of Agriculture and Rural Development FMARD further reported that from 2011-2015, rice subsector in Nigeria has attracted over $2billion over private sector investments. It was further reported that the Federal Government of Nigeria has saved about $800 million by encouraging local production of rice in the country (Premium Times, 2018). In order to boost agricultural production in the past, the Nigeria government and some non-governmental organizations had initiated agricultural programmes that aimed at improving the livelihood of the farmers and at the same time creating conducive environment for the adoption of the introduced agricultural programmes (Ango, 2011). Opined that for a successful adoption of new technology, farmers must not only know about it, but must be able to follow the recommendations attached to the technology. It is well known fact that, not all the farmers adopt technologies at the same rate due to differences in behavior to the technologies and their socio-economic attributes (Van den Ban and Hawkins, 1996). Therefore, adoption by voluntary methods depends solely on the effectiveness of demonstration, which may be very rapid or slow. Many studies (Aremo *et al*, 2015, Abd, 2013 and Bawa, 2011), reported that the adoption of agricultural technologies in the agricultural extension transfer process that can be applied in the transfer of various technologies and innovations in the agricultural sector, the transfer process had been done from agricultural research centers to extension personals and finally to farmers who were able to be convinced and latter adopt these agricultural techniques in order to evoke agricultural development and raise their economic level. Farmers experience in farming is one of the factors, which determine the adoption of agricultural technology. In accordance to Mamuda *et al,* (2012), years of farming experience is positively related to determining the level of adoption of modern agricultural technologies by households. It's in view of these that this study is to find out the Effect of FARO 58 Rice Production Package and Challenges Faced by the Farmers in Katsina State. The broad objective is to determine the effect of FARO 58 Rice Production Package and Challenges Faced by the Farmers in Katsina State.

The specific objective is to:

a. Determine the socio-economic characteristics by the farmers
b. Examine the differences in rice output between FARO 58 package and local rice variety

c. Find out the constraints faced by the FARO 58 rice package in the study area.

Test for hypothesis

There is no significant difference in rice yield between FARO 58 and local rice variety in the study area.

METHODOLOGY

Study area

This study was conducted in Katsina state, Nigeria. The area falls within the Sudan Savannah agro-ecological zone of Nigeria. Katsina state has 34 Local Government Areas. The state lies between latitude 12° 52'N and 13° 19'N and longitude 7° 16'E and 8° 43'E. The climate of the study area is generally classified as Semi-arid (Tomlinson, 2010) with a long dry season of about 7-8 months (November to May) and a hot rainy season lasting for 4 months (June to September). Temperatures are high in most part of the year with the mean daily maximum temperature ranging between 27^0C to 40^0C occurring between (March to May) and the mean minimum ranging between 18^0C to 25^0C.

Methods of Data Analysis

Data generated for the study were analyzed using both descriptive (frequency, percentage, mean, and standard deviation) and inferential (t-test) statistics.

Sampling Procedure and Sampling Size

Stratified random sampling to ensure representation across different regions within Katsina State. Random selection of villages within each stratum and Systematic random sampling of smallholder farmers within selected villages. And sample size was Calculated based on the population of smallholder farmers in the selected villages, ensuring statistical significance.

RESULTS AND DISCUSSION

Socio-economic characteristics the farmers

This is a concept that describes economic status of individual farmers. It also provides information on the descriptive analysis using frequency, percentages, mean and standard deviation and inferential statistical results and their discussion.

Age of the respondent

Age is an important factor affecting crop production, consumption and household food security in Nigeria (Habibu, 2012).

Results presented in Table 1 below indicated that 24.2% of the respondents were within the age range of 46 – 55 years, 24.0% were within the age bracket of 25 - 35 years, 22.6% were within the ages of 36 – 45 years, 19.1% were within the ages of 56 – 65 years and 10.1% were within the age bracket of 66 years and above. In addition, the mean age of the respondents was 47.61 years. This finding implies most of the farmers were at adulthood and were capable to adopt new technologies than the older ones.

Household size

Household size refers to number of persons in a family including wives, children and labour force for farm activities that live in the same house and eat for the same pot of food. It is also an important variable, which indicates the availability of labour to the households (Habibu, 2015). Table 2, Further reveals that 23.6% of the respondents had a family size of 6 - 10 members in their households, 22.7% had a family size of between 11 and 15 members, and 22.2% of them had a family size of 1 to 5 members. The mean household size of the respondents was 12 people. This implies that the household size of the respondents in the study area was large.

Farming experience

This explained the duration by which the farmer engages themselves in farming practices. As indicated in Table 3 reveal that 31.4% of the respondents had 1 - 10 years of farming experience, 31.0% of the respondents had a farming experience of 11 – 20 years, 15.6%, of the respondents had a farming experience of 21 – 30 years, 11.5% of the respondents had 31 – 40 years of farming experience and only few (10.8%) of the respondents had a farming experience of 41 years and above. The mean farming experience of the respondents was 19.42 years. This finding implies that the respondents had ample farming experience in the study area.

Differences in Rice output Between FARO 58 Package and Local Rice Variety

T- test analysis result in Table 4 shows a significant increase in the mean yield of FARO 58 production package with (1940kg) compared to the mean yield of rice local variety (1189.5kg). The differences of mean of FARO 58 rice production package was 50.5kg. This implies that there is significance differences in yield of 750.5kg of rice production package after the programme.

Hypothesis Test

There is no significant difference in rice yield between FARO 58 and local rice variety in the study area.

The t-test analysis result presented in Table 4 above shows that there is significant differences in rice yield of FARO 58 than local variety at ($P < 0.001$) level of probability in the study area.

Therefore, it was concluded that FARO 58 rice package have significant influence on farmer's yield. Hence, null hypothesis is rejected

Constraints faced by the FARO 58 rice Production Package

Constraints faced by respondents refers to the inhibiting factors that may result to consequences. Constraints may also be the problems, which farmers faced during adoption of improved rice variety. These constraints are categorized in to biotic, abiotic and environmental factors (KATARDA, 2017).

Result presented in Table 5 revealed that 29.6% of the respondents' faced constraints of pest and diseases, 29.4% of the respondents faced a problem of inadequate water supply, 26% of the respondents faced a problem of credit facilities, 7.3% of the respondents faced a problem of farmer harder conflict, 4.4% of the respondents had a problem of inadequate soil nutrient.

Pest and diseases had the highest mean and was ranked first, indicating that, it's the most pressing constraint faced by respondents in the study area. This is seconded by inadequate water supply to the rice crops in the study area. Studies conducted by), Singh and Jay, (2010) reported that constraints faced by rice farmers in Jabalpur, India include high cost of technology, lack of training on technology and also problem of pest and diseases

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it is concluded that majority of the respondents had the age bracket of 46 – 55 years and 1 – 10 hectares of farming experience. Theres a significance differences in yield of 750.5kg of rice production package after the programme. Financial constraints emerge as a significant barrier to the widespread of FARO 58 rice package. Many farmers face challenges in accessing credit and resources required for implementing the recommended practices. The research suggests that FARO 58 has a positive impact on rice production outcomes, as evidenced by improved yields and quality. Farmers who have successfully adopted the package report enhanced productivity, indicating the potential for FARO 58 to contribute to food security and economic well-being in the region. Based on the findings of the study, it's concluded that the constraints faced by the rice farmers in the study area were pest and diseases, inadequate water supply and lack of credit facilities. Government should develop and implement targeted financial support programs to assist smallholder farmers in accessing credit and resources necessary for FARO 58 rice farmers. This can include low-interest loans, grants or subsidies to alleviate financial constraints. Katsina Agricultural Development Agency

(KATARDA) should provide agrochemicals (herbicide, pesticide and insecticides) and sustainable water supply to the improved rice production in the study area.

REFERENCES

Abdu, H. (2013). Role of Extension Centers on Farmers Training for Using Modern Agricultural Technology in Polly plastic. *Journal of Sustainable Development and Green Economics*, 2 (12): 96-99.

Ango, A. K. Abdullahi, A. N. Abubakar, B. B. (2011). Role of Socio-economic Parameters in Determining the Efficiency of Urban Agriculture in Providing Food Security in Birnin Kebbi Metropolitan Area, Kebbi State, North Western Nigeria. International Research *Journal of Agricultural Science and Soil Science*, 1 (6): 185-192

Aremu, P., Kolo, I., Gana, A. Adelere F. (2015). The Crucial Role of Extension Workers in Agricultural Technologies Transfer and Adoption", *Global Advanced Research Journal of Food Science and Technology*, 4 (2): 18.

Bawa, D.B. (2011). Analysis of the Utilization of Improved Maize Production Technology among Farmers in Southern Borno, Nigeria. Ph.D Thesis, University of Maiduguri, Maiduguri, Borno State, Nigeria. *International Journal of Environmental Research and Public Health*, 13(1):107

Federal Ministry of Agriculture and Rural Development FMARD (2015). Rice Transformation Programme

Habibu, A. H. (2015). Factors Influencing Adoption of FARO 52 Rice Package by Farmers in Niger State. M.Sc. Dissertation, Faculty of Agriculture, Department of Agricultural Extension and Rural Development, Usmanu Danfodiyo University, Sokoto, 20-68

Kormawa, P. Akande, T. (2004). The Configuration of Comparative Advantage in Rice Production in West Africa: A Survey of Empirical Studies. Rice Policy and Food Security in Sub-Saharan Africa. http/www.wardacgar.org/publication/policy.

Katsina State Agricultural and Rural Development Agency KATARDA (2017). Agricultural Development Programme. Report on Anchor Brower Programme Delivered to the Ministry of Agriculture, Katsina. 8th June, 2017.

Mamuda A. A., Guo, E. Dadzie, S. K. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors influence their Decision; *Journal of Biology Agriculture, and Healthcare*, 2 (3): 34-68.

Premium Times (2018). Rice Production Saves Nigeria ₦800m. Published on Monday, November 26, 2018.

Nigerian Forum (2007). Nigerian Agriculture. Encyclopedia of the Nations. http://www.nationsencuclopidia.com. Index.html.retrieved 4.9, 2013.

Singh, P.K. Jay, V.G (2010). Adoption of Modern Varieties and Fertilizer Use on Rice in Eastern Tarain of Nepal. *Journal of Agricultural Economy*, 36:409-419.

Van den Ban, H. Hawkins, H.S. (1996). Agricultural Extension, 2nd Edition. Blackwell Science ltd, London, 96-119.

Table 1: Distribution of Respondents According to Age (n= 220)

Age (years)	Frequency	Percentage	Mean	S.D
25 – 35	52	24.0		
36 – 45	50	22.6		
46 – 55	53	24.2	47.61 years	13.18
56 – 65	43	19.1		
66 years and above	22	10.		

Table 2: Distribution of Respondents According to Household Size (n= 220)

Household Size	Frequency	Percentage	Mean	SD
1 – 5	49	22.2		
6 – 10	52	23.6		
11 – 15	50	22.7	12 people	7.044
16 – 20	33	15.1		
21 people and above	36	16.3		

Table 3: Distribution of Respondents According to Farming Experience (n= 220)

Farming Experience (years)	Frequency	Percentage	Mean	SD
1 – 10	69	31.4		
11 – 20	68	31.0		
21 – 30	34	15.6	19.42years	13.35

31 – 40	25	11.5
41 years and above	24	10.8

Table 4: Distribution of Respondents According to Rice Yield output of FARO 58 Package and Local Rice Variety (n= 220)

Yield (kg)	Mean	S.D	S. E	D.F	P-value
FARO 58 Rice	23.79	15.50	1.045		
Local Verity Rice	38.80	25.39	1.712	219	0.000***
Differences	15.01	9.89			

Significant level = 0.001%

Table 5: Distribution based on Constraints Faced by the FARO 58 rice Production Farmers (n= 220)

Constraints	Frequency	Percentage	Mean	Rank
Pest and Diseases	214	29.6	3.288	1st
Inadequate Nutrients	32	4.4	0.488	5th
Inadequate Water Supply	213	29.4	3.266	2nd
Farmers Herders Conflict	53	7.3	0.811	4th
Lack of Knowledge/Skills on Package	11	1.5	0.166	6th
Lack of Credit Facilities	188	26.0	2.888	3rd
Insufficient Farm Size	6	0.8	0.088	7th
High Cost of Input	5	0.7	0.088	8th
Complexity to Practice	2	0.3	0.033	9th

*** 724** ** Multiple Response*

PROFITABILITY OF MILLED RICE MARKETING IN GOMBE STATE, NIGERIA

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ABSTRACT

Marketing involves all the legal, physical, and economic services which are necessary in moving products from producers to buyers. Rice marketing ensures the flow of rice from producers to buyers in the form, time and place of need. This study examined profitability of milled rice marketing in, Gombe State, Nigeria. Data were collected using structured questionnaires from ninety randomly selected rice marketers in Gombe metropolis. The data were analyzed using descriptive statistics, farm budget technique and regression analysis. The study revealed total rice marketing cost incurred by rice marketers to be ₦6, 610,214.70. This gave an average of ₦73, 446.83 per marketer and ₦37.30 per Kilogram of rice. The Gross Income for rice marketers in Gombe metropolis was ₦15, 064,600.00. This value gave an average of ₦167, 384.44 per rice marketer or N85.00 per kilogram of rice. The study also revealed net income for all rice marketers to be ₦8, 454,385.30. This gave an average of ₦93, 937.61 per rice marketer or ₦47.70 per Kilogram of rice. The study further revealed marketing margin, marketing efficiency and return per naira invested on rice marketing to be 39.30%, 150.16% and ₦0.56 respectively. However, the main constraints to rice marketing in Gombe metropolis include inadequate electricity, capital, high transportation cost, instability of prices and low patronage among others. The study recommends provision of adequate electrical power supply in the State especially the State capital and also encouraging rice marketers in Gombe metropolis to form cooperative societies so as to have easy access to credit facilities especially from the formal sources.

Keywords: Rice Marketers, Milled Rice, Cost and Return, Marketing Margin, Efficiency, Profitability.

INTRODUCTION

Rice *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice) is a staple cereal grain, which is widely consumed in most part of the world, especially in Asia and the West Indies (Maddox, 2006). According to Food and Agricultural Organization (FAOSTAT) (2018) rice is grain with the second-highest worldwide production, after maize (corn). The word "rice" derives its name from the Old French *ris*, which comes from Italian *riso*, in turn from the Latin *oriza*, which derives from the Greek ὄρυζα (*oruza*).

According to Maddox (2006), African rice has been cultivated for 3500 years. Between 1500 and 800 BC, *Oryza glaberrima* propagated from its original center, the delta area of river Niger, and extended to Senegal. However, it never developed far from its original region. Its cultivation even declined in favor of the Asian species, which was introduced to East Africa early in the common era and spread westward (Maddox, 2006). Rice has become a highly strategic and priority commodity for food security in Africa and its consumption is growing faster than any other major staple on the continent, because of high population growth, rapid urbanization, preference of rice, availability and adjudged as single most important source of dietary energy in West Africa and third most important for Africa (Seck *et.al*. 2013, Tiamiyu, 2014, AbdulAzeez *et. al*., 2018 and Filli *et. al*., 2018).

Rice is the staple food of over half the world's population. It is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice provides more than one-fifth of the calories consumed worldwide by humans, while wheat supplies 19% and maize 5% (, FAO, 2004). A detailed analysis of nutrient content of rice suggests that the nutrition value of rice varies based on a number of factors. It depends on the strain of rice, that is between white, brown, black, red and purple varieties of rice – each prevalent in different parts of the world. It also depends on nutrient quality of the soil rice is grown in, whether and how the rice is polished or processed, the manner it is enriched, and how it is prepared before consumption (Juliano,1993).

The demand for rice in Nigeria has been soaring partly as a result of increasing population growth, increased income levels, rapid urbanization and associated changes in family/occupational structures. The average Nigerian now consumes 24.8kg of rice per year, representing 9% of the total calorie intake (FAO, 2005).

Marketing is the critical link between farmer production sector on one hand and nonfarm sector, industry and urban economy, on the other. The role of marketing in developing any economy including agriculture cannot be overemphasized. It involves all the legal, physical, and economic services which are necessary in moving products from producer to consumers (Olukosi, Isitor and Ode, 2005). The more efficient the marketing functions are performed the better the marketing system for both the farmers, food marketing firms, consumers and the society at large. Thus rice marketing ensures the flow of product from producers to consumers in the form, time and place of need. Buyers are in need of the products while the sellers in turn need to improve their socioeconomic status through higher profits and enhanced income. For the purpose of this study we adopt a mix between social and managerial definition of marketing.

In another development, Profitability is defined as a firm's capacity to obtain profit from its economic activity, by using its resources and it represents an economic instrument which underlies all the company' decisions regarding activity management and relationships (Cojocaru, 2000). According to Geamanu, M. (2016), "Profitability, synthetically defined as the enterprise's capacity to obtain profit is considered a decisive instrument for the market economy mechanism, for shaping production according to consumers' needs. Profitability means obtaining an income from production sale that should exceed expenses. As a consequence, profitability mirrors the efficiency of an enterprise's whole economic activity. Profitability is one of the most important forms of economic efficiency. Regardless of the types of economic activities and resources involved or consumed, the economic effects are finally materialized in the profit obtained by an enterprise. Of course, profit and profitability characterize the economic efficiency of production at micro-economic level, in tight connection with other indicators used for measuring an enterprise's economic performance, such as: labour productivity, production quality, production costs, etc. From among these, labour productivity has the highest influence on profit and profitability. It leads to profit growth on the one hand by increasing the volume of production and on the other hand by decreasing costs per production unit." (p.116)

Despite the fact that, marketing provides the means of meeting these necessities (utilities) involved in the flow of goods and services; and therefore has an important multiplier effect in the development of any economy. It is beset with a lot of problems which includes unorganized and inefficient marketing system arising from seasonal variations, transportation, storage, processing, grading and communication (Anyaebugan *et.al.*, 2011). Therefore, this study is aimed at answering these questions: -

1. What are the cost and return to rice marketing in Gombe metropolis?
2. Is rice marketing profitable in Gombe metropolis?
3. What are the problems facing rice marketers in Gombe metropolis?

Hence the major objective of this study is to determine the profitability of milled rice marketing in Gombe Metropolis. However, specific objectives of , the study are to : -

1. determine the cost and return to rice marketing in Gombe metropolis,
2. determine the profitability of rice marketing in the metropolis,
3. determine the relationship between marketing margin and socio-economic variables in Gombe metropolis, and
4. identify the problems facing rice marketers in the metropolis.

METHODOLOGY

Description of the Study Area

Gombe is a metropolitan city having a Local Government Area in the North-eastern Nigeria. It is the capital city of Gombe State and has an estimated population of 261,536 (NPC, 2006). Gombe LGA occupies an area of $52km^2$.and is located between latitude 9º 30´ and 12º 30´ North and longitude 8º 45´ and 11º 45´ East.

Gombe town shares common boundaries with Akko Local Government Area to the North, South and Southwest, Kwami Local Government Area to the West and Yamaltu/Deba to the East. The prominent ethnic groups in Gombe Town include Fulani, Hausa, Bolewa, Tera, Kanuri, Tangle, Tula, etc. Gombe is the commercial centre of the State.

Sample and Sampling Procedure

Gombe metropolis was purposively selected for the study based on the intensity of rice processing and marketing in the area. The city of Gombe has a total of five markets: Gombe Main market, Kasuwan Mata, Pantami, Jekadafari and Bogo. Out of these three markets were purposively selected based on their sizes: Gombe Main, Pantami, and Kasuwan Mata. A total of ninety copies of well-structured questionnaire were administered to randomly selected rice marketers in these markets.

Data Analysis

Descriptive statistics like percentage, mean, frequency distribution was used to analyse the socio-economic characteristics of the rice marketers in Gombe metropolis.

The Profitability Index (PI) which is the ratio of net income to gross income was used to determine the profitability of milled rice marketing in Gombe metropolis. It is mathematically given as:

$$PI = \frac{\text{Net Income}}{\text{Gross Income}} \times 100$$

Productivity ratios were used to determine gross ratio (ratio of total marketing cost to gross income) and operating ratio (ratio of total variable cost to gross income).

Marketing margin represent the difference in the price paid by the final consumer and that received by the producer at different stages of time, place and possession as the product move from its producer to its ultimate consumer (Arene, 1998 and Olukosi *et al*, 2005). It is mathematically defined as: -

$$\text{Marketing Margin (MM)} = \frac{\text{Resell Price} - \text{Purchase Price}}{\text{Resell Price}} \times 100$$

Budgeting technique was used to analyze the cost and return to rice marketing in the study area. Regression analysis was used to determine the relationship between marketing margin and variables included in the model.

Marketing Efficiency (ME): - This was used to measure the performance of rice marketing system as a whole. It describes how well the process of marketing is performed by rice marketers in Gombe Metropolis to maximize profit (Olukosi *et al*., 2005). The model is mathematically specified as:

$$\text{Marketing Efficiency (ME)} = \frac{\text{Value Added}}{\text{Processing and Marketing Cost}} \times 100$$

RESULTS AND DISCUSSION

Cost of marketing rice in Gombe Metropolis

Information on costs components of rice marketing in Gombe town is shown in Table 1. The table shows total rice marketing cost incurred by all rice marketers to be **N**6, 610,214.70. This gave an average of N73, 446.83 per marketer and **N**37.30 per Kilogram of rice. The total cost is made up of variable and fixed costs. The study revealed that, among the variable costs, cost of paddy rice constituted 80.38% of the total cost of marketing. Transportation, Packaging, milling, loading, uploading and Miscellaneous expenses constituted 4.62%, 2.28%, 1.78%, 0.91%, 0.63% and 0.80% respectively. The total variable cost was ₦6, 041,925.0. The fixed costs constituted 8.60% of the total cost of marketing rice in Gombe town. The low level of fixed cost is a reflection of low level of capital investment in rice marketing in Gombe town. The absence of “interest charges” from the list of fixed cost indicated that none of the rice marketers got loan from financial institutions in Gombe town. The total fixed and variable costs were ₦ 568, 289.70 and ₦ 6, 041,925.00 respectively.

Gross Income for Rice Marketers in Gombe Metropolis

The Gross Income for rice marketers' in Gombe town was found to be ₦ 15, 064,600.00. The value was obtained by multiplying the physical quantity of milled rice by the unit (retail) price and summing together for all the respondents. This value gave an average of ₦ 167, 384.44 per rice marketer and/or ₦ 85.00 per kilogram of rice. The distribution of rice marketers according to their gross income is shown in Table 2. The table shows that 23.33% of rice marketers in Gombe metropolis had a gross income of less than ₦ 50, 000.0. The study also revealed that 16.67% each had a gross income of between ₦50, 000.0 to ₦100, 000.0 and ₦100, 001 to ₦150, 000.0. The study further revealed that 7.77% and 5.56% of rice marketers had gross income of between ₦200, 001.0 to ₦250, 000.0 and ₦250, 001.0 to ₦300, 000.0 respectively.

Net Income from rice marketing in Gombe Metropolis

The net income was obtained by subtracting the total cost of rice marketing from the gross income. The net income for all rice marketers was ₦8, 454,385.30. This gave an average ofN93, 937.61 per rice marketer or ₦47.70 per Kilogram of rice. The study also revealed a gross ratio (ratio of total marketing cost to gross income) of 0.439 and operating ratio (ratio of total variable cost to gross income) of 0.401. Since these ratios are less than one, it means that rice marketing is profitable in the study area. The distribution of rice marketers according to their net income is shown in Table 3. The Table shows that 13.33% had a net income of less than one naira (**N**1.00) this shows that they incurred a lost. The table also shows that 47.78%, 22.22%, and 6.66% each had net incomes of between ₦1.00 and ₦100, 000.00, ₦100, 001.00 and ₦200, 000.00, ₦200, 001.00 and ₦300, 000.00 and ₦300, 001.00 and ₦400,000.00 respectively. The table further revealed that 1.11% each had a net income of between ₦400, 001.00 to ₦500, 000.00, ₦500, 001 to ₦600, 000.00, ₦600, 001.0 and ₦700, 000.00 (Table 3).

Profitability Index (PI), marketing efficiency and net income per kilogram of milled rice sold

Table 4 below shows the Profitability Index (PI), Marketing Efficiency (ME) and Net Income (NI) of milled rice sold in Gombe metropolis. The profitability index was found to be 56.12%. This shows that for every one naira (₦1.00) invested on rice marketing in Gombe Metropolis, N0.56 is returned as profit. This shows that rice marketing is a profitable business in Gombe Metropolis. The result agrees with findings of Achike and Okoye (2004) which found that small-scale rice marketing is a profitable enterprise. Similarly, Marketing Efficiency (ME) was found to be 150.16%. This implies that market performance was good with respect to prices of milled rice in Gombe Metropolis. The result agrees with the findings of Bose *et al* (2012), which found a market performance of 130.46% for milled rice in Dass Local Government Area of Bauchi State. The distribution of rice marketers according net income per kilogram of milled rice sold is shown in Table 4. The result revealed that 14.44% of rice marketers in Gombe Metropolis had a net income per kilogram of less than ₦1.00. The result also revealed that 28.89%, 40.0% and 15.56% had a net income per kilogram of between ₦1.00 to ₦50.0, ₦50.1 to ₦100.0, and ₦101.1 to ₦150.0 respectively.

Marketing Margin

The marketing margin for milled rice marketers in Gombe Metropolis was found to be 39.30%. This shows that majority of rice marketers (66%) received a marketing margin range of 1.0% to 40.0% with a mean of 39.3% among the respondents. The distribution of rice marketers in Gombe Metropolis based on marketing margin is shown in Table 5. The table shows that 3.33% of rice marketers had a marketing margin of less than 1.00%. The table also shows that 18.89%, 24.44% and 5.56% had a marketing margin of 1.0% to 10.0%, 10.1% to 20.0% and 30.1% to 40.0%. The table further revealed that 30.0% and 13.33% had a marketing margin of 60.1% to 70.0% and greater than 70.0% (Table 5).

Production function estimates and analysis

Multiple regression analysis was used to measure the effect of Age (X_1), Marital Status (X_2), Sex (X_3), Level of Education (X_4), Source of Capital (X_5), Transport Cost (X_6), Selling Price (X_7), Purchase Price (X_8), Quantity of Milled Rice Sold (X_9) and Tax (X_{10}) on Marketing Margin (Y). The result of regression model was obtained for the Linear, Semi log and Cobb-Douglas functional forms. Table 6 shows the regression coefficients and t-ratios for the three functional forms. The coefficient for each variable shows the extent to which variation in that variable explains variation in the marketing margin (dependent variable). The choice of Cobb-Douglas form of the model was based on its conformation with *a priori* expectation in terms of signs and magnitude of the coefficients, the number of significant variables, coefficient of multiple determination (R-square value), and F ratio. The results revealed that variables like Age, Sex and Cost of Transportation are positive and significantly affect marketing margin of rice marketers in

Gombe Metropolis (P≤ 0.001). Therefore, a 1.0% change in these variables will lead higher marketing margin for milled rice in Gombe Metropolis. However, the results also revealed that Level of Education, Source of Capital, Selling Price, Quantity of Milled Rice sold and Tax even though significant, negatively affect marketing margin of milled rice in Gombe Metropolis (P ≤ 0.05). Thus, a 1.0% change in these variables will lead to lower marketing margin for milled rice in the study area. The result further revealed R^2 (Adjusted) and F ratio to be 57.5% and 13.060 (Table 6). This means that 57.5% of variation in marketing margin of milled rice in Gombe Metropolis is explained by variables included in the model. The significant F-statistics of 13.06 implies that the joint effects of all the explanatory variables included in the model are significant.

The Problems faced by Rice Marketers in Gombe Metropolis

Table 7 shows the problems faced by milled rice marketers in Gombe metropolis. The Table shows that inadequate electrical power supply and capital, instability in prices of paddy and milled rice, high cost of transportation (due to inadequate vehicles poor road networks especially in rural areas) ranked 1st, 2nd, 3rd and 4th were the major problems facing marketers of milled rice in Gombe metropolis. This result is in line with the findings of Biam and Koko (2007) who found that inadequate capital is one of major problems facing small-scale rice business in Benue state of Nigeria. Awoyinka (2009) also found that inadequacy of transport facilities especially in rural areas leading to high transportation cost, inefficient and inadequate storage facilities, poor marketing of agricultural produce are some of the problems facing marketing of agricultural produce in Nigeria. Similarly, low demand or patronage from consumers, shortage of product especially paddy rice, low quality of paddy rice and so the milled rice, poor road networks in rural areas, problem of rainfall (which sometimes make it difficult for drying of paddy rice before milling as well as for transactions to take place due lack of shades especially in rural markets) and inadequate storage facilities were ranked 5th, 6th, 7th, 8th, 9th and 10th problems facing marketers of milled rice in Gombe metropolis.

CONCLUSION

From the findings of this study it could be concluded that milled rice marketing is a profitable enterprise in Gombe metropolis. This is because rice marketers realized a marketing margin, marketing efficiency and return per naira invested on rice marketing of 39.30%, 150.16% and **N**0.56 respectively. Empirical evidence from the study indicated that 57.5% of the variation in marketing margin for rice in Gombe metropolis was explained by explanatory variables included in the model with age, sex and cost of transportation significantly contributing positively. There is little or no investment in capital assets: milling, par-boiling, de-stoner, polishers and packaging machines. Rice marketing in Gombe metropolis is constrained by shortage of product during certain periods of the year, poor road networks, inadequate capital, electricity and price instability among others.

RECOMMENDATIONS

Based on the findings, the study recommends that rice marketers should be encouraged to invest on fixed assets especially milling machines with components for parboiling, de-stoning, and polishing in order to add value to rice marketed and also improve the quality of locally milled rice in Gombe metropolis. Gombe State Government should improve on the quality of existing road networks in the state and also construct more so that rice marketers will have easy access to rice producers especially in rural areas at minimum cost. Rice marketers in Gombe metropolis should be encouraged to form cooperative associations. This will enable them have easy access to loans from formal financial institutions in Gombe state. Power Holding Company of Nigeria (PHCN) should improve supply of electricity to the State capital. Local Government Councils in Gombe State should construct shades for marketers so that their product will not be destroyed by rain, too much sunlight etc. Gombe State Government should provide rice farmers with improved varieties of rice that is of high yielding and quality.

REFERENCES

AbdulAzeez, R.O., AbdulRahman, S. and Oladimeji, Y. U. (2018) Economic Diversification Strategies of Farmers Under Kogi State Accelerated Rice Production Programme (KARPP) A Rationale to Sustainable Economy. In Anamayi, S.E., Balogun, S.O, Shauna, H., Olagunju, O.E, Adelani, O.O., Akinyemi, M. M., Ariyo, C.O, Onwegbunam, D. O., Olagunju, S. O., Awotide, O. G., Ogechi, N., Kehinde, F., Lukman, A.S. and Alabi, O. (Eds) Diversification of the Nigerian Economy Where Lies Agriculture. Proceedings of 16th Annual

Achike, A. I. and Okoye, F. U. (2004). Cooperative Profitability Analysis of Selected Rice Enterprise in Anambra State. In. Nwaru, J.C.; Mejeha, R. O.; Okoye, B. C.; Nwachukwu, I.N.; Nwachukwu, I.; Ekumankama, O.O.; Agugo, B.A.C.; Iheke, O.R.; Ogbe, S.E. (Eds)

Adelani, O.O., Akinyemi, M. M., Ariyo, C.O, Onwegbunam, D. O., Olagunju, S. O., Awotide, O. G., Ogechi, N., Kehinde, F., Lukman, A.S. and Alabi, O. (Eds) Diversification of the

Nigerian Economy Where Lies Agriculture. Proceedings of Annual National Conference of Nigerian Association of Agricultural Economists (NAAE) held at Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria 15th – 18th October, 2018, pp 1075 - 1081.

Agricultural Productivity and Growth: Strategies for Meeting the Millennium Development Goals (MDGs). Proceedings of the 26th Annual Conference of the Farm Management Association of Nigeria (FAMAN) held at the Michael Okpara University of Agriculture, Umudike, Nigeria 15th – 19th October, 2012, pp 307 – 309.

Anyaegbumam, H. N; Nwosu, A. C. And Mbasanor, J. A. (2011). Spatial Price analysis of Sweet potato marketing in the South-east agro-ecological Zone of Nigeria. *The Nigerian Agricultural Journal,* 42:130-137.

Arene, C. J. (1998). Introduction to Agricultural Marketing Analysis for Developing Economies. In. Nwaru, J.C.; Mejeha, R. O.; Okoye, B. C.; Nwachukwu, I.N.; Nwachukwu, I.;

Awoyinka, Y. A. (2009). Cassava marketing: option for sustainable agricultural development in Nigeria. In: Musa YN, Reuben J, Magaji I.Y. 2013. Problems associated with agricultural produce marketing in Nigeria: the experience of milled rice women marketers from southern taraba state, nigeria. Research Journal of Agricultural and Environmental Management. 2

Biam, C.K. and Koko, E. K. (2007). Economic Appraisal of Small Scale Rice Processing Business in Benue State, Nigeria. In: Nwaru, J.C.; Mejeha, R. O.; Okoye, B. C.; Nwachukwu, I.N.; Nwachukwu, I.; Ekumankama, O.O.; Agugo, B.A.C.; Iheke, O.R.; Ogbe, S.E. (Eds) Agricultural Productivity and Growth: Strategies for Meeting the Millennium Development Goals (MDGs). Proceedings of the 26th Annual Conference of the Farm Management Association of Nigeria (FAMAN) held at the Michael Okpara University of Agriculture, Umudike, Nigeria 15th – 19th October, 2012, pp 307 – 309.

Bose, A. A.; Sani, M. H.; Atman, F. M. and Sylvester, B. (2012). Economics of Paddy Rice

Cojocaru C., 2000, Financial-economic Analysis of Agricultural and Forestry Exploitations, Economic Publishing House, Bucharest;

Criteria for Types of Rice in Togo. A Choice Modelling Approach. The 4th International Conference of the African Association of Agricultural Economists, September, 22-25, 2013, Hammamet, Tunisia, pp 1-20.

Dictionary of Marketing Terms, 2d ed., ed. Peter D. Bennett (Chicago: American Marketing Association, 1995).

Ekumankama, O.O.; Agugo, B.A.C.; Iheke, O.R.; Ogbe, S.E. (Eds) Agricultural Productivity and Growth: Strategies for Meeting the Millennium Development Goals (MDGs). Proceedings of the 26th Annual Conference of the Farm Management Association of Nigeria (FAMAN) held at the Michael Okpara University of Agriculture, Umudike, Nigeria 15th – 19th October, 2012, pp 312 – 317.

Filli, F. B., Audu, I. A. and Olayiwola, S. A. (2018). Implication of Policy of Importation Embargo on Shift in Rice Demand and Consumption between 2015 and 2017 Among Dwellers of Wukari, Taraba State, Nigeria. In Anamayi, S.E., Balogun, S.O, Shauna, H., Olagunju, O.E,

Food and Agricultural Organization (2004) Rice is Life. In. Wikipedia, the free encyclopedia. http://en.wikipedia.org/wiki/Rice. Accessed on 11/12/2022.

Food and Agricultural Organization (2005) Rice Statistics. Food and Agricultural Organization. Rome. Italy. http://www.riceweb.org. Accessed on 10/08/2022.

Food and Agricultural Organization (2006) Production Statistics. FAO Statistics. In Food and Agricultural Organisation. Rome. http://www.faoproductionstat.

Food and Agricultural Organization (2018) (FAOSTAT) Crops/Regions/World list/Production Quantity, Rice Paddy, Production Statistics. FAO Statistics. In Food and Agricultural Organization. Rome. http://www.faoproductionstat.

Geamanu, M. (2016). *Economic efficiency and profitability*. *April*.

Juliano, Bienvenido O. (1993). "Rice in human nutrition". Food and Agricultural Organization of the United Nations.

Maddox, Gregory [ed.] (2006). Sub-Saharan Africa: An Environmental History. In. Wikipedia, the free encyclopedia. http://en.wikipedia.org/wiki/Rice. Retrieved on 11/11/2022.

Mejeha, R. O.; Okoye, B. C.; Nwachukwu, I.N.; Nwachukwu, I.; Ekumankama, O.O.;

National Conference of Nigerian Association of Agricultural Economists (NAAE) held at Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria 15th – 18th October, 2018, pp 1075 - 1081.

National Population Commission. **(**2006). Result of the 2006 population census. NPC, Abuja, Nigeria. 2007.

National Research Council (1996). "African Rice". *Lost Crops of Africa: Volume I: Grains*. Lost Crops of Africa **1**. National Academies Press. Retrieved December 18, 2022.

Olukosi, J. O.; Isitor, S. U. and Ode, M. O. (2005). Introduction to Agricultural Marketing and Prices: Principles and Application. In. Nwaru, J.C.; Mejeha, R. O.; Okoye, B. C.; Nwachukwu,

Peter Drucker, Management: Tasks, Responsibilities, Practices (New York: Harper & Row, 1973), pp. 64–65.

Tiamiyu, M. S. A. (2014) Trends Analysis of Milled Rice Consumption in Nigeria. International Journal of Agricultural Policy and Research. 2(10):352 – 356.

Wikipedia (2023) Rice –Wikipedia https://en.m.wikipedia.org Retrieved 7th March, 2023.

Table 6: Gross income, components of fixed and variable cost

Item	Value (₦)	Percentage of total costs
Variable Costs		
Paddy rice	5,313,200	80.38
Loading	59, 973	0.91
Uploading	41, 635	0.63
Milling	117, 980	1.78
Transportation	305, 555	4.62
Packaging	150, 700	2.28
Miscellaneous (Feeding etc)	52, 880	0.80

Total variable cost	041,925	91.40
Fixed cost		
Tax	25,340	0.38
Rent	535, 450	8.10
Depreciation on fixed assets (mud)	7, 499.70	0.11
Total Fixed Cost	568,289.70	8.60
Total Cost	6,610.214.7	100
Gross Income	15,064,600	
Gross Margin	9,022,675	
Net Income	8,454385,30	
Quantity of Milled Rice (kg)	177,223.20	

Source: Field Survey, 2021

Table 7: Gross Income from Rice marketing in Gombe Metropolis

Gross Income (#)	**Number of Respondents**	**Percentage**
< 50, 000.0	21	23.33
50, 001.0 – 100, 000.0	15	16.67
100, 001.0 –150, 000.0	15	16.67
150, 001.0 –200, 000.0	12	13.33
200, 001.0 –250, 000.0	7	7.77
250,001.0 – 300, 000.0	5	5.56
>300, 000.0	15	16.67
Total	90	100

Source: Field Survey, 2021

Table 8 Net Income from Rice Marketing in Gombe Metropolis

Net Income (N)	**Frequency**	**Percentage**
< 1.00	12	13.3
1.00 – 100, 000.00	43	47.8
100, 001.00 – 200,000.00	20	22.2
200, 001.00 – 300,000.00	6	6.7
300, 001.00 – 400,000.00	6	6.7
400, 001.00 – 500,000.00	1	1.1
500, 001.00 – 600,000.00	1	1.1
600.001.00 – 700,000.00	1	1.1
Total	90	100

Source: Field Survey, 2021

Table 9: Net Income per Kilogram of Milled Rice Sold

	Number of Respondents	Percentage
< 1.0	13	14.44
1.0 – 50.0	26	28.89
50.1 – 100.0	36	40.00
100.1 –150.0	14	15.56
>150.0	1	1.11
Total	90	100

Source: Field Survey, 2021

Table 10: Distribution of Rice Marketers According to Market Margin

Marketing Margin (%)	Number of Respondents	Percentage (%)
< 1.00	3	3.33
1.00 – 10.0	17	18.89
10.1 – 20.0	22	24.44
20.1 – 30.0	3	3.33
30.1 – 40.0	5	5.56
40.1 – 50.0	-	-
50.1 – 60.0	1	1.11
60.1-70.0	27.12	30.0
>70.0	90	99.99

Source: Field Survey 2021

Table 11: Estimated regression on result for determinants of marketing margin for milled rice

Variable	Production Function					
	Linear		Semi- log		Cobb-Douglas	
	Coefficients	t-ratio	Coefficients	t-ratio	Coefficients	t-ratio
Constant (a)		6.202ns		-1.045ns		2.449**
Age (X_1)	0.21	0.838**	0.132	2.062**	0.226	2.588***
Marital Status (X_2)	-0.062	-2.299ns	-0.140	-2.044ns	-0.088	-0.937ns
Sex (X_3)	0.095	3.842**	0.189	3.020**	0.015	0.187***
Level of Education (X_4)	-0.009	-0.435ns	-0.132	-2.445ns	-0.215	-2.608**

Source of Capital (X_5)	-0.004	-0.200ns	-0.057	-1.016ns	-0.091	-1.233**
Transport Cost (X_6)	0.029	0.954**	0.170	2.186**	0.468	4.852***
Selling Price (X_7)	0.403	17.203**	0.088	1.476ns	-0.099	-1.317**
Purchase Price (X_8)	-1.083	-44.086**	-0.852	-13.662**	-0.592	-6.815**
Quantity of Milled Rice Sold (X_9)	-0.022	-0.853ns	-0.130	-2.002ns	-0.204	-2.135**
Tax (X_{10})	-0.010	-0.355ns	-0.025	-0.344ns	-0.026	-0.242**
R^2	0.527		0.586		0.623	
Adjusted R^2	0.493		0.519		0.575	
F ratio	8.419		9.061		13.060***	
Durbin- Watson	1.151		1.799		1.883	

Where *** = Significant at 1%, ** = Significant at 5%. NS = Not Significant at either 1% or 5%.

Table 12: Distribution of respondents according to constraints of milled rice marketing

Problems	Frequency	Percentages (%)	Rank
Inadequate electricity	*43*	47.8	1st
Inadequate capital	41	41.11	2nd
Price fluctuations	30	33.33	3rd
High transportation cost	28	31.11	4th
Low patronage	24	26.70	5th
Shortage of paddy rice	21	23.00	6th
Low quality of paddy and milled rice	*17*	18.89	7th
Poor road network	*14*	15.56	8th
Rainfall	11	12.22	9th
Inadequate storage facilities	6	6.67	10th
Poor packaging (Bagging)	5	5,56	11th
Lack of Workers	4	4.44	12th
Poor sunshine (During rainy season)	3	3.33	13th
Problem of communication (language barrier)	2	2.22	14th
Credit purchase	2	2.22	14th
Insecurity, illiteracy, low profit and high taxation	1	1.11	15th

Source: Field Survey, 2021

ADDING VALUE TO AGRICULTURAL PRODUCE FOR FOOD SECURITY AND INCOME GENERATION

MICROALGAE AS A POTENTIAL CROP IN AQUAFEED FOR IMPROVED AQUACULTURAL PRODUCTION AND VALUE ADDITION

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ABSTRACT
Microalgae are rich in essential nutrients, including proteins, lipids (especially omega-3 fatty acids), vitamins, and minerals, which are crucial for fish growth and health and offer a sustainable alternative to fish meal and fish oil, helping to reduce the aquaculture industry's reliance on wild fish stocks. Certain microalgae species can enhance fish growth rates, potentially improving farm productivity. The research aimed at establishing the most suitable substrate and optimum condition for *Chlorella vulgaris* and Spirulina *platensis* cultivation for use in aquafeed. It has been concluded from the research findings that BG-11 medium as a medium for algal growth support the growth of *Chlorella vulgaris* at pH of 7.4 but could not support that of *S. platensis* hence Zerrouk's medium which is a modification of BG-11 at pH of 9.0 and different salinity. Moreover, *S. platensis* grow faster than *C. vulgaris.*
Keywords: Microalgae *Spirulina Chlorella* Bioreactor Aquaculture Aquafeed

INTRODUCTION

Microalgae play an important role as feed ingredients for fishes, because of their nutritive properties, vibrant pigment profiles and a high content of bioactive compounds with cytostatic, antiviral, anthelmintic, antifungal and antibacterial activities as detected in green, brown and red algae (Chacon-Lee *et al.*, 2010; Ansari *et al.*, 2021). Previous research has focused extensively on the microalgae *Spirulina* (*Arthrospira*) and *Chlorella* due to their notable characteristics. These species have drawn interest for their rapid cultivation potential and rich nutritional profiles. Specifically, they are prized for their high concentrations of proteins, amino acids, lipids including polyunsaturated fatty acids (PUFAs) and sterols, as well as various pigments (Raji *et al.*, 2020).

Chlorella as a food and supplement has been reported by many researchers to contain nutrients and vitamins that are absent in plant derived food such as vitamin D and B_{12} and folate and iron than any other plant derived food (Bito *et al.*, 2020; Nasreen *et al., 2020*). When dried, it is about 45% protein, 20% fat, 20% carbohydrate, 5% fibre, and 10% minerals and vitamins (Chen *et al.*, 2021). *Spirulina*, a nutrient-dense microalga, has gained commercial popularity due to its exceptional nutritional profile. It serves dual purposes as a health-boosting dietary supplement for humans and a cost-effective feed additive for livestock. In the realm of aquaculture, *Spirulina* has proven valuable for enhancing the immune response and survival rates of young farmed fish, while also acting as a natural colorant to improve the appearance of their flesh (Tongsiri *et al*., 2010).

MATERIALS AND METHODS

Study Area

The study was conducted at Tissue Culture Laboratory, Centre for Dry Land Agriculture, Bayero University Kano.

Collection of water sample

Water sample was obtained from earthen pond of Department of fisheries and aquaculture farm Bayero University Kano around 8:05am using plankton net.

Identification of Microalgae

Water sample microscopy was done immediately after concentrating the samples. cells were viewed using a Hund Wetzer H 60D electron Microscope attached to an Am scope MD 900E Camera at ×400 and were identified using standard Phycological keys, illustrations and morphological criteria as described by Palmer (1980); Komarek and Anagnostidis (2005).

Isolation and obtaining Pure Culture of Algae

Isolation of algal cells was done through Capillary Pipette isolation method as described by Hordy (1993). This involved putting small droplets containing algal cells on a sterile glass slide. The drops were examined under the microscope and single algal cells were isolated with a sterile capillary pipette and transferred into a fresh BG 11 medium for *C. vulgaris* at 24^{o}C (Temraleeva *et al*., 2016) and Zerrouk's medium for *S. platensis* at 30^{o}C (Zerrouk, 1966) and incubated for 96 hours under light and dark phase of 16:8 (Dineshkumar, 2015).

Purification of Algal Culture

The pure cultures were purified against contaminants by using a combination of antibiotics and antifungal containing Chloramphenicol 25mg/l, Penicillin 10mg/l and Griseofulvin 50mg/l (Korn, 1994).

Preparation of BG 11 Medium

The BG11 (Table 1) was prepared following the method outlined by Temraleeva *et al*. (2016). The stock solutions of macronutrients (100ml), micronutrients (10ml) were mixed and made up to one litre (1 L) with distilled water. The medium was stirred using a magnetic stirrer (RS Lab, India), pH was checked using a pH meter (Jenway 3520, UK) and adjusted to 7.4 with 1M NaOH and 1M HCl. The medium was then sterilized in an autoclave (Nuve, Turkey) at 121°C and 15 psi for 15 minutes and allowed to cool down before inoculating the *C. vulgaris* isolate.

Preparation of Zerrouk's medium

The medium (Table 2) was prepared as described by Zerrouk *et al* (1966). Macronutrients were dissolved in distilled water. After then, micronutrients were added into the solution and mixed thoroughly. The medium pH was checked using pH meter (Jenway 3520, UK) and adjusted to 9.0 using IM HCl and 1M NaOH. The prepared medium was autoclaved at 121°C for 15 minutes. It was then cooled to room temperature and kept in a refrigerator for further use.

Production of Microalgae in a 5L Photobioreactor (Cleaver, UK)

One ml of pure algal culture (plate i) of *S. platensis* and *C. vulgaris* were inoculated into test tubes containing 9 ml of freshly prepared Zerrouk's medium at 30°C (Dineshkumar, 2015) and BG 11 medium at 24°C (Temraleeva *et., 2016*) respectively for 96 hours under light and dark regime of 16:8. The Culture was scaled up to 90 ml of medium in a 100 ml conical flask, which was subsequently transferred into a 1000 ml flask containing 900 ml for Zerrouk's medium and BG 11 medium. The final culture (1 L) was poured into a 5 L photo-bioreactor (Plate ii) as described by Wang *et al.* (2019); Sirohi *et al.* (2022).

Plate i: Pure algal Culture

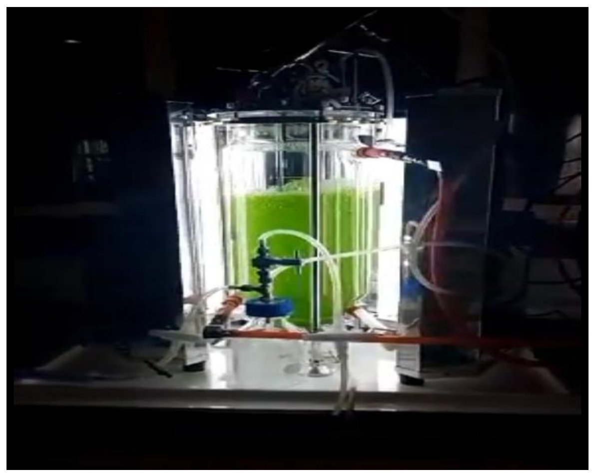

Plate ii: Culturing of Microalgae in Photobioreactor

Harvesting and Processing of Microalgal Biomass

Different methods of harvesting the culture of *C. vulgaris* and *S. platensis* biomass were adopted as reported by Patidar and Gulab (2018) and show (2020). Centrifugation was done using a centrifuge model Centromix, Huddersfield, England at 1500 rpm for 3 minutes and subsequent freeze drying and grinding (Plate iii, iv & v) at room temperature was employed to obtain the algal meal (Wang *et al.*, 2019; Aljabri *et al*., 2023).

Plate iii: Harvested Microalgae

Plate iv: Freeze drying of Microalgae

Plate v: Microalgal Meal

RESULTS & DISCUSSION

Conditions for Growth of the Purified Microalgae

Figure 2 and 3 shows the pure culture of *C. vulgaris* cultured with BG-11 medium. However, the BG-11 failed to support the growth of *S. platensis* at pH of 7.4, while Zerrouk's medium which is a modification of BG-11 at pH of 9.0 supported its growth and this is in line with the study findings of Dineshkumar, 2015, 2017. This could be due to the fact that *S. platensis* grows in a higher pH than *C. vulgaris* and variation in nutritional requirements as depicted in their media composition. However, the finding of this research WANGcontradicts that of Joshi *et al*., 2018 who increases the temperature of his set up during his trial with BG-11 and found the BG 11 medium the best algal medium among the three media studied. Five (5) day old culture (*C. vulgaris and S. platensis*) were harvested from the bioreactor, centrifuged, freeze dried and grinded stored in a refrigerator for further use.

Morphological Description of Purified Microalgae

Chlorella vulgaris

The cells are spherical to ellipsoidal in shape (2–10µm in diameter) with a single pyrenoid present as described by Prescott (1954). A single parietal chloroplast nearly fills the cell. The cells are non-motile and surrounded by a thin and smooth cell wall (Plate vi)**.**

Spirulina platensis

S. platensis appeared to be unbranched, spiral as the result of regular screw-like coils, trichome may be short or long as described by Janes *et al.* (2006). Cylindrical with apical or end cells rounded which may have thickened walls (Plate vii).

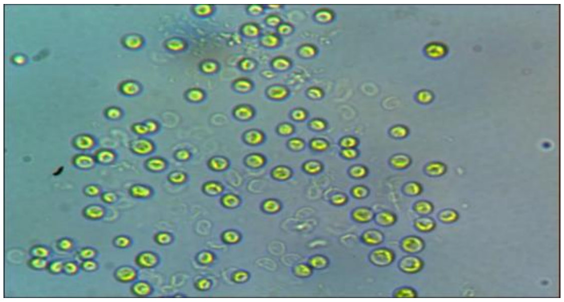

Plate vi: *Chlorella vulgaris* (×400)

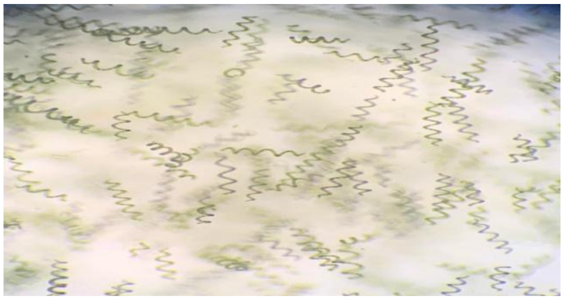

Plate vii: *Spirulina platensis* (×100)

CONCLUSIONS

The present investigation was chosen with the basic aim of selecting correct medium for *C. vulgaris and S. platensis* strains for biomass production and incorporation into aquafeed. The present study concluded that Zarrouk's medium is the best medium for *S. platensis* as it grows at higher salinity, temperature and pH than *C. vulgaris* which grows at BG-11 under different conditions.

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REFERENCES

Aljabri, H., Cherif, M., Siddiqui, S. A., Bounnit, T. and Saadaoui, I. (2023). Evidence of the drying technique's impact on the biomass quality of Tetraselmis subcordiformis (Chlorophyceae). *Biotechnology for Biofuels and Bioproducts.* 16. Doi: 10.1186/s13068-023-02335-x.

Ansari, F.A., Guldhe, A., Gupta, S.K., Rawat, I. and Bux, F. (2021). Improving the feasibility of aquaculture feed by using microalgae. *Environ.l Sci. and Pollution Research*, 28: 43234 - 43257.

Bito, T., Okumura, E., Fujishima, M. and Watanabe, F. (2020). Potential of *Chlorella* as a Dietary Supplement to Promote Human Health. *Nutrient.* 12(9): 2524. Doi: 10.3390/nu12092524.

Chacon-Lee, T.L. and González-Marino, G.E. (2010). Microalgae for "healthy" foods-possibilities and challenges. *Comprehensive Review in Food Science and Food Safety*, 9: 655-675.

Chen, F., Leng, Y., Lu, Q. and Zhou, W. (2021). The Application of Microalgae Biomass and Bio-products as Aquafeed for Aquaculture. *Algal Research*. Vol. 60. Doi: 10.1016/j.algal.2021.1025.

Dineshkumar, R., Sampathkumar, P. and Narendran, R. (2015). Cultivation of *Spirulina platensis* in different selective media. *Indian J. Mar. Sci.*, 45 (12): 1749-1754.

Janse van Vuuren, S., Taylor, J., Gerber, A., & Van Ginkel, C. (2006). *Easy identification of the most common fresh Water Algae: A guide for the identification of microscopic algae in South African freshwaters.* ISBN: 0-621-35471-6.

Joshi, V.P., Chauhan, P.M., Joshi, K.B. and Joshi, N.H. (2018). Growth Parameter Optimization and Biochemical Appraisals of *Spirulina platensis*. *Int. J. Curr. Microbiol. App. Sci* (2018) 7(11): 160-169.

Komarek, J. and Anagnostidis, K. (2005). Subwasserflora Von Mitteleuropa. Cyanoprokaryota. 2 Teil. 19/2. Pp759.

Nasreen, M., Abdulrahman, S., Abid, H. and Mustafa, K. (2020). Effect of microalgae *Chlorella pyrenoidosa* as feed additive on common carp (*Cyprinus carpio* L.) nutritional performance, proximate composition and organoleptic evaluation. *Biological and Applied Environmental Research*, 3 (2): 118-126.

Palmer, C. M. (1980). *Algae and Water Pollution: The Identification, Significance and Control of Algae in Water*. Castle House Publications, Los Angeles.

Patidar, S. K. and Gulab Singh (2018). Microalgae Harvesting Techniques: A Review. *Journal of Env. Management*. 217 (6) 499-508.

Prescott, G. (1954). *The Fresh Water Algae. 3rd ed.* (H. Jaques, Ed.) Michigam: WM. G Brown Company. Lowa, USA. 384p.

Raji, A. A., Jimoh, W. A., Abu Bakar, N. H., Mohd, Taufek, N. H., Muin, H. Alias, Z., Milow, P. and Abdul Razak, S. (2020). Dietary use of *Spirulina* (Arthrospira) and *Chlorella* instead of fish meal on growth and digestibility of nutrients, amino acids and fatty acids by African catfish. *Journal of Applied Phycology*. Doi: 10.1007/s10811-020-02070-y.

Singh, J.S., Kumar, A. and Singh, M. (2019). Cyanobacteria: a sustainable and commercial bio-resource in production of bio-fertilizer and bio-fuel from waste waters. *Environ. Sustain. Indicat.* 2019:3:100008.

Sirohi, R., Pandey, A. K., Ranganathan, P., Singh, S., U, A., Awasthi, M. K., Hoang, A. T., Chilakamarry, C. R., KiM, S. H. and Sim, S. J. (2022). Design and Applications of Photobioreactors. A Review. *Bioresourse Technology*. 349, 126858, 2022. Doi. 10.1016/j.biortech.2022.126858.

Temraleevaa, A. D, Dronovaa, S. A, Moskalenkoa, S. V. and. Didovich, S. V. (2016). Modern Methods for Isolation, Purification, and Cultivation of Soil Cyanobacteria. *Microbiology*, 2016, Vol. 85, No. 4, pp. 389–399.

Tongsiri, S., Mang-Amphan, K. and Peerapornpisal, Y. (2010). Effect of Replacing Fishmeal with *Spirulina* on Growth, Carcass Composition and Pigment of the Mekong Giant Catfish. *Asian Journal of Agricultural Sciences 2(3): 106-110, 2010.*

Wang, Q., Peng, H. and Higgins, B. T. (2019). Cultivation of Green Microalgae in Bubble Column Photobioreactor and an Assay for Netral Lipids. *J. Vis Exp*.7(143). Doi.10.3791/59106.

Zarrouk, C. (1966). *Contribution a l'edtude d'une cyanobacterie*: Influence de divers facteurs physiques et chimiques sur la croissance et la photosynthese de *Spirulina maxima* (Setchell et Gardner) Geitler. PhD thesis. University of Paris; France.

Table 1: Chemical Composition of BG 11 Medium

Ingredients	Quantity (g)
i- Stock solution (I) per litre	
$NaNO_3$	1.5
K_2HPO_4	0.04
$MgSO_4.7H_2O$	0.075
$CaCl_2.2H_2O$	0.036
Na_2CO_3	0.02
Citric acid	0.006
$FeNH_3$-citrate	0.006
ii- Stock solution (II) per 500ml	
H_3BO_3	2.86
$MnCl_2.4H_2O$	1.81
$ZnSO_4.4H_2O$	0.222
Na_2MoO_4	0.390
$CuSO_4.5H_2O$	0.079
$Co(NO_3)_2.6H_2O$	0.049
$Na_2EDTA.2H_2O$	1.000
Distilled Water	1 L

Table 2: Chemical Composition of Zerrouk's Medium

Ingredients	Quantity
Macronutrients	
NaCl	1.0
$CaCl_2.2H_2O$	0.04
$NaNO_3$	2.5
$FeSO_4 \cdot 7H_2O$	0.01
EDTA (Na)	0.08
K_2SO_4	1.0
$MgSO_4 \cdot 7H_2O$	0.2
$NaHCO_3$	16.8
K_2HPO_4	0.5
Micronutrients	
H3BO3 (2.29), MnCl2.4H2O (1.81), ZnSO4.4H2O (0.222), Na2MoO4 (0012), CuSO4.5H2O (0.08)	1ml
Distilled Water	1 L

EFFECT OF FIELD SPRAY OF SELECTED BOTANICALS AGAINST TARO LEAF BLIGHT ON SHELF LIFE OF STORED TARO (*Colocasia esculenta*) CORMELS CULTIVARS IN NSUKKA, SOUTHEASTERN NIGERIA

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ABSTRACT

Taro leaf blight caused by *Phytophthora colocasia*e and postharvest losses are the most serious challenges among taro producers, marketers and processors, thereby affecting the quantitative, qualitative and functional properties of *Colocasia esculenta* (L.) cultivars globally. Therefore, the aim of this study was to determine the effect of field spray of selected botanicals on postharvest attributes of stored *Colocasia esculenta* (L.) cormels cultivars at Department of Crop Science, Research and storage barn, University of Nigeria, Nsukka. The study was laid out as 3×5 factorial in completely randomized design (CRD) with three replications. The treatments were three taro cultivars under three botanical field sprays: River red gum (*Eucalyptus camaldulensis*), siam weed (*Chromolaena odorata*) and neem (*Azadiratchta indica*), Ridomil Gold plus (positive control) and Zero treatment (Negative control). It was evident that significant variability existed across the taro cultivars and botanical sprays on postharvest weight loss and rots. Field botanical sprays significantly ($P \leq 0.05$) reduced the postharvest weight loss and rots; improved the survival and viability percentages of taro cultivars in storage. *Eucalyptus spp*, siam weed (*Chromolaena odorata*) and neem (*Azadiratchta indica*) leaves extracts showed the least degree of percentage weight loss and rots followed by Ridomil Gold plus compared to control samples.

Key words: Taro cultivars, botanical spray, postharvest, shelf life, storage

INTRODUCTION

Nature is vast and contains plenty of botanicals that can assist in protecting crops against many infections. Postharvest losses start from field to storage stage. *Colocasia esculenta* (L.), also known as taro (Ugwuoke *et al.*, 2008; Eze *et al.*, 2015), is a significant edible herbaceous underground starch-rich tuber crop in a number of developing Nations of Central and West Africa (CWA), and the Pacific. It is the third most major root and tuber crops in Nigeria after cassava and yam, as well as the first most significant vegetable crop in Ghana (Echebiri, 2004). According to Brooks (2005), it is the fourteenth most significant vegetable crop worldwide. Omeje *et al.*, (2020), observed that the consumption systems of taro cultivars are changing exponentially from poor resource income families, low-income women, large families, scarcity food to year-round food, public ceremonial/social function foods to all poor and rich income resource families and groups due to its high delicacy, nutritional, therapeutic, industrial, socio-economic, and cultural benefits, as well as its increased versatility and use in various food formulations.

At present, Taro leaf blight (TLB) and postharvest loss causing pathogens are the most serious challenges among the taro production stakeholders, processors and marketers influencing the quality and quantity of tubers for use as food, planting materials, and other taro agro-based industrial purposes globally. The rotting of taro tubers is a major factor after TLB that affect the qualities and quantities of tubers for consumption and planting materials (Eunice and Osuji, 2008) and other taro agro-based industrial uses. The resulting rapid decline in taro production and postharvest storage are threating the survival and existence of the crop and extinction is obvious (Ugbaja and Uzoegbunam, 2012), thereby making nations sustainable food production, nutritional, medicinal and socio-economic empowerment impracticable and less effective. In most instances, the management of postharvest losses should start before harvest in the field during production cycle. The first line of proper postharvest losses management is the adoption of pre-harvest infection management especially against the soil borne pathogens. The field management of TLB still rely on the use of synthetic fungicides. However, many botanicals and their phytochemical compounds have been proven by many researchers to have promising fungicidal values of which Neem, *Azadrachta indicia* (A Juss), Siam weed, *Chromolaena odorata* and River red gum, *Eucalyptus camaldulensis* leaves extracts are inclusive. The efficacy of plant extracts activities against soil borne plant pathogens management have been conducted in greenhouse, and in-vitro with little or no trials in field conditions and has yet to meet the expectations for disease management efficacy under field conditions.

The immediate and effective management option against Oomycetes fungal pathogen especially Taro leaf blight disease is by the spray of Ridomil gold plus (active ingredient (a.i), 6% metalaxyl and 60% copper oxide) at weekly or bi-weekly spray regimes depending on disease severity (Omeje, *et al*., 2015) and weather conditions. This is an imported product that is costly, not easily available and procured by all levels of taro production stakeholders. Therefore, there is need to determine the effect of botanicals against Taro leaf blight on improvement of postharvest qualities of taro cultivars. Thus, the specific objective of the study was to determine the effect of field spray of botanicals on shelf-life of taro cultivars in storage.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Department of Crop Science Teaching and Research Farm and taro storage barn of University of Nigeria, Nsukka, Enugu State, Southeastern, Nigeria. Nsukka is situated at latitude 60 52" North and longitude 070 24" East in the derived savannah Zone, at an altitude of 447.26 meters above sea level (m.a.s.l). The average annual rainfall in the region is between 1500 and 2000 mm. The rainfall pattern is bimodal, with peaks in June and September and a brief period of low rainfall and relative humidity stress in August that is usually referred to as "August break." The rainfall pattern begins in March/April and ends in October/November. The dry season lasts from November – March. The soil is a well-drained sandy clay loam classified as an ultisol (USSD) classification belonging to Nkpologwu series (Amuji *et al.*, 2013).

Collection of three taro cultivars

The most popularly growing cultivars in the study area: Nachi (Ede ofe/purple taro/Nce003), Ede ofe /green taro/Nce002) and Ugwuta (Coco- India/ Nce001) were sourced from Opi- Nsukka main market for the study. The rational for the selection of the cultivars were on abundant, popularity, productivity, high prospect, and general acceptance as good cultivars in the study area.

Selection of botanical samples: Botanicals used for the study include; Neem leaves, Siam Weeds and *Eucalyptus* leaves.

Preparation of the botanicals

Fresh leaves of the botanicals were collected and washed thoroughly with tap water and then distilled water separately. They were air-room dried for a week at a point they will be dry enough for milling. The dried samples were separately grinded in a laboratory Mill (Thomas Willey Model ED-5 made in USA) after which the ground samples were sieved to obtain processed powdered samples for the extraction. The processed powdered samples were kept in a sealed/hermetic air tight container to avoid contamination. By adoption of cold solvent extraction method (Doughari *et al*., 2007), the 100 g of each processed powdered sample was mixed with 100 mL of solvent separately in larger rounded conical flask bottle to produce 100% extract concentration, respectively and were allowed to stand for 72 hours.

The extracts were sieved through four layers of sterile cheese cloth filter and stored in sterile round conical flask which was used for field studies on growth, yield and management of Taro leaf blight disease at weekly spray intervals for three months after planting. Therefore, the concentration was calculated by dividing the 50 grammes of plant samples separately by 500 mL of distilled water (aqueous extract) recommended by Ijalo *et al.,* (2010) modified method at the rate of 100 g of plant extract in one liter (1L) of distilled water on weekly extraction and spray schedules.

$$\frac{g}{100} \times \frac{500\ mL}{1}$$

Where g is the grams of the plant sample and mL is the milliliter of solvent (distilled water).

Source of Taro cormels after harvest: Harvested fresh cormels free from any form of postharvest damage and rot were selected from different botanical treated samples and stored in an improved barn for 4 months after harvest (December/January – March/April).

Experimental Design: The study was laid out as 3 ×5 factorial in completely randomized design (CRD) with three replications. The treatments were three taro cultivars under botanical treatments. Each sample of cormels bulk containing 50 pieces were weighed and put at random into a black polythene bag (45 bags). The bags were stacked in the barn at random manner for the period of four months (December/January – March/April).

Measurements of temperature and relative humidity: Temperature and relative humidity of the storage environment were monitored at 10:00 am and 4:00 pm (daily) using a thermocouple. Relative humidity was kept at a range of 70 - 85 % by weekly spray of water on dwarf concrete wall of the storage barn and the entire ground floor below the stacked polythene bag samples by some modification of Chukwu *et al.,* (2008). The fresh weight of the cormels (50 pieces were scaled before storage. During the storage periods, the following parameters were collected using the formula as below.

Determination of post-harvest losses of taro tubers (cormels) cultivars

Weight loss: It was determined by the difference between the initial weight and successive weight loss divided by the initial weight and multiplied by 100 to obtain the percentage weight loss.

$$\text{Weight loss:} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Percentage rot: This was obtained by dividing the total taro rots with the total number of stored taro × 100.

$$\text{Rot (\%)} = \frac{\text{Total taro cormels rotted}}{\text{Total taro cormels stored}} \times 100$$

Survival % at 120 days storage period:

$$\text{Survival (\%)} = \frac{\text{Initial number of taro stored} - \text{Number of taro after storage}}{\text{Initial number of taro stored}} \times 10$$

Percentage sprout at 120 days storage period

$$\text{Sprout (\%)} = \frac{\text{Number of survived taro cormels} - \text{sprouted cormels after storage}}{\text{Number of survived taro cormels after storage}} \times 100$$

The data collected were subbjecte3d to analysis of variance (ANOVA) was carried out using Genstat Discovery edition VSN 3 release 7.22DE (Gentat , 2011). Treatment means were significant (P ≤0.05) was separated by Fisher's Least significant at 5% probability level according to Obi, (2002).

RESULTS

Main effect of cultivars and botanicals on storage shelf life (%) of taro (*Colocasia esculenta*)

The result of main effect of cultivar on percentage weight loss (%) varied significantly (P≤0.05) across the cultivars throughout the storage periods (30 -120) days in storage after harvest (Table 1). Nachi cultivar had the highest significant (P≤0.05) percentage weight loss (%) of 14.7, 24.95,29.00 and 32.39 at 30 - 120 days in storage, respectively. In contrast, Ugwuta cultivar recorded the least percentage weight loss (%) (9.39, 13.94, 20.27 and 31. 08), respectively.

Among the botanicals, there were also significant variation (P≤0.05) on percentage weight loss throughout the storage periods as presented in Table 1. Control sample consistently had the highest significant (P≤0.05) percentage weight loss (%) of 15.46, 20.65, 29.90 and 34.90 at 30 – 120 days in storage, respectively, whereas *Eucalyptus* sample consistently recorded the least percentage weight loss of 7.85, 16.94,18.05 and 19.17 at 30 – 120 days in storage, respectively.

Table 2 showed the significant (P≤ 0.05) differences throughout the storage periods interaction effect of cultivars by botanicals on percentage weight loss at 30 – 120 days in storage after harvest. Nachi cultivar by Neem interaction effect had the highest significant (P ≤ 0.05) variation on percentage weight loss of 10.01%, while that of Ugwuta cultivar by Ridomil gold recorded the least (4.51%) percentage weight loss at 30 days in storage after harvest. Nachi cultivar by Neem interaction effect consistently had the highest significant (P≤ 0.05) percentage weight loss (%) of 35.01, 42.50 and 45.01 at 60 - 120 days in storage after harvest, respectively. In contrast, Ugwuta cultivar interaction with siam weed; and Ugwuta interaction with *Eucalyptus* recorded the least significant (P < 0.05) percentage weight loss (%) of 8.32, 11.10 and 15.70 at 60 - 90 days; and 120 days in storage after harvest, respectively.

Table 3 showed the main effect of cultivars and botanicals on percentage rot (%), survival and sprout of stored taro cormels cultivars at 30 – 120 days in storage after harvest. There were non- significant (P ≥0.05) differences across the taro cultivars cormels on percentage rot throughout the storage periods. Both cultivars and botanicals non-significantly (P ≥ 0.05) recorded 0.00% on percentage rot at 30 - 60 days in storage, respectively. Ugwuta cultivar consistently had the highest non- significant (P ≥ 0.05) percentage rot (%) of 2.00(1.35) and 2.22 (1.51) at 90 – 120 days in storage after harvest, while the least percentage rot (%) of 1.11(1.01) and 1.85(1.11) were consistently recorded by Nachi cultivar at 90 - 120 days in storage.

Among the botanicals (Table3), there were significant (P≤ 0/05) variations on percentage rot (%) at 90 – 120 days in storage. Control sample had the highest significant (P≤ 0.05) percentage rot (%) of 3.33(1.78), and 33.33(1.78) at 90 -120 days in storage, respectively, whereas the least significant rot percentage of 0.00% and 0.00% were consistently recorded by Neem. On percentage survival across the cultivars and botanicals, there was non- significant (P ≥ 0.05) differences on percentage survival (%) across the cultivars at 120 days in storage. Nachi cultivar had the highest non-significant (P > 0.05) variation on percentage survival of 98.22%, and the least percentage survival of 97.78% was recorded by Ugwuta cultivar at the sampling period in storage. Among the botanicals, botanicals showed a significant (P ≤ 0.05) differences on percentage survival (%) at 120 days in storage as seen in Table 33. Neem recorded the highest significant (P ≤ 0.05) effect on percentage survival (100.00%) at 120 days in storage, while the least significant (P≤0.05) percentage survival (%) of 96.67 was recorded by control sample at 120 days in storage after harvest.

On the percentage sprout (%), there were significant (P≤ 0.05) variability on percentage sprout among the cultivars and botanicals at 120 days in storage. Ugwuta cultivar had the highest significant (P ≤ 0.05) percentage sprout (%) of 47.74, and the least percentage sprout (5.78 %) was recorded by Nachi cultivar at 120 days in storage. In all the botanicals, the highest significant (P≤ 0.05) percentage sprout (33.15%) was recorded by Siam weed, whereas the least percentage sprout (%) (18.79) was recorded by control sample at 120 days in storage after harvest

Table 4 showed the interaction effect of cultivars and botanicals on percentage rot (%), percentage survival (%) and percentage sprout (%) of taro cormels cultivars at 30-120 days in storage. On the percentage rot (%), there were significant ($P \leq 0.05$) variation on percentage rot of cultivars and botanicals interaction effect except at 30 – 60 days in storage. However, the interaction effect of all cultivars by botanicals non-significantly ($P \geq 0.05$) had 0.00% on percentage rot at 30 – 60 days in storage periods. The interaction effect of Ugwuta cultivar by control significantly ($P \leq 0.05$) recorded the highest 6.6 (2. 68)% rot at 90 and 120 days in storage, respectively, while the least percentage rot (%) of 0.00(1.71) were recorded in Nachi cultivar by Ridomil gold and control; Odogolo cultivar by Neem and control; Ugwuta cultivar by *Eucalyptus*, Neem and siam weed at 90 days in storage. Also, Ugwuta cultivar by control interaction effect significantly ($P \leq 0.05$) had the highest percentage rot (%) of (6.66 (2.68), whereas the least percentage rot (%) of 0.00 (0.71) was recorded on Nachi cultivar by Ridomil gold, Neem and control; Odogolo cultivar by Neem and control; and Ugwuta cultivar by *Eucalyptus*, Neem and siam weed at 120 days in storage after harvest.

DISCUSSION

Effect of botanicals on shelf-life of stored taro cultivars cormels (*Colocasia esculenta*) in the barn at 30 -120 days in storage

Pre-agronomic practices are key determinant of the proper development of crops and if well adopted will effectively promote both field and postharvest attributes of *Colocasia esculenta* cultivars.

Field spray of botanicals which are cheap, biodegradable, environmentally friendly, non- toxic to non-target organisms and easily available to taro growing farmers may act as protectants against microbial growth, insects and nematode pests attack, thereby prolonging the storage life of stored fresh taro cormels cultivars. Good storage environment with optimum temperature and relative humidity with good pre-harvest agronomic treatments plays an important role in the storage of fresh taro tubers**.** The result of the present study showed high significant variability among the cultivars and botanicals on percentage weight loss throughout the storage periods. These could be due to genotypic differences, biochemical, and other physiological processes like respiratory activities among the cultivars. The significant high percentage weight loss in Nachi cultivar, and the least in Ugwuta cultivar may be related to the physical and biochemical compositions of the cormels like the skin and the nature of internal tissue texture. Nachi cultivar is known for its thicker and rough/scaly skins compared to the other taro cultivars. This suggests that Nachi cultivar have coarser texture with large air spaces which may promote fast moisture loss in stored taro cormels cultivars. These agro - morphological properties of Nachi cultivar explains its high total energy/carbohydrate contents, water/oil absorption capacity, swelling power and utilization as the best soup-thickening agent than the other taro cultivars. The low moisture content of fresh cormels meant increase in dry matter contents. However, Ugwuta cultivar with thinner and smooth skins has finer texture and tiny air spaces that reduced moisture loss from the taro cormels during storage. It is worthy to note within the limit of the present study that literature on the chemical nature of taro cultivars is still sketchy compared with other roots and tuber crops in relation to weight loss. It has been reported that weight loss in fresh yam tubers were highly dependent on genetic or cultivar variability (Girardin *et al.*,1998) and storage environment (such as temperature, rate of air circulation, air moisture conditions and degree of evaporation) in the taro storage environment. The ideal air moist levels that support physiological activities of taro tubers also enhance curing of wounds and reduces water loss (Manner and Taylor, 2011).

The botanicals used significantly improved taro weight loss. This might be attributed to the phytochemical compounds of the botanicals utilized in this study. The treatment of infected banana fruits with aqueous extract of *A. indca* had a good control of *Fusarium oxysporum* disease development with minimum percentage loss in fruit weight (Singh *et al.*,1993). Bioactive compounds exhibiting antifungal activities can be considered as fungicides alternatives (Diaz *et al.*,2011). Plant extracts have played significant role in the inhibition of seed borne pathogens and in improvement of seed quality (Nwachukwu and Umechuruba,2001). The lower percentage weight loss among the botanicals compared to the control treatment and the standard positive control (Ridomil gold) is a good indication of their high protective potential against postharvest storage weight loss. *Eucalyptus*, Neem and Siam weed showed the lowest degree of percentage weight loss, followed by Ridomil gold plus and then the highest was the control sample. The use of synthetic fungicides, even though proved promising in reducing postharvest losses of fresh taro cormels are limited by cost, availability and may cause food poisoning, nutritional imbalance, health hazard to peasant farmers and the environment (Kosalec *et al.*,2009; De Curtis,2010). The order of reducing taro cormels percentage weight loss among the botanicals were: *Eucalyptus* > Siam weed > Neem> Ridomil gold > Control treatment.

Botanicals and taro cultivars significantly reduced postharvest rot syndrome. These may be attributed to genetic differences, storage environment and differences on efficacy of botanicals utilized. The high percentage rot observed on Ugwuta cultivar is a good indication of its high moisture contents, thinner skins, finer tissue texture, and higher protein and fats contents compared with other cultivars. It has been reported that agricultural products with higher moisture contents, low pH and high nutrient compositions like fats and protein are associated with high rate of deterioration after harvest (Kolawole *et al*.,2014; Shukla *et al*.,2012), and also very susceptible to attack by pathogenic organisms, which cause rot and produce mycotoxins (Moss, 2002). These findings were in line with reports of other researchers (Ogbonna and Nweze, 2012; Omeje *et al.*, 2015) who stated that Ugwuta cultivar is the most susceptible to rots than other cultivars, while Nachi cultivar is less susceptible to myco-rot organisms. However, the non – significant variations among the cultivars during entire study periods may be partly due to proper agronomic practices adopted from field stage to storage environment. This agrees with the report that improper agronomic practices such as poor harvesting methods, handling, seed selection for storage, packaging, transportation to storage environment and poor storage condition might result in decay of agricultural products (Wilson *et al.,* 1991).

Significant variation among the botanicals on postharvest rot in the present study confirms the effectiveness of botanicals in reducing postharvest rot losses. It has been reported that, generally rotting starts from field and progresses to the storage environment (Enyiukwu *et al.,* 2014). Pre-harvest agronomic practices play a key role in reducing postharvest rot inducing organisms if well adopted. Several studies have showed the effectiveness of botanicals in the management of pre and post- harvest rot inducing organisms, although on different botanicals and crops (Ugwuoke *et al*., 2008; Eze *et al.,* 2015). Result from the present work agree with the work of Ijato *et al*., (2011) who reported that Siam weed (*Chromolaena odorata)* leaf extracts, *Tridax procumbens,* bitter leaf (*Venonia amygadalina)* and neem (*Azadiratchta indica*) leaf extracts exhibited inhibitory effect on the growth of fungal rot organisms. The high promising potential of Siam weed in reducing postharvest rot loss in the present study has confirmed its choice among taro growers as the most suitable agricultural field in Nsukka agricultural zone. Botanicals significantly reduced the postharvest rot syndromes of taro. This might be attributed to the presence of some anti-fungal and anti-bacterial properties, like flavonoids, tannins, alkaloids, phenols among others that reduce rots in the stored taro cultivars cormels.

The non-significant differences on survival percentage across the cultivars, explains the effectiveness of proper agronomic strategies adopted from field to storage environment irrespective of genotypic differences among the taro cultivars utilized. However, the low survival percentage recorded on

Ugwuta cultivar was associated with its higher moisture contents and biochemical compositions. Eze *et al*., (2015) reported that low shelf- life among taro cultivars could be attributed to their high moisture contents and chemical compositions.

Botanicals revealed significant improvement on percentage survival of taro cultivars cormels. These could be due to potential effect of botanicals on enhancing storage life of taro cultivars. The higher incidence of cormel rot recorded by the control treatment compared with other pesticide treatments were probably related to lower survival percentage of the taro cormels, thereby predisposing the cormels to higher metabolic activities and pathogenic attack (Passam,1977). The high incidence and severity of taro leaf blight (TLB) in the control taro stands supports the higher rot recorded in the control treated stands. These findings were in support of the work by Orji, (2019) who stated that TLB causes early senescence and poor tuber formation resulting in poor yield and storability. It has also been reported that TLB causes serious postharvest decay of taro tubers (Misra, 1997) resulting in low percentage survival in untreated taro stands.

Cultivars and botanicals significantly differed on percentage sprout after storage. These might be attributed to cultivar differences and storage environment. Girardin *et al.,* (1998) earlier observed that in yam, length of dormancy was genetic or cultivar dependent. The poor dormancy of Ugwuta cultivar which is linked to high sprout potential than other cultivars may be associated with its high moisture contents and other physiological activities like high respiration rate. It has been a common experience that Ugwuta cultivar sprouts earlier than other cultivars either in the field or storage barn/bags particularly in the presence of any little soil or atmospheric moisture conditions. On the other hand, Nachi and Odogolo cultivars need a cold and adequate soil and atmospheric moisture environment before any germination process. Omeje *et al*., (2016) has reported earlier field establishment percentage of Ugwuta cultivar compared to other taro cultivars. The high percentage sprout of Ugwuta cultivar due to its high moisture content is also common to water yam (*Dioscorea alata*) which shows the same physiological process in terms of high sprouting conditions.

The significant differences among the botanicals on percentage sprout might be attributed to potential of the botanicals in improving the health status of the harvested produce for storage. The primary aim of field crop disease management is to enhance disease free produce for consumption and next season planting. These findings agree with the report of Passam, (1977) who observed that when dormancy finished and sprouting started, cormels became senescent and could no longer store effectively.

CONCLUSION AND RECOMMENDATIONS

The study conducted showed that field sprays of botanicals were significantly effective in improving storage shelf life of taro cultivars cormels against weight loss, taro rots, low survival and viability in storage. The resistant taro cultivar with any botanicals utilized are highly recommended for improved agronomic and postharvest qualities of taro cultivars for a healthier nutrition. Botanicals were found to be promising for the improvement of postharvest storage qualities in this order of potentiality: Siam weed (*Chromolaena odorata*) > Neem (*Azadirtchta indica* (A.Juss) > *Eucalyptus* leaves extract (*Eucalyptus spp).* Botanicals utilized are therefore, recommended as the natural alternative pesticides to synthetic pesticides in reducing taro cultivars cormels rots from field to storage environment.

REFERENCES

Amuji, C.F., Ogbonna, P.E. and Uguru, M.I. (2013). Seasonal Evaluation of Advanced Generations of Interspecific Hybrids of two Solanum Specific in the Derived Savannah Agro ecology of Southeastern Nigerian. *Nigerian Journal of Crop Science,* Vol.1 No.1,61 -70.

Brooks, F.E. (2005). Taro leaf blight, Plant Health Inspector. 10.1094/PHI -1- 2005 – 0531 - 01. http://www.apsnet.org/edcenter/intopp/lessons/fungi/Oomycetes/Pages/TaroLeafBlight.aspx , *American Phytopathological SocietyLink*.

Chukwu, G.O., Nwosu, K.I., Madu, T.U., Chinaka, C. and Okoye, B. C. (2008). Development of Gocing Storage method for Cocoyam Storage. *National Root Crops Research Institute Umudike, Abia State*. http://mpra.ub.uni–muenchen. de.No.1744.

Doughari, J. H., El-Mahood, AM. and Tyoyina, I. (2007). Antimicrobial activity of leaf extracts of *Senna obtusfo1ia* L. *African Journal of Pharmacy and Pharmacology* 2:1 1-133

Echebiri, R.N. (2004). Socio economic factors and resources allocation in cocoyam production in Abia State, Nigeria: A case Study. *Journal of Sustainable Tropical Agricultural Research*, 9: 69-73.

Enyiukwu, D.N., Awurum, A.N.and Nwaneri, J.A. (2014). Efficacy of plant derived pesticides in the control of myco induced post-harvest rots of tubers and agricultural products: A rewiew. *Net Journal of Agricultural Science*, 2 (1): 30-36, ISSSN: 2315 -9766.

Eunice. O. N. and Osuji, J. O. (2008). Evaluation of plant extracts for antifungal activity against *Sclerotium rolfsii* causing cocoyam cornmel rot in storage. *Research Journal of Agriculture and Biological Sciences* 4:784-787.

Eze, S.C., Ugwuoke, K.I., Ogbonna, P.E., Ona, R.N., Onyeonagu, C.C and Onyek, C.C. (2015). Evaluation off indigenous technologies of fresh cocoyam (*Colocasia esculenta* (L.) Schott) Storage in Southeastern Nigeria. *African Journal of Agricultural Research*, Vol. 10(8), pp.737 – 741

Gardner, R.M., Kipper, M., Tofail, F., Bottai, M., Hamadani, J., Grander, M., Nermell, B., Palm, B., Rasmussen, K.M., Vahter, M. (2013). Environmental exposure to metals and children growth to age 5 years: A prospective cohort study. *American Journal of Epidiomology*. 177: 1356 -1367.doi: 10.1093/aje/kws43. [Google Scholar].

GenStat Release 10.3Discovery Edition (DE) (2011). Discovery Edition 4VSN International Ltd Rothamsted Experimental Station, Hewel Hempstead, UK.

Girardin, O.C., Nindjin, Z., Farah, F., Escher, P.S. and Otokore, D. (1998). Use of Gibberellic acid to prolong Dormancy and reduce losses during traditional storage of yams. *Journal of Science, Food and Agricultur*e. 77: 172 -178.

Ijalo,J. Y., Oyemi, S.D., Ijadunola, J.A. and Ademuyiya, A.(2010) . Allelopathic effect of leaf extracts of *Azadiratchta indica* and *Chromolaena odorata* against postharvest and transit rot of tomato *Lycopersicum esculenta*. *Journal of American Science*, 6: 1595- 1599.

Ijato, J.Y., Adebiyi, A.O. and Ijadnola, J.A. (2011). Antifungal effects of four tropical plant aqueous and ethanoic extracts on post -harvest rot of tomato (*Lycopersicon esculenta*) in Ado Etkiti Nigeria, *New Science Journal* .4(1): 64 – 68.

Kolawole, O. Falade Chidinma., Okafor, A. (2014). Physical, functional, and pasting properties of flour from corms of two cocoyam (*Colocasia esculenta* and *Xanthosoma sagitifolium*) cultivars. *Food Science Technology*, 52(6): 34s40 -3448.

Manner, H.I. and Taylor, M. (2011). Farm and Forestry Production and Marketing Profit of taro (*Colocasia esculnta*). In Elevltch. C.R.(ed). Specilty crops for Pacific Island Agroforestry. *Permanent Agriculture Resource (PAR) Honolulu, Hawa*ii http//agroforestry. Net/scps.11 -21.

Misra, R.S. (1997). Diseases of Tuber Crops in Northern and Eastern India, CTCRI *Technical Bulletin Series* 22, CTCRI Thiruvananthapuram, pp.27.

Moss, M.O. (2002). Mycotoxin review: *Aspergillus* and *Penicillium*. *Mycologist*, 16: 16 -119.

Obi, I. U. (2002). *Statistical Methods of Detecting Differences Between Treatment Means and Research Methodology Issues in Laboratory and Field Experiments* (ed.2*). Ap. Express Publishing Company Limited, Nsukka, Nigeria*. pp. 117.

Ogbonna, P.E. and Nweze, N.J. (2012). Evaluation of growth and yield responses of cocoyam *(Colocasia esculenta)* cultivars to rates of NPK 15:15:15 fertilizers. Available*: http://www.academicjournals.org/Ajar;2012* doi:10.5897/AJAR12.553 ISSN 1991-637x © 2012 *Academic Journals*.

Omeje, T. E., Ugwuoke, K.L., Adinde, J.O., Ogwulumba, S. I. and Unigwu L.O. (2016). Effect of Cropping Season on the Control of Taro Leaf Blight (*Phytophthora colocasiae*) of Cocoyam (*Colocasia esculenta* (L.)) in Nsukka, Southeastern Nigeria. *International Journal of Biological Research* Vol. 6 2016: 30-39 www.scienceandnature.org.

Omeje, T.E., Ugwuoke, K.I., Aba, S.C., Eze, xx., Ogwulumba, S.I. and Ezema, R. A. (2015). Field Management of *Phytophthora* Blight Disease of cocoyam (*Colocasia esculenta* L.) with spray Regimes of selected fungicides in Nsukka, Southeastern Nigeria. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extention.* Vol 14 No 2 May 2015 35-45 doi: http://doi. org/10.4314/asv1412.6

Omeje, T.E., Ugwuoke, K.I., Eze, S.C. and Ezema R.A. (2020). A comprehensive study on field management of *Phytophthora* leaf blight disease of cocoyam with spray regimes of selected fungicides in Nsukka, Southeastern Nigeria. *Cut Edge Research in Agriculture Science*.3, 99 -19. https://doi.org/10: 9734/BP/eras/v3.99 -119

Orji, K. O. (2019). Cocoyam production in Nigeria: A Review of its potentials, problems, and prospect. In: *Proceedings of 6th Annual National Conference of Crop Science Society of Nigeria,* (Owerri, 2019), 8416 -854.

Passam, H. (1977). Sprouting and apical dorminance of yams tubers. *Tropical Science*. 19(1), 29 -39.

Shukla, AM., Yadav, R.S., Shashi, S.k., Dikshit, A. (2012). Use of plant metabolites as an effective source for the management of post-harvest fungal pest: A review int *J Curr Discoveries Innovations* 1 (1): 33-35.

Ugbaja, M.O. and Uzuegbunam, C.O. (2012). Causative factors of decline in cocoyam production in Ezeagu Local Government Area, Enugu State: Implication for Sustainable Food Security. *Journal of Agriculture and Veterinary Science*, 4: 2 -3.

Ugwuoke, K.I, Oyeke, C.C. Tsopmbeng, N.G.R. (2008). The efficacy of botanical protestants in the storage of cocoyam (*Colocasia esculenta* (L.) Shott) *Agro- Science Journal. Trop Agric Food Envioen Ext.* **7** (2): 93-98.

Wilson, C.I., Wisiniewski, M.E., Biles, C. I., Melaughlin, R., Chaulz, E. and Droby, S. (1991). Biological control of post -harvest diseases of fruits and vegetables: Alternative to synthetic fungicides. *Crop Protection*.10:172 -177.

Table 1: Effects of cultivars and botanicals on percentage weight loss (%) of stored taro cultivars (*Colocasia esculenta*) cormels recorded at 30 - 120 days after storage.

	Percentage weight loss (%) at 30 – 120 days in storage			
Treatments	**30 Days**	**60 Days**	**90 Days**	**120 Days**
Cultivars				
Nachi	14.97	24.95	29.00	32.39
Odogolo	11.96	17.28	20.66	31.08
Ugwuta	9.39	13.94	20.27	26.46
F-LSD$_{(0.05)}$	0.01	0.01	0.01	0.01
Botanicals				
Ridomil gold	13.59	19.47	23.63	34.90
Eucalyptus	7.85	16.94	18.05	19.17
Neem	13.56	19.16	22.91	25.92
Siam weed	10.07	17.41	22.05	31.16
Control	15.64	20.65	29.91	36.74
Grand mean	12.11	18.73	23.31	29.97
F-LSD$_{(0.05)}$	0.01	0.01	0.01	0.01
C.V. (%)	0.1	0.1	0.1	0.1

F-LSD$_{(0.05)}$ = Fisher's least significant difference at 0.05 probability level, CV % = Percentage coefficient of variation.

Table 2: Interaction effect of cultivars and botanicals on percentage weight loss (%) of stored taro cultivars (*Colocasia esculenta*) cormels recorded at 30 - 120 days after storage.

		Percentage weight loss (%) at 30 – 120 days in storage			
Cultivars	**Botanials**	**30 Days**	**60 Days**	**90 Days**	**120 Days**
Nachi	Ridomil gold	8.32	30.54	33.31	38.87
	Eucalyptus	6.67	13.32	16.66	20.01
	Neem	30.01	35.01	42.50	45.01
	Siam weed	22.21	30.54	33.32	38.87
	Control	7.67	15.36	19.22	19.22
Odogolo	Ridomil gold	8.32	13.37	21.42	35.01
	Eucalyptus	13.02	21.73	21.72	21.73
	Neem	7.68	10.36	15.36	15.37
	Siam weed	13.01	13.37	21.72	21.73
	Control	15.37	23.07	23.07	38.44
Ugwuta	Ridomil gold	4.54	9.07	35.01	36.35
	Eucalyptus	10.52	15.78	15.77	15.77
	Neem	8.70	13.03	13.02	17.38
	Siam weed	5.55	8.32	11.10	38.87
	Control	17.64	23.52	26.46	47.05
	Grand mean	12.11	18.72	23.31	29.97
	$F\text{-}LSD_{(0.05)}$	0.01	0.01	0.01	0.01
	C.V. (%)	0.1	0.1	0.1	0.1

$F\text{-}LSD_{(0.05)}$ = Fisher’s least significant difference at 0.05 probability level, CV % = Percentage coefficient of variation.

Table 3: Effects of cultivars and botanicals on percentage rot (%), survival percentage (%) and percentage sprout (%) of stored taro cultivars (*Colocasia esculenta*) cormels recorded at 30 - 120 days after storage.

Treatments	**Percentage rot (%) at 30 – 120 days in storage**				**Percentage survival (%) at 120 days**	**Percentage sprout (%) at 120 days**
	30 Days	**60 Days**	**90 Days**	**120 Days**		
Cultivars						
Nachi	0.00	0.00	1.11 (1.01)	1.83 (1.11)	98.22	5.78
Odogolo	0.00	0.00	1.78 (1.37)	2.00 (1.35)	98.00	13.29
Ugwuta	0.00	0.00	2.00 (1.35)	2.22 (1.51)	97.78	47.74
$F\text{-}LSD_{(0.05)}$	NS	NS	NS	NS	NS	2.95
Botanicals						
Ridomil gold	0.00	0.00	1.11 (1.12)	1.11 (1.12)	97.41	20.28
Eucalyptus	0.00	0.00	1.85 (1.34)	3.04 (1.52)	97.04	18.86
Neem	0.00	0.00	0.00 (0.71)	0.00 (0.71)	98.89	20.26
Siam weed	0.00	0.00	1.85 (1.27)	2.59 (1.49)	100.00	33.15
Control	0.00	0.00	3.33 (1.78)	3.33 (1.78)	96.67	18.79
Grand mean	0.00	0.00	1.63 (1.24)	2.01 (1.32)	98.00	22.27
$F\text{-}LSD_{(0.05)}$	NS	NS	0.50	0.63	NS	3.81
C.V. (%)	0.0	0.0	41.3	49.6	3.0	17.8

Note: Mean separation was applied to the square root transformed values enclosed in parentheses.

$F\text{-}LSD_{(0.05)}$ = Fisher's least significant difference at 0.05 probability level, CV % = Percentage coefficient of variation.

Table 4: Interaction effects of cultivars and botanicals on percentage rot (%), survival percentage (%) and percentage sprout (%) of stored taro cultivars (*Colocasia esculenta*) cormels recorded at 30 - 120 days after storage.

Cultivars	Botanicals	Percentage rot (%) at 30 – 120 days in storage				Percentage survival (%) at 120 days	Percentage sprout (%) at 120 days
		30 Days	60 Days	90 Days	120 Days		
Nachi	Ridomil gold	0.00	0.00	0.00 (0.71)	0.00 (0.71)	96.67	4.44
	Eucalyptus	0.00	0.00	2.22 (1.36)	5.79 (1.88)	100.00	6.38
	Neem	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	7.69
	Siam weed	0.00	0.00	3.33 (1.55)	3.33 (1.55)	100.0	6.67
	Control	0.00	0.00	0.00 (0.71)	0.00 (0.71)	94.44	3.70
Odogolo	Ridomil gold	0.00	0.00	3.33 (1.96)	3.33 (1.96)	96.67	39.08
	Eucalyptus	0.00	0.00	3.33 (1.96)	3.33 (1.96)	96.67	3.33
	Neem	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	10.00
	Siam weed	0.00	0.00	2.22 (1.54)	4.44 (2.20)	95.56	7.14
	Control	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	6.90
Ugwuta	Ridomil gold	0.00	0.00	3.33 (1.96)	3.33 (1.96)	96.67	50.00
	Eucalyptus	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	46.67
	Neem	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	49.43
	Siam weed	0.00	0.00	0.00 (0.71)	0.00 (0.71)	100.00	53.71
	Control	0.00	0.00	6.66 (2.68)	6.66 (2.68)	93.33	38.89
	Grand mean	0.00	0.00	1.63 (1.24)	2.01 (1.32)	98.00	22.27
	$F\text{-}LSD_{(0.05)}$	NS	NS	0.86	1.09	4.90	6.59
	C.V. (%)	0.0	0.0	41.3	49.6	3.0	17.8

Note: Mean separation was applied to the square root transformed values enclosed in parentheses.
$F\text{-}LSD_{(0.05)}$ = Fisher's least significant difference at 0.05 probability level, CV % = Percentage coefficient of variation.

SENESCENCE LONGEVITY OF FLAG LEAF IMPROVES THE GRAIN YIELD AND MILLING QUALITY OF RICE (*Oryza sativa* L.)

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ABSTRACT

Flag leaf senescence is a crucial physiological aspect linked to Rice (*Oryza sativa* L.) yield and quality. Enhancing rice's grain yield potential and quality is essential to meeting the growing food demand, particularly under the changing environmental conditions. However, the genetic variations among rice genotypes with flag leaf premature senescence traits remain insufficiently explored. This study evaluated the genotypic differences in flag leaf indices, photosynthesis grain quality, and milling efficiency between two mutants (*psf;* premature senescence flag leaf and esf; early senescence flag leaf) and their corresponding wild-type: WT1 and WT2 (stay grain) rice genotypes. The results reveal significant variations across all measured traits, exhibiting superior performance. The WT1 and WT2 had higher flag leaf area retention (65.0% and 66.2%) and chlorophyll retention (93.1% and 90.1%), contributing to better grain filling and yield potential. In contrast, the mutants, particularly *psf*, showed higher leaf area loss (149.5 cm²) and accelerated senescence, reflected by their lower chlorophyll retention and grain-filling ratios. Furthermore, improved milling qualities, including higher brown rice rates and head rice percentages were observed with the WT genotypes, while *psf* and *esf* mutants had reduced milling efficiency and increased white core grain rates. The yield potential of WT1 and WT2 was significantly higher compared to the mutants. These findings suggest that delayed senescence and higher leaf area retention are critical traits for enhancing rice grain yield and quality. Thus, offering insights for future rice breeding strategies aimed at improving productivity and grain quality.

Keywords: Leaf area, Leaf senescence, Grain quality, Milling efficiency, Rice

INTRODUCTION

Rice (*Oryza sativa* L.) is the third most important staple crop worldwide, providing a primary source of calories for over half of the global population (FAO, 2023). Improving the grain yield and quality of rice are essential to meeting the rising food demand driven by population growth and dietary changes (Khush, 2013). However, the optimization of yield and quality traits is constrained by various biotic and abiotic factors, which negatively affect crop physiology, particularly during the grain-filling stage (Zhang *et al*., 2016). Leaf senescence, especially of the flag leaf, is a key factor, as it contributes 50%–80% of the photosynthates needed for grain development (Shiratsuchi *et al*., 2018. Zakari *et al*. (2020) have earlier documented the sensitivity of grain filling to changes in photosynthetic efficiency due to early or premature leaf senescence. Prolonging green leaf area, commonly referred to as delayed senescence "staygreen", has been shown to proportionally improve grain yield and quality, due to greater carbon assimilation and nutrient supply during grain filling (Gregersen *et al*., 2013; Spano *et al*., 2003). Conversely, early senescence leads to reduced photosynthetic capacity and nutrient remobilization, resulting in lower grain filling and less grain quality (Thomas & Howarth, 2000; Gregersen *et al*., 2013).

Leaf senescence and chlorophyll retention are genetically regulated processes that differ between crop genotypes. Wildtype crops typically show delayed senescence and better chlorophyll retention compared to mutant genotypes (Hörtensteiner, 2006). Early senescing genotypes exhibit faster chlorophyll degradation, which shortens the duration of effective photosynthesis, reducing yield and affecting grain quality parameters such as head rice rate, brown rice rate, and grain length (Kusumi *et al*., 2017). The timing of senescence is a critical trait in rice breeding, with the goal of increasing grain filling period which improves yield and quality (Zhou *et al*., 2017). Despite this significance, understanding the specific relationship between flag leaf senescence, chlorophyll degradation, and rice quality traits remains limited, especially in the context of both early and premature mutant rice genotypes.

Additionally, rice grain quality and yield are influenced by physiological processes like panicle development, grain filling ratio, and seed setting rate (Yang & Zhang, 2010) during grain filling. Cereal crops with slower leaf senescence and better chlorophyll retention during grain filling have been found to achieve higher grain filling ratios and grain weight, leading to improved yield (Tang *et al*., 2017). In contrast, early senescing crops often have lower grain filling rates and reduced yield due to insufficient assimilate production and translocation (Peng *et al*., 2014). Grain quality is another vital aspect in rice production, and it is closely linked to physiological status of the crop (Lyman *et al*., 2013). Quality traits such as milling efficiency, head rice percentage, and grain shape are influenced by the duration of photosynthetic activity and the efficiency of nutrient translocation during grain filling (Yang *et al*., 2007). Studies have demonstrated that prolonged leaf functionality enhances grain quality by allowing optimal carbohydrate accumulation and proper grain development (Zhao *et al*., 2020).

Given the important role the flag leaf senescence plays in influencing both grain yield and quality, this study was designed to understand the difference between genotypes in flag leaf area retention, chlorophyll degradation, grain filling, and milling qualities in mutant rice genotypes. We hypothesize that rice grain yield and quality will be positively related to delayed senescence and improve photosynthesis at the grain-filling stage. These findings will contribute to the understanding of the variation of grain yield and quality traits variation among rice genotypes, and toward the development of rice breeding strategies that focus on improving grain yield and quality of rice under various environmental conditions.

MATERIALS AND METHODS

The experiment was carried at the teaching and experimental farm of Zhejiang University, Zijingang campus (30°18′N, 120°04′E), Hangzhou, China in (2018 cropping season). Two rice senescence mutants: the premature senescence mutant (*psf*) and its wild-type counterpart Zhehui 7954 (WT2), as well as the early senescence mutant (*esf*) and its corresponding wild-type Fu143 (WT2) were tested. Each mutant was developed through gamma irradiation of the indica restore lines Zhehui 7954 and Fu143, respectively, and has been cultivated following continuous self-pollination for seven generations, resulting in stable genetic expression of the senescence trait. The genotypes were experimented in a completely randomized block design, which was replicated three times. Matured seeds were germinated under field conditions at the experimental station of the College of Agriculture and Biotechnology (ZJU) and the seedlings were transplanted in rows within each plot, with a spacing of 17 cm between plants and 22 cm between rows, resulting in a total of 27 m^2. The genotype entries were managed in accordance with local cultivation protocols. The soil was characterized as periodically waterlogged, with a total nitrogen content of 1.69 g/kg, available phosphorus at 24.5 mg/kg, and exchangeable potassium at 103.7 mg/kg. From the preliminary studies, it was observed that the plant height and number of tillers in both senescence mutants were comparable to their respective wild types. However, the flag leaves of the senescence mutants began to exhibit symptoms of senescence post-heading, while the wild types stay green during the same period. At the flowering stage, about 25 plants that flowered on the same day were randomly selected and labeled. Upon maturity, 20 plants were randomly harvested from each plot for the assessment of key agronomic and yield traits. After threshing, the rice was air-dried, and the following parameters were measured: brown rice rate, milled rice rate, whole milled rice rate, grain length, grain type, and chalkiness as previously described in Wang *et al*., (2016) in accordance with the national standard for high-quality rice. The Leaf Area was measured a week before anthesis and harvesting using a digital leaf area meter (YMJ-A Model) and chlorophyll content was measured using the SPAD-502 (SPAD-502, Minolta Camera Co. Ltd., Japan). For each measurement, 20 rice flag leaves were taken. The data collected was subjected to Analysis of Variance (One-way ANOVA). To evaluate significant differences between the means of the four rice varieties, using Tukey's HSD (post-hoc test;) was employed, using SPSS package software (Chicago, USA).

RESULTS AND DISCUSSION

The results of the flag leaf area (FLA) and retention data (Table 1) reveal significant genotypic differences in both pre-anthesis and during-harvest measurements. The WT1 and WT2 exhibited larger flag leaf area retention compared to the mutants. For leaf area retention, higher values were recorded for WT1 (65.0%) and WT2 (66.2%) compared to the mutant *psf* and *esf* which have values of 40.24% and 49.31%, respectively. The higher leaf area retention in the WT aligns with the findings of Wang *et al*. (2020), who reported that indigenous rice plants typically retain more leaf area during grain filling due to delayed senescence, which prolongs photosynthetic activity. In contrast, the mutants, especially *psf*, show a higher rate of flag leaf area loss of 4.27 cm^2/day, indicating accelerated senescence, which is consistent with findings by Zhang *et al*. (2022), who observed similar trends in senescence-accelerated mutants. The leaf area loss rate for the *psf has* been the highest might contribute to the lower grain yield potential of rice plants with similar phenotype character.

The results presented in Figure 1 show the changes in flag leaf chlorophyll content across different rice genotypes at three time points. At the heading stage (Fig. 1A), all the genotypes exhibited relatively similar chlorophyll content, ranging between 46.3 and 47.9 There was a generally a decline in chlorophyll across all the genotypes at 20 days after heading (20 DAH) (Fig. 1B). However, higher chlorophyll was observed for WT1 (44.48) and WT2 (45.2), compared to the mutants: *psf;* 35.5 and *esf;* 30.4. This may signify a potential advantage of the WT genotypes for increased photosynthetic activity longer than the mutants. Chlorophyll plays an essential role in photosynthesis, thus, the higher chlorophyll levels of the WTs after heading reflect their ability to sustain photosynthetic activity for a longer period during grain filling. This extended activity supports increased carbohydrate production and translocation to the grains, potentially contributing to better grain filling and yield (Yang & Zhang, 2010; Gregersen *et al.*, 2013). By the harvest period, the WT1 and WT2 retained most of their chlorophyll, with 44.6 and 41.71, respectively, while about 35% and 50% of the chlorophyll was loss respectively by the *psf* and *esf* compared to their immediate previous measurement. While this may imply premature senescence, it also points to the high possibility of the mutants resulting in lower grain yield due to reduced carbohydrate assimilation into the grains (Zhao *et al.*, 2020). Chlorophyll retention (CR) is another important physiological trait influencing photosynthetic efficiency and grain-filling duration. WT2 exhibited the highest CR of 97.6% at 20 days after heading and 91.0% at harvest, followed closely by WT1 with 92.86% and 93.11%, respectively (Table 2). These results are similar to those of Chen *et al.* (2021), who demonstrated that stay green rice genotypes generally maintain higher chlorophyll levels during grain filling, enhancing their grain yield potential. The mutants, especially *esf*, had significantly the lowest CR of at both 20DAA: 65.24% and 20DAH: 35.54% sampling stages. The higher senescence rates observed in the mutants, particularly *esf* having 0.81 SPAD units/day, may result from earlier degradation of photosynthetic pigments, reducing photosynthetic activity and assimilate supply to the grains. Previously, Zakari *et al.* (2020) have also shown that mutations affecting chlorophyll metabolism resulted in accelerated senescence and reduced grain filling duration, as observed with the *esf* and *psf* mutants. The *esf* mutants displayed the poorest performance, with a milling efficiency of 63.7% and a negative quality index (-28.5). The poor performance of *esf* mutants is due to genetic mutations that weaken grain structure, causing increased breakage during milling and altered rain hardness, and sensitivity to early senescence. This finding was supported by the work of Zhang *et al.* (2020), who found that untimely senescence in rice negatively affects grain size and quality, leading to lower head rice yield and a higher percentage of white-core grains, as observed in the *psf* and *esf* mutants. The significant increase in white-core degree in the mutants: 41.3% and 69.7% for *psf* and *esf*, respectively, indicates poor grain filling, which could be attributed to their lower LA and CR. The yield potential of the genotypes followed the same trend as the grain filling and LAR. WT2 had the highest yield potential of 2787.4, trailed by WT1 with 2746.8, while the *psf* and *esf* mutants had significantly lower yields of 794.5 and 549.1, respectively (Table 3). These differences can be explained by the combined effects of chlorophyll degradation, leaf area loss, and grain-filling deficiencies in the mutants. Studies by Xu *et al.* (2021) demonstrated that genotypes with higher LAR and chlorophyll stability during grain filling generally have superior yield potentials, which aligns with the findings for WT1 and WT2 in this research.

Significant differences in grain quality were also observed between the genotypes (Table 3). The WT1 and WT2 recorded the highest grain filling ratios of 76.7% and 77.1%, respectively, while the mutants *psf* and *esf*, had much lower of 26.44% and 19.76%, respectively. This substantial difference in grain filling ratio might be linked to the differences in leaf area retention and chlorophyll content, as reported by Yang *et al.* (2021), who found a strong correlation between delayed leaf senescence and improved grain filling in rice. The mutants, especially *esf*, showed reduced panicle length, total grains per panicle, and filled grains per panicle, which likely contributed to their lower grain yield potential of 549.12 and 794.46 for the *psf*. These results corroborate previous research by Li *et al*. (2022), which demonstrated that premature senescence rice mutants lead to reduced grain filling and overall yield loss. In terms of milling efficiency and quality index, WT2 showed the best performance with a milling efficiency of 97% and a quality index of 20.57. That was followed by WT1 and *psf* with efficiency of 89.01 and 89.23% respectively (Table 4).

CONCLUSION

The WT exhibited superior performance across all measured parameters compared to the mutants. The higher flag LAR, CR, grain filling ratio, and milling efficiency in the WT contributed to their significant higher yield potentials. The mutants, particularly *psf*, showed accelerated senescence, leading to lower grain quality and yield. Thus, emphasizes the importance of delayed leaf senescence and effective CR in enhancing rice yield and quality, providing crucial information for rice breeding programs aimed at improving rice crop productivity and grain quality. Future research could explore the genetic basis of these differences to aid in the development of new rice varieties with enhanced performance traits.

REFERENCES

Dingkuhn, M., Luquet, D., QuilotTurion, B., & Tao, Z. (2017). Functional structural modeling of the crop: from organs to genetic networks. *Frontiers in Plant Science*, 8:11-79.

FAO (2023). *World Food and Agriculture – Statistical Yearbook 2023*. Rome.

Gregersen, P. L., Holm, P. B., & Krupinska, K. (2013). Leaf senescence and nutrient remobilisation in barley and wheat. *Plant Biology*, 15(5):713-727. https://doi.org/10.1111/plb.12048

Hörtensteiner, S. (2006). Chlorophyll degradation during senescence. *Annual Review of Plant Biology*, 57:55-77.

Khush, G. S. (2013). Strategies for increasing the yield potential of cereals: case of rice as an example. *Plant Breeding*, 132(5):433-436.

Kusumi, K., Iba, K., & Mochizuki, S. (2017). Staygreen: regulatory factors and mechanisms of leaf senescence. *Rice Genomics and Genetics*, 7(2):64-76.

Lyman, N. B., Jagadish, S. V. K., Nalley, L. L., Dixon, B. L., & Siebenmorgen, T. J. (2013). Neglecting rice milling yield and quality underestimates economic losses from high temperature stress. PLoS ONE, 8(8), e72157.

Peng, S., Huang, J., Sheehy, J. E., Laza, R. C., Visperas, R. M., Zhong, X., ... & Cassman, K. G. (2014). Rice yields decline with higher night temperature from global warming. Proceedings of the National Academy of Sciences, 101(27): 9971-9975.

Spano, G., Di Fonzo, N., Perrotta, C., Platani, C., Ronga, G., Lawlor, D. W., & Napier, J. A. (2003). Physiological characterization of 'stay green' mutants in durum wheat. *Journal of Experimental Botany*, 54(386): 1415-1420. https://doi.org/10.1093/jxb/erg146.

Shiratsuchi, H., Ookawa, T., & Hirasawa, T. (2018). Importance of flag leaf characteristics on grain yield in rice. *Plant Production Science*, 21(3):184-192.

Tang, Y., Li, L., Wang, H., ... & Wang, Y. (2017). Increased leaf senescence is associated with yield reduction in rice plants under low nitrogen conditions. *Journal of Experimental Botany*, 68(16): 4695-4709.

Thomas, H., & Howarth, C. J. (2000). Five ways to stay green. *Journal of Experimental Botany*, 51(342): 329-337.

Wang, C., Chen, T., Zhang, Y., Zhu, H., Shi, X., Zhao, L., & Zhao, H. (2016). Characterization of whitecore grain in rice and its impact on the physicochemical properties and cooking quality. *Journal of Agricultural and Food Chemistry*, 64(19)3849-3857.

Yang, J., & Zhang, J. (2010). Crop management techniques to enhance harvest index in rice. *Journal of Experimental Botany*, 61(12):3175-3185.

Yang, J., Zhang, J., Wang, Z., Zhu, Q., & Liu, L. (2007). Activities of starch hydrolytic enzymes and sucrose phosphate synthase in the stems of rice subjected to water stress during grain filling. *Journal of Experimental Botany*, 52(358): 2169-2179.

Yang, J., Zhang, J., Wang, Z., Zhu, Q., & Liu, L. (2016). Water and nitrogen use efficiency in rice: optimization through crop management. *Field Crops Research*, 207: 1-10.

Zakari, S. A., Asad, M.-A.-U., Han, Z., Guan, X., Zaidi, S.-H.-R., Gang, P. & Cheng, F. (2020). Senescence-related translocation of nonstructural carbohydrate in rice leaf sheaths under different nitrogen supply. *Agronomy Journal, doi:10.1002/agj2.20163.*

Zhang, H., Mittal, N., Leamy, L. J., Barazani, O., & Song, B. H. (2016). Back into the wild—Apply untapped genetic diversity of wild relatives for crop improvement. *Evolutionary Applications*, 10(1), 524.

Zhao, X., Liu, L., & Zhang, Z. (2020). Improvement in grain quality by delaying senescence in rice. *Field Crops Research,* 249: 107760.

Zhou, Z., Jiang, Y., Liu, D., et al. (2017). Rice senescence and yield loss due to heat stress during late grainfilling periods. *Field Crops Research*, 206: 40-48.

Yang, J., & Zhang, J. (2010). Grain filling of cereals under soil drying. *New Phytologist*, 182(4): 675-684. https://doi.org/10.1111/j.1469-8137.2009.02854.x

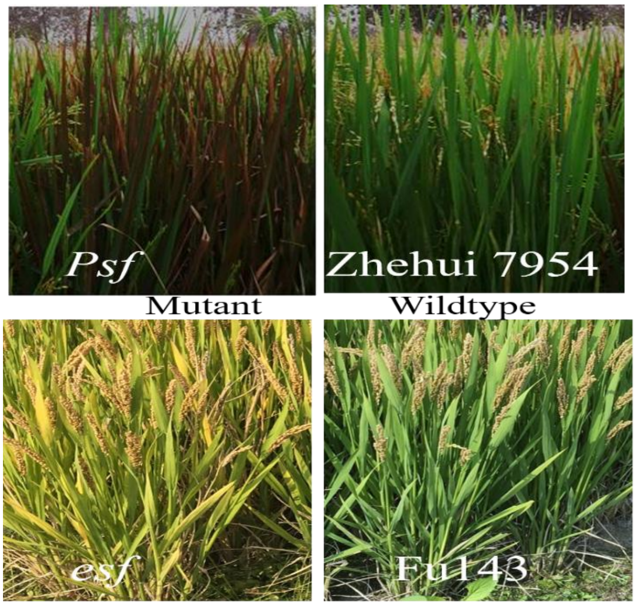
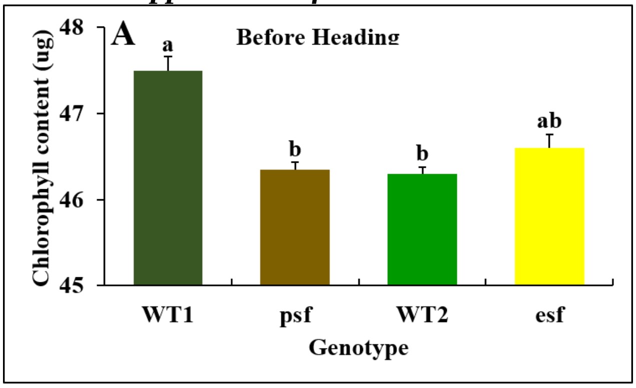


*Plate 5. **Visual Appearance of the mutants and Rice***



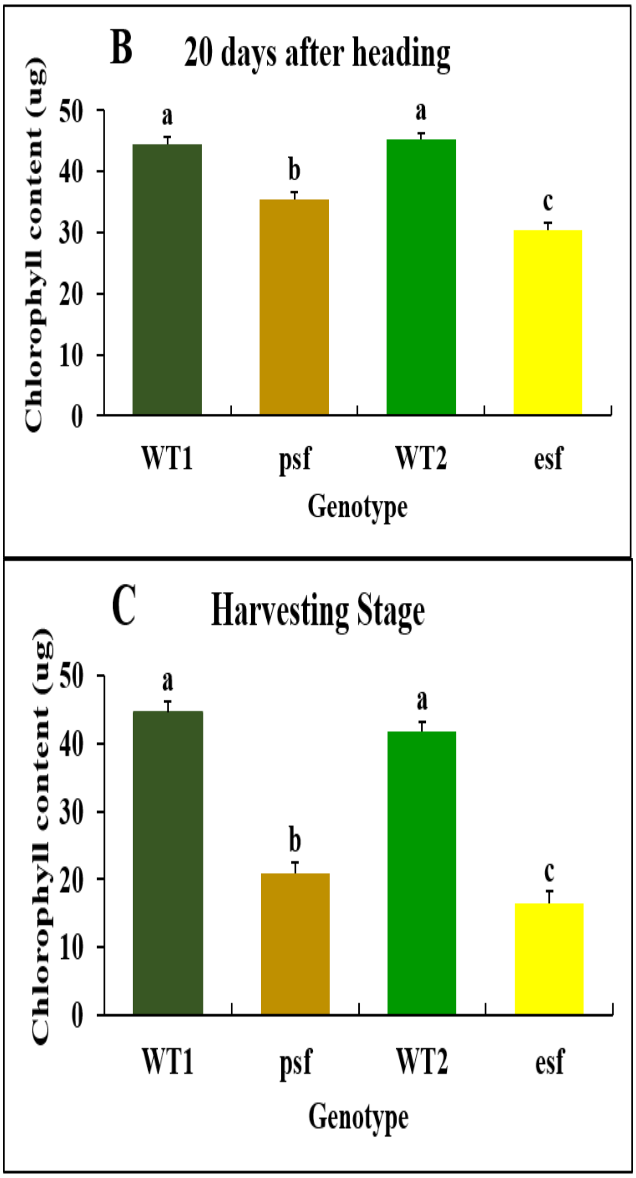


Figure 1. ***Temporal Pattern of the Chlorophyll Content***

Table 13: ***Genotypic Differences in Leaf Area Indices among the Genotypes***

Genotype	FLA (Before Anthesis) (cm²)	FLA (At Harvest) (cm²)	FLA Retention (%)	FLA Loss (cm²)	FLA Loss Rate (cm²/day)
WT1	***315.6ᵇ***	***205.0ᵇ***	***65.0ᵃ***	***110.6ᵈ***	***3.2ᵇ***
psf	***250.1ᶜ***	***100.7ᵈ***	***40.2ᶜ***	***149.5ᵃ***	***4.3ᵃ***
WT2	***340.7ᵃ***	***225.6ᵃ***	***66.2ᵃ***	***115.2ᶜ***	***3.3ᵇ***
esf	***246.4ᶜ***	***121.5ᶜ***	***49.3ᵇ***	***124.9ᵇ***	***3.6ᵇ***
SE±	23.65	30.67	6.29	8.67	0.25

FLA: Flag Leaf Area. Leaf Area Retention (%) = (LA at Harvest Stage /LA a Week Before Anthesis) ×100. Leaf Area Loss=Leaf Area a Week Before Anthesis−Leaf Area at Harvest Stage. Leaf Area Loss Rate (cm²/day) =Leaf Area Loss/35 Days from Anthesis to Harvest .

Table 14: ***The Overall Changes in Chlorophyll Indices among the Rice Genotypes***

Genotype	CR (20DAA) (%)	CR (Harvesting) (%)	Senescence Rate (SPAD units/day)
WT1	92.9ᵃ	93.1ᵃ	0.2ᶜ
Psf	76.6ᵇ	45.1ᵇ	0.5ᵇ
WT2	97.6ᵃ	90.1ᵃ	0.1ᵈ
Esf	65.2ᶜ	35.5ᶜ	0.8ᵃ
SE±	7.46	14.95	0.17

CR: Chlorophyll Retention, DAA: Days After Anthesis,
Chlorophyll Retention (%) = (SPAD at 20 days/SPAD at 0 days) ×100.
Senescence Rate = SPAD at 0 days − SPAD at 20 days/ Time (in days).

Table 15: ***Differences in Grain Quality indices among the Genotypes***

Genotype	Panicle Length	Total Grains Panicle^{-1}	Filled Grains Panicle^{-1}	GFR (%)	Yield Potential
WT1	20.2	177.3^{b}	136.1^{b}	76.7^{a}	2746.8^{a}
Psf	18.8	159.4^{c}	42.2^{c}	26.4^{b}	794.5^{b}
WT2	19.7	183.0^{a}	141.2^{a}	77.1^{a}	2787.4^{a}
Esf	18.0	153.7^{d}	30.4^{d}	19.8^{d}	549.1^{c}
SE±	0.47	7.01	9.66	5.59	21.99

GFR: Grain Filling Ratio, = (Filled Grains per Panicle/Total Grains per Panicle) ×100.

Yield Potential=Filled Grains per Panicle × Panicle Length

Table 16: ***Differences in Milling Quality among the Genotypes***

Genotype	BRR (%)	MRR (%)	HRP (%)	WCGR (%)	GLR	Milling Efficiency (%)	Quality Index
WT	66.04^{b}	58.87^{b}	108.77 ± 1.5^{a}	29.0^{d}	1.13 ± 0.05^{a}	89.01 ± 0.12^{b}	35.00 ± 2.1^{a}
psf	54.87^{b}	49.01^{c}	80.82 ± 2.0^{c}	41.3^{c}	0.92 ± 0.06^{b}	89.23 ± 0.10^{b}	-1.68 ± 1.8^{c}
WT	70.18^{a}	68.12^{a}	85.61 ± 1.8^{bc}	37.7^{b}	1.02 ± 0.04^{a}	97.00 ± 0.15^{a}	20.57 ± 2.0^{b}
esf	72.88^{a}	46.38^{d}	89.00 ± 1.7^{b}	69.7^{a}	0.77 ± 0.08^{b}	63.67 ± 0.20^{c}	-28.48 ± 3.0^{d}
SE±	3.97	4.97		8.82			

BRR: Brown Rice Rate, MRR: Milled Rice Rate, HRP: Head Rice Rate Percentage, WCD: White Core Degree. WCGR: White Core Grain Rate. GLR: Grain Length Ratio. Grain Length Ratio=Grain Length/0.60 (0.60 is standard). Milling Efficiency= (Milled Rice Rate/Brown Rice Rate) ×100. Head Rice Percentage= (Head Rice Rate/Milled Rice Rate) ×100. Quality Index=Head Rice Rate−White Core Grain Rate

DETERMINATION OF PHYSICAL AND CHEMICAL PROPERTIES OF ROSELLE *(Hibiscus sabdariffa* Linn.*)*

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ABSTRACT

A laboratory experiment was conducted during the 2023 cropping season at the Department of Agronomy, Soil Science and Animal Science laboratories, Faculty of Agriculture, Bayero University, Kano to determine the physical and chemical properties of Roselle. The materials consist of four germplasms of Roselle seed laid out in Completely Randomized Design, repeated three times. Data were collected on physical and chemical parameters. Analysis of variance revealed highly significant differences for all traits. Data on 100 seed weights among the germplasms varied from 2.53g-3.800g. The germplasm *Zobo Baki Kumo* had the highest seed swelling ratio, seed width, seed length, % ash content, % dry matter content, and % fat content. Moreover, Bakin *Mai Kofi Jigawa* had the highest seed weight, seed density, germination percentage, moisture content, and % nitrogen-free extract. Therefore germplasms *Zobo Baki Kumo* and *Bakin Mai Kofi Jigawa* are recommended and more research is needed to validate these findings.

Keyword: Physical and Chemical Properties, *Mai Kofi*, *Zobo Baki*

INTRODUCTION

Roselle *(Hibiscus sabdariffa* L.*)* belongs to the family Malvaceae and is a popular vegetable in Indonesia, India, West Africa, and many tropical regions like Nigeria and Niger republic. The calyces of Roselle are rich in anthocyanin, ascorbic acid, and other phenolic compounds (Anonymous, 2013). It is water soluble with a brilliant and attractive red color and with a sour and agreeable acidic taste, which aids digestion. Roselle has been used by people for preparing soft drinks such as *Zobo* and in traditional medicine. It has been observed that its components, such as vitamins (C and E), polyphenol acids, and flavonoids, mainly anthocyanin, have functional properties (Abou-arab *et al*., 2011). They contribute benefits to health as a good source of anti-oxidants as well as a natural food colorant. The other health benefits of this plant include diuretic and choleretic properties, intestinal antiseptic, and mild laxative actions. It is also used in treating heart and nerve disorders, high blood pressure, and calcified arteries. Due to the perceived safety and physiological advantage of natural colorants over synthetic ones, interest is being geared toward the search for new natural colorants and the verification of the safety of existing ones. In this respect, Roselle calyces appear to be good and promising sources of water-soluble red colorants that could be utilized as natural food colorants. Anthocyanins present in Roselle are delphinidin 3-sambubioside, cyanidin 3-sambubioside, delphinidin 3-glucoside, and cyanidin 3-glucoside (Diane *et al*., 2009).

Production of Roselle in Nigeria is facing many problems, which resulted in unstable total production. The main yield-limiting factors are: Roselle cultivation is underutilized by Nigerian farmers, the amount and distribution of rainfall, labour requirement for harvesting which amounts to about half the total cost of production. Moreover, the cultivars used for production are local types, which are characterized by low yield potential. The traditional farmers in Nigeria had sown roselle in a very wide space, crop productivity is still very low. On the other hand, there is increasing evidence that the uses of poor cultural practices (especially the practice of wide spacing), as well as traditional cultivars, are the main yield-limiting factors. Yet, the improvement of yield through manipulation of plant density and genetic improvement is possible (Ajayi *et al*., 2012). As the crop continues to play important horticultural roles in Nigeria, its improvement will surely enhance agricultural productivity, alleviate poverty, and facilitate food security. Unfortunately, very little research attention has been given to the improvement of the crop. This background has made it necessary to collect and evaluate the germplasm of the crop, as a basis for research into its development and promotion as a major crop in Nigeria.

Roselle (*Hibiscus sabdariffa)* is an underutilized multipurpose crop with enormous potential for medicinal value as well as industrial use. Roselle has been used as a refrigerant in the form of tea, as flavoring for sauces, jellies, marmalades, and soft drinks, or as a colorant for foods which Roselle appears to be a good and promising source of water-soluble natural red pigments. Several pharmacological and clinical studies suggest Roselle can be a good source of natural color in the form of antioxidant, antimicrobial, antihypertension, and many other properties like anti-inflammatory, hepatoprotective, and antitumoral effects have been reported. Nevertheless, Roselle cultivation is underutilized by Nigerian farmers. As such, there is needed to document the physical and chemical parameters of the Roselle germplasms so as to assist breeders in coming up with an improved varieties.

MATERIALS AND METHOS

Experimental site

The experiment was conducted at the Agronomy, Soil Science, and Animal Science Laboratories of the Faculty of Agriculture, Bayero University, Kano, within Sudan Ecological zones of Nigeria. Their locations lie between Latitude 11°59'E and Longitude 8°25E' and 466m above sea level.

Experimental materials

Four different germplasms of Roselle seeds were used for the study which were sourced from Gombe, Komo, and Jigawa. They were laid out in Completely Randomized Design, repeated three times at the Faculty laboratories. Data were collected on physical and chemical parameters. Their description is presented in the Table 1.

Data Collection Procedures:

The following procedures were carefully done and data were recorded accordingly;

Seed Weight (g)

One hundred seeds were counted from each lot, weighed separately on weighing balance, and recorded as 100 seed weight (g). The procedures were repeated three times.

Seed Volume (cm^3)

The volume of one hundred seeds counted and weighed above was estimated using a 50-milliliter Pyrex measuring cylinder. The seeds were poured onto the measuring cylinder containing a known volume of water (V_1). The final volume of water was observed and recorded as V_2. The difference between these volumes (V_2-V_1) being the volume of one hundred seeds was estimated and recorded as seeds volume (V_3). The measuring containing the soaked water was for 24 hours. The water volume was observed and recorded as volume (V_4).

Dry volume (Vd)= V_2-V_1

Wet volume (V_4)=V_3-V_2

Seed Density (g/cm^3)

The density of each variety was determined by dividing the seed weight by its corresponding dry seed volume.

P= M/V

M= weight of seeds (g)

V= seeds volume (m/s)

P= density (g/m/s)

Seed Swelling Ratio

This is calculated simply by dividing the wet seed volume (Vw) by the dry seed volume (Vd) as follows:

$$\frac{Vw}{Vd} = Swelling\ Ratio$$

Cotyledon/Seed Coat Ratio

Following the estimation of the wet seed volume, the seed coat was separated from the Cotyledon. Both were sun-dried for three days and weighed.

Seed Width

The width of the randomly selected seeds was taken using a digital veneer caliper. The seed was placed in between while the reading was taken and the procedures were repeated three times for all the genotypes.

Seed Length

The length of the randomly selected seeds was taken using a digital Caliper. The seeds were placed between the caliper while the readings were taken and the procedures were repeated three times.

Germination Percentage (%)

Ten seeds from each germplasm were randomly selected, wet with distilled water, and subjected to germination on the top of filter paper inside a petri dish; germination was then observed and recorded in percentage.

Ash (Dm basis)

The crucible with cover was removed and has been dried for at least 2 hrs at 100°C from the oven to the desiccator. It was cooled and the weight was recorded as (W_1) to the nearest 0.1mg. 1.5 to 2.0 g of sample was weighed into the crucible, and recorded to the nearest 0.1mg as (W_2). Ash was put into a furnace to less than 200°C and placed crucibles in a desiccator with a vented top. The cooled crucible with ash was weighed and recorded to the nearest 0.1mg as (W_3).

Calculation:

$$\%\,Ash\;(DM\;basis) = \frac{W3 - W1}{W2 - W1} \times 100$$

Where:

W_1= tare weight of crucible in grams

W_2= weight of crucible and sample in grams

W_3= weight of crucible and ash in grams

Moisture Content (Oven dry method)

The containers were dried at 100°C (105°C) for at least 2 hours. The container was covered and rapidly moved to the desiccator and covered immediately and then allowed the container to cool at room temperature. The weight of the container with a cover was taken as (W_1). 2 grams of ground sample was weighed as (W_2) into each container. The crucible was shaken gently to uniformly distribute the sample and expose the maximum area for drying. The samples were placed into the oven that had been preheated to 100°C (105°) at least 3 hours before use. The samples were left in the oven for 24 hours at 100°C or 16 hours (or overnight) at 105°C. The samples were then moved into a desiccator and the cover on each container as it was transferred. The desiccator was sealed and allowed to cool for at least 1 hour but not more than 2 to 3 hours. The container with cover was then weighed as (W_3) and recorded to the nearest 0.1mg.

Calculation: percent moisture

$$\%\,Total\;moisture = \frac{W3 - W2}{W2 - W1} \times 100$$

Where:

W_1= tare weight of the container (with cover in grams)

W_2= weight of sample and container in (with cover) in grams

W_3= dry weight of sample and container (with cover) in grams.

Percentage Dry Matter (DM basis)

The total weight of the container was taken before drying and recorded as (W_1). The weight of the container and sample was also taken after drying and recorded as (W_2). It was subtracted from the total weight of the container to determine the total weight of the sample after drying. The weight of dry matter was divided by the weight of wet matter (W_3) and then multiplied by a hundred.

Calculations:

$$\% \, Dry \, matter = \frac{W2 - W1}{W3} \times 100$$

Where:

W_1= tare weight of the container (with cover in grams)

W_2= Weight of the sample and container (with cover) after drying in grams

W_3= Weight of wet sample and the container (with cover) in grams.

% Crude Fiber (%)

2g of the sample was accurately weighed and recorded as (W_1), transferred to a 9cm hard filter paper supported on a filter cone in a 60° funnel, extracted with 25ml portions of ether, and applied to the vacuum until the sample was fully dried. The extracted sample was transferred quantitatively by brushing into a 600ml beaker of the digestion apparatus. 200ml of 1.25% Sulphuric acid solution was added. The beaker was then placed on a digestion apparatus with pre- adjusted heater and boiled for at least 30 minutes, rotating the beaker periodically to keep the solid from adhering to the sides. The beaker was then removed and filter content was through the California Bucher funnel. The beaker was rinsed with 50-75ml of boiling water, washed through the funnel, repeated with three 50ml portions of water, and sucked dry. The residue was returned to the beaker by flowing back through the funnel for exactly 30 minutes. The beaker was removed and filtered as before and 25ml of alcohol was added. The fiber mat and residue were added at 130+_ 2°C for 2 hours. Cooled in the desiccator, weighed, and recorded as (W_2). Ignited at 600+_ 15°C to constant weight (30 minutes usually sufficient), then cooled in a desiccator, weighed, and recorded as(W3).

Calculation:

$$\% \, Crude \, Fibre = \frac{W2 - W3}{W1} \times 100$$

Ether Extract (DM basis)

Extraction: The filter paper was folded into a thimble shape and weighed as (W_1). 1-2g of sample was weighed and placed into the thimble (W_2). The thimble was slipped into a thimble holder. About 250ml of Pet. Ether/diethyl ether was added using a glass funnel on the top of the condenser. The heater was switched, the main power was also switched, and the condenser water was turned on. After the ether had begun to boil, ether leakage was leaked, by sniffing around the ring clamp.

Extract was made for a minimum of four hours on a setting (condenser rate of 5 to 6 drops per second), or for 16hr on a low setting (condenser rate of 2 to 3 drops per second). After extraction, the heater was lowered down and shut off the power and water, allowing the ether to drain out of the thimbles. The thimbles were removed from the holder and allowed to drain and dry at 70°C for 30 minutes. The desiccator was cooled, weighed, and recorded to the nearest 0.1mg (W3).

Calculations:

$$\% \, Crude \, Fat \, (DM \, basis) = \frac{(W1 + W2) - W3}{W2} \times 100$$

Where;

W_1= Initial thimble weight in grams

W_2 = Sample weight in grams

W_3= Weight of sample and thimble after extraction in grams.

Percentage crude protein by Kjeldahl (Block digestion)

Digestion: 0.2g of sample was weighed out into the digestion tube. 15ml Conc Sulphuric acid was added, and the tube was gently swirled until the sample and acid were thoroughly mixed. 5g Kjeldahl catalyst mixture was added and cautiously heated until the solution cleared. The temperature was raised and heated to a boil for 2 hours after the solution had cleared. It was then allowed to cool, and the content was transferred into a 100-volumetric flask, diluted the volume with distilled water, and mixed thoroughly.

Distillation: 10ml of 2% boric acid was measured and 1-2 drops of the mixed indicator were also put into 100ml Erlenmeyer flask. 10ml aliquot of the digest was transferred into a distillation apparatus. 15 ml of 40% NaOH was added to the mixture. N was distilled into the boric acid/indicator flask for at least 10-15 minutes. The condenser tip was rinsed with distilled water.

Titration: the distillate was titrated with standard 0.025N sulphuric acid to a pink end point and takes, and the burette was recorded as (TV)

Calculation:

$$\%N = \frac{0.014(MeN \div 100g) \times Volume \, of \, digst \, (100ml) \times Normality \, of \, acid(0.025)}{Weight \, of \, sample \, (0.2) \times Volume \, of \, aliquot \, used \, (10ml)} \times 100$$

$$\% \, Crude \, Protein = \% \, N \times 6.25$$

*6.25 is a factor by which the N content of a feed is multiplied to determine the protein content, it depends on the amino acid composition of the protein.

Percentage Nitrogen Free Extract

Nitrogen Free Extract represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in the sample.

Calculation:

$$NFE = \%\, DM - (\%\, EE + \%\, CP + \%\, Ash + \%\, CF)$$

Where:

NFE= Nitrogen Free Extract

DM= Dry Matter

EE= Ether Extract

CP= Crude Protein

CF= Crude Fiber

Statistical Analysis

All data collected were subjected to analysis, using Statistical Analysis System (SAS, 2004) and means were separated using SNK.

RESULTS AND DISCUSSION

Mean square from the ANOVA

The Mean square from ANOVA for the physical and chemical properties of the Roselle is presented in Table 2 below. The table indicated that there were highly significant differences among the germplasms for all characters under study except for Moisture content and Dry matter content in which significant differences were observed. The significant differences observed indicated variability for those traits. Similar results were also been reported by Ameru *et al.* (2006). The highly significant difference was also observed in similar findings reported by (Aremu *et al.*, 2006; Fagbenro *et al.* 2010). Additionally, significant differences were also recorded for ash content, similar findings have been reported by Emmy *et al*. (2008a, b) and Abu-Tarboush *et al.* (1997).

Mean Performance for Physical and Chemical Properties

Mean Performance is presented in Table 3 below. The results indicated that the germplasm *Red Kwami Gombe* and *Bakin Mai Kofi Jigawa* had the highest seed weight (3.80g) each, while *White Kwami Gombe* recorded the lowest (2.53g). The germplasm *Zobo Baki Kumo* recorded the highest seed volume (3.27cm^3), while *White Kwami Gombe had* the lowest (1.40cm^3). Germplasm *White Kwami Gombe* had the highest seed density (1.83gcm-^{3}) while *Zobo Baki Kumo* had the lowest (1.10g/cm^3). The germplasm *Zobo Baki Kumo* recorded the highest seed swelling ratio (4.34), while *White Kwami Gombe* recorded the lowest (3.37). Germplasms *Zobo Baki Kumo* and *Red Kwami Gombe* recorded the highest seed width (2.76mm), while *White Kwami Gombe* had the lowest (2.55mm). Germplasm *Zobo Baki Kumo* recorded the highest seed length (4.77mm) while *Bakin Mai Kofi Jigawa* had the lowest (3.86mm). The germplasm *Bakin Mai Kofi Jigawa* recorded the highest germination percentage (94.00%) while *White Kwami Gombe* had the lowest (65.00%). Germplasm *Bakin Mai Kofi Jigawa* recorded the highest Seed cotyledon ratio (69.84%) while *White Kwami Gombe* had the lowest (65.43%). Germplasm Zobo *Baki Kumo* has the highest ash content (6.60%) while *Bakin Mai Kofi Jigawa* has the lowest (4.07%). The germplasm *Bakin Mai Kofi Jigawa* recorded the highest moisture content (9.74) while *Zobo Baki Kumo* had the lowest (8.40). The germplasm *Zobo Baki Kumo* recorded the highest dry matter content (91.60) while *Bakin Mai Kofi Jigawa* had the lowest (90.26). Germplasm *Red Kwami Gombe* recorded the highest crude protein (22.03) while *Bakin Ma*i *Kofi Jigawa* had the lowest (19.14). The germplasm *White Kwami Gombe* and *Zobo Baki Kumo* recorded the highest fat content (6.53) while *Bakin Mai Kofi Jigaw*a had the lowest (2.47). Germplasm *White Kwami Gombe* recorded the highest crude fiber of 23.06, while *Red Kwami Gombe* had the lowest (20.22). Germplasm *Bakin Mai Kofi Jigawa* recorded the highest nitrogen-free extract (39.59) while *White Kwami Gombe* had the lowest (31.50).

The significant differences observed among the germplasm for seed density, seed volume, seed swelling ratio, seed length, seed width, and seed cotyledon ratio are due to natural diversification of the germplasms, genetic make-up as well as environmental influence. The values obtained for crude protein in this study were within the range of 19.14-22.03%, which is similar to the findings of Fagbenro *et al*. (2010). Abu El-Gasim *et al*., (2008) reported that raw Roselle seed contained 21-35% crude protein. The presence of an adequate level of fiber in both raw and Roselle seeds reveals that the seed can be utilized as a better source of fiber for animals. The physical properties of the seeds were found to increase as the moisture content increased except for bulk density which decreased (Bamgboye *et al*., 2009).

CONCLUSION AND RECOMMENDATION

From the present investigation, it is concluded that the Roselle germplasms exhibited a wide range of variability for almost all the traits. Some germplasms possessed desirable genes for more than one character and hence could be utilized directly in hybridization programs. The differences observed in the physical and chemical properties of Roselle seeds utilized in this study may have serious implications in food processing industries. The germplasms can greatly be exploited in breeding programs for improvement purposes. Based on the findings of this study, *Zobo Baki Kumo* and *Bakin Mai Kofi Jigawa* are recommended and more research is needed to validate these findings.

REFERENCES

Abou-Arab, A. A., Abu- Salem, F. M., & Abou-Arab, E. A., (2011). Physicochemical properties of natural pigments (anthocyanin) extracted from Roselle calyces (*Hibiscus sabdariffa*). *Journal of American Science,* 7(7), 445-456.

Abu El-Gasim, L; (2008). Effect of soaking, sprouting, and cooking on chemical composition, bioavailability of minerals, and in vitro protein digestibility of Roselle (*Hibiscus sabdariffa* L.) seeds. *Pakistan Journal Nutrition,* 7 (1): 50-56.

Abu-Tarboush, H. M., Ahmed, S. A. B., & Al Kahtani, H. A., (1997). Some nutritional and functional properties of Karkade (*Hibiscus sabdariffa*) seed products. **Cereal Chemistry,** (74): 352-355.

Ajayi, O. A., Olawale, A. S., & Adefila, S. S., (2012). Conversion of sorrel (*Hibiscus sabdariffa*) calyces to glucose. *International Journal of Scientific & Technology Research,* 1(8), 130-138.

Anonymous, (2013). All About Roselle, **The Earth of Indi**a, *http://theindianvegan.blogspot.in/2013/02/all-about-roselle.html* (Accessed on 12 June 2019).

Aremu, M.O., Olonisakin, A., Atolaye, B.O., Ogbu, C.F., (2006). Some nutritional and functional studies of Prosopis Africana. *Electron. J. Environ. Agric. Food Chem*. 5(6): 1640-1648.

Bamgboye A.I., Adejumo O.I(2009). Physical Properties of Roselle (*Hibiscus sabdariffa L.*) Seed. *Agricultural Engineering International: the CIGR Ejournal. Manuscript* (6):1154.

Diane, L. M., Chen, O., Saltzman, E., & Blumberg, J. B. (2009). *Hibiscus sabdariffa L. tea* (tisane) lowers blood pressure in prehypertensive and mildly hypertensive adults. *The Journal of Nutrition*, 140(2), 298-303.

Emmy Hainida K,I., Amin, I., Normah, H., Mohd-Esa, N., (2008a). Nutritional and amino acid contents of differently treated Roselle (*Hibiscus sabdariffa L.*) seeds. *Food Chem*. (111): 906-911.

Emmy Hainida K, I., Amin, I., Normah, H., Norhaizan, M.E., Ainul, Z.,(2008b). Effects of defatted dried Roselle (*Hibiscus sabdariffa L.*) Seed powder on lipid profiles of hypercholesterolemia rats. *Journal Sci. Food Agric*. 88: 1043-1050.

Fagbenro, O.A., Adeparusi, E.O., Jimoh, W.A.,(2010). Nutritional evaluation of sunflower and sesame seed meal in *Clarias gariepinus*: An assessment by growth performance and nutrient utilization. *African Journal For Agricultural Research*. 5(22): 3096-3101.

SAS 2004, SAS Users guide, Statistical Analytical System, version 7th ed. SAS Inst.Inc. Cary, NC, USA.

Table 1: Description of Germplasms used for the study

S/N	Genotype	Coat color Variation	Texture	Source
6	*White kami Gombe*	dark brown	Wrinkled and coarse	Gombe
7	*Red kami Gombe*	Brownish	Wrinkled and coarse	Gombe
8	*Zobo baki Kumo*	dark brown	Wrinkled and coarse	Gombe
9	*Baki Mai Kofi Jigawa*	Brownish	Wrinkled and coarse	Jigawa

Table 2: Mean Square for Physical and Chemical Properties of Roselle at BUK, 2023

S.V	DF	Sw (g)	Sv (cm^3)	SD (g/cm^3)	SSR	SWt (mm)	Sl (mm)	GP (%)	Ash (%)	DM (%)	MC (%)	CF (%)	Fat (%)	CP (%)	NFE (%)
Germplasm	3	1.10**	2.31**	0.33**	0.61**	0.04**	0.44**	527.6**	3.94**	1.23*	1.23*	23.17**	11.34**	5.87**	39.97**
Error	8														
Total	11														

Key: S.V: Source of Variability, Df: Degree of freedom, SW(g): Seed Weight in gram, Sv: Seed volume, SD: Seed Density, SSR: Seed Swelling Ratio, SWt: Seed Width, Slmm: Seed length in millimeter, GP: Germination percentage, Ash: Percentage ash contents, DM: Dry Matter, MC: moisture content, CF: Crude fiber, Fat: Fat content, CP: Crude protein, NFE: Nitrogen Free extract.

Table 3: Means Performance for Physical and Chemical Properties of Roselle at BUK, 2023

Germplasm	SW(g)	Sv	SD	SSR	SWt	Slmm	GP	Ash	DM	MC	CF	Fat	CP	NFE
WKG	2.53^{b}	1.40^{b}	1.83^{a}	3.37^{b}	2.55^{b}	4.11^{b}	65.00^{c}	4..47^{bc}	90.43^{b}	9.57^{a}	26.03^{a}	6.53^{a}	21.90^{a}	31.50^{c}
ZBK	3.57^{a}	3.27^{a}	1.10^{b}	4.34^{a}	2.76^{a}	4.77^{a}	81.67^{b}	6.60^{a}	91.60^{a}	8.40^{b}	21.47^{b}	6.53^{a}	20.21^{b}	36.79^{b}
RKG	3.80^{a}	3.10^{a}	1.20^{b}	4.03^{a}	2.76^{a}	4.21^{b}	92.00^{a}	5.60^{ab}	91.23^{ab}	8.77^{ab}	20.22^{b}	4.53^{b}	22.03^{a}	38.85^{a}
BKJ	3.80^{a}	3.07^{a}	1.27^{b}	4.27^{a}	2.55^{b}	3.86^{c}	94.00^{a}	4.07^{c}	90.26^{b}	9.74^{a}	25.00^{a}	2.47^{c}	19.14^{b}	39.59^{a}
Mean	3.425	2.708	1. 350	4.008	2.655	4.239	83.167	5.183	90.882	9.118	23.171	5.017	20.820	36.684
CV	6.795	9.533	10.903	6.522	2.866	1.736	3.771	11.919	0.522	5.200	3.168	10.033	3.109	2.807

Key: WKG: *White Kwami Gombe*, ZBK: *Zobo Baki Kumo*, RKG: *Red Kwami Gombe*, BKJ: *Bakin mai Kofi Jigawa*, SW(g): Seed Weight in gram, Sv: Seed volume, SD: Seed Density, SSR: Seed Swelling Ratio, SWt: Seed Width, Slmm: Seed length in millimeter, GP: Germination percentage, Ash: Percentage ash contents, DM: Dry Matter, MC: moisture content, CF: Crude fiber, Fat: Fat content, CP: Crude protein, NFE: Nitrogen Free extract.

APPROPRIATE MECHANIZATION FOR TRANSFORMING CROP PRODUCTION

EFFECT OF OPERATIONAL PARAMETERS ON THE PERFORMANCE OF SOLAR-GAS DRYER FOR TOMATOES DRYING

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ABSTRACT

The drying process is a heat and mass transfer phenomenon where water migrates from the interior of the drying product onto the surface from which it evaporates. Heat is transferred from the surrounding air to the surface of the product. Drying of agricultural products is one of the key postharvest activities necessary to enhance the storability of harvested products. This research is to evaluate the effectiveness of a Solar gas (sol-gas) dryer for drying tomatoes. The sol-gas dryer consists of a drying chamber, heating chamber, blower, thermometer, temperature controller, and solar energy system which consists of a battery and solar panel. The solar system was fitted to power the blower while gas is used as a heat source. The drying chamber consists of drying trays; a chimney and can handle 500 kg of tomato in a batch. The effects of operational parameters, including temperature, tomato thickness, and air flow rate, on the drying period were evaluated. Three levels of temperatures (50, 60 and 70˚C) and two levels of airflow rates (1 and 1.5 m/s) were evaluated. The airflow rates were achieved by different regulations of the 12-volt dc fan. The effects of these parameters were evaluated using three different thicknesses of tomatoes (2.5, 3.5 and 5mm thickness). The results showed that higher temperatures reduced the drying period, but the drying period was, however, elongated as a result of an increase in the tomato thickness. Higher airflow velocity affected the heat retention period thereby resulting in cake-harding. The sol-gas dryer is therefore a cost-effective and sustainable technology for drying tomatoes.

Keywords: *Crop drying, sustainable mechanization, Solar energy, Sustainable agriculture*

INTRODUCTION

Drying process is a heat and mass transfer phenomenon where water migrates from the interior of the drying product onto the surface from which it evaporates. Heat is transferred from the surrounding air to the surface of the product. Apart from this, heat is transferred to the interior of the product, causing a rise in temperature and formation of water vapor, and the remaining amount is utilized in the evaporation of moisture from the surface (Gupta et al., 2016). Drying is one of the oldest methods known for the preservation of agricultural products such as fruits and vegetables. Drying agricultural products enhances their storage life, minimizes losses during storage, and saves shipping and transportation costs (Amer et al. 2019).

A dry food product is less susceptible to spoilage caused by the growth of bacteria, molds, and insects. The activity of many microorganisms and insects is inhibited in an environment in which the equilibrium relative humidity is below 70% (Feng, 2020). Likewise, the risk of unfavorable oxidative and enzymatic reactions that shorten the shelf life of food is reduced. Many favorable qualities and nutritional values of food may be enhanced by drying. Packaging, handling, and transportation of a dry product are easier and cheaper because the weight and volume of a product are less in its dried form. A dry product flows easier than a wet product; thus, gravity forces can be utilized for loading and unloading and short-distance hauling. Food products are dried for improved milling, mixing, or segregation. A dry product takes far less energy than a wet product to be milled. A dry product mixes with other materials uniformly and is less sticky compared with a wet product. Drying has also been used as a means of food sanitation (Minz and Subramani, 2018). Insects and other microorganisms are destroyed during the application of heat and moisture diffusion.

Over the years, many types of dryers have been developed for drying agricultural products, solar dryers, hot air–drying, microwave drying, and freeze-drying. Sun drying is a common practice to preserve and store fruits and vegetables, while hot-air drying is widely employed in industrial applications (Udomkum, 2020). Solar drying could be direct drying or indirect drying. The indirect one is by far more efficient than the direct one for the quality of the products after drying. Direct drying is the conventional and most primitive way of drying crops and other products. This method involves direct exposure of the products to solar radiation, enabling the release of moisture into the atmospheric air.

In this work, we evaluated the performance of a solar-gas dryer that was developed for drying various agricultural products. Although the dryer has been used intermittently, its performance and the effect of the operational parameters have not been evaluated. This work is therefore aimed at evaluating the effects of operational parameters on the performance of the solar-gas dryer in drying agricultural products such as tomatoes. The work is expected to contribute to the ongoing efforts to provide the appropriate technologies and processes for enhancing the quality of agricultural products.

METHODOLOGY

Materials

UTC tomatoes were procured for the drying. An electric multi-crop slicer was used to slice the tomatoes into the designed thickness. A hand-held Anemometer was used to measure the airflow rate and a thermo-hygrometer was employed to measure temperatures and relative humidity. A stopwatch was utilized to record the drying time.

Description of the Sol-Gas Dryer

The developed Sol-Gas dryer (Fig. 2) consists of a drying chamber, heating chamber, blower, thermometer, temperature controller, and Solar energy system which consists of a battery, and solar panel. The solar system was fitted to power the blower while gas is used as a heat source. The drying chamber consists of drying trays, and a chimney and can handle 500 kg of tomatoes at a batch. It is made of 2mm sheet metal outside and 1.5 galvanized iron sheet inside 2m by 1m long. The dryer was insulated to prevent heat loss.

Principle of operation of the dryer

The process of drying food involves the process of changing the form of water in food to gas. Then remove it from the food products using heat obtained from hot air. Therefore, the operational principle of the dryer involves heating the heating chamber through gas energy, blowing and pushing the heated air to the drying chamber after loading, with the aid of a blower fitted to the solar energy system which consists of a battery and solar panel. This process involves changing the form of water in food to gas and then, removing it from products to the atmosphere through the chimney continuously. The temperature is controlled by the gas burner using a thermometer attached to the dryer's door. The door is expected closed while drying for more than fifteen hours, to ensure faster drying of the food products.

Experimental Procedure

Tomatoes were sorted, washed, sliced, and drained, and the dryer was pre-heated for 10 minutes before drying. The dryer was loaded with the sliced tomatoes, and two trays at the base; the middle and top of the dryer were assigned for the experiment. For the measurement of the drying rate, the assigned trays were removed hourly for the determination of the weight changes. This was done as quickly as possible to minimize the influence of environmental factors. The drying continued until safe moisture content (12%) was achieved as reported by existing research (Sohail et al., 2011).

Effect of operational parameters on the performance

The Solar-gas dryer was evaluated using factors such as temperature, air flow rate and thickness of the tomatoes.

Temperature

A digital thermometer was attached to the dryer's door to read the temperature within the drying chamber. When heat is supplied to the inner of the drying chamber from the heating chamber with the aid of gas energy and its burner, the degree of temperature is shown for reading. The rate at which heat is increasing can be controlled by reducing the burning gas through the gas burner. Therefore, when the drying chamber containing tomatoes reaches a prescribed temperature, then the gas burner is controlled. Three ranges of temperatures (50, 60, and 70˚C were achieved and evaluated on the drying time. These selections were achieved through the three different sizes of the gas burner (top, middle and bottom) respectively

Air flow rate

An anemometer was placed inside the drying chamber where a blower's air was passing, which caused the rotation of an anemometer, and through this rotation, the amount of air mass passing to the drying chamber was measured by the reading obtained from the anemometer. Two ranges of airflow rates (1 and 1.5 m/s^2) were achieved and evaluated on the drying time. These were achieved by different regulations of the 12volt dc fan.

Tomato thickness

A multi crops slicer was used to slice different thicknesses of tomatoes by changing its washer of different sizes. Therefore, three different thicknesses of tomatoes (2.5, 3.5, and 5mm thickness) respectfully were achieved and evaluated on the drying time.

Determination of Drying time

The performance index determined was drying time. This is the period at which the safe moisture content (12%) of the dried tomatoes was achieved. Moisture content determination was determined using Equation 1.

$$MC = \frac{W_2}{W_2 - W_1} \times 100 \qquad \text{......} \quad 1$$

Where W_1 = Initial weight of the tomatoes (Kg)

W_2 = Final weight of the tomatoes (Kg)

RESULTS AND DISCUSSION

Effects of temperature on the drying time

The effect of temperature on the drying time is presented in Table 1. It can be seen that an increase in temperature decreases the time required to dry an equal amount (kg) of the tomato to safe moisture content. This is to say; the higher the temperature, the shorter the drying rate. This could be because at higher temperatures, there is higher specific heat which agitates the moisture molecules within the tomatoes and as a result facilitates faster migration of moisture to the surface where vaporization takes place. Drying times of 1545, 1500, and 1320 minutes were achieved for 50, 60 and 70 ^{0}C respectively.

Effects of thickness on the drying time

The effect of tomato thicknesses on the drying time is depicted in Fig 3. It can be seen that an increase in thickness increases the time required to dry an equal amount (kg) of the tomato to a safe moisture content. This is to say; the higher the thickness, the longer the drying time. This could be because, at lower thickness, moisture/water contained in the tomatoes migrate faster to the surface where vaporization takes place. Hence, faster drying is achieved. Drying times of 1265, 1470, and 1734 minutes were achieved for 2.5, 3.5, and 5 mm respectively.

Effects of air-flow rate on the drying time

The effect of the air-flow rate on the drying time is shown in Fig. 4. It can be seen that an increase in air-flow rate elongates the retention period thereby resulting in lower moisture removal per unit time. A higher air flow rate could cause a cooling down of temperature which can increase the drying time. Drying times of 1200 and 1620 minutes were achieved for 1 and 1.5 m/s respectively.

CONCLUSION

The performance of the sol-gas dryer in drying tomatoes was successfully evaluated. An increase in temperature reduces the time required to dry tomatoes. However, the drying period was elongated as a result of the increase in tomato thickness. Higher airflow velocity affected the heat retention period thereby resulting in cake-harding. A drying period of 1545, 1500 and 1320 minutes were achieved for temperatures of 50, 60 and 70˚C respectively. Drying periods of 1265, 1470, and 1734 minutes were recorded for thicknesses of 2.5, 3.5, and 5 mm respectively. Drying periods of 1200 and 1365 minutes were recorded for airflow rates of 1 and 1.5 m/s respectively. The Sol-gas dryer can be considered an efficient and cost-effective drying technology. It is recommended that the dryer should be re-evaluated for drying other commodities such as peppers and fruits.

REFERENCES

Amer, M., Nour, M, Ahmed, M, Ookawara, S, Nada, S, and Elwardany, A, (2019). The effect of microwave drying pretreatment on dry torrefaction of agricultural biomasses, Bioresour. Technol., vol. 286.

Feng, Y, (2020). Effect of freeze-thaw cycles pretreatment on the vacuum freeze-drying process and physicochemical properties of the dried garlic slices, Food Chem., vol. 324, p. 126883.

Gupta, P, Ahmed, N, Singh, J., Chauhan, H., Anjum, A and Kour, H, (2016). Different Drying Methods: Their Applications and Recent Advances, *International journal of*

Minz, P. S. and Subramani, P (2018). Study of heating pattern during heat treatment of milk by ohmic heating, vol. 7, no. 2, pp. 3033–3036.

Udomkun, P (2020). Review of solar dryers for agricultural products in Asia and Africa: An innovation landscape approach, J. Environ. Manage., vol. 268, p. 110730.

Fig 1. (a) Electric slicer (b) anemometer used in the work

Fig. 2 The front and back view of the Sol-Gas Dryer

Table 1: Effect of temperature on the drying time of tomato with 3.5 thickness and 1(m/s)

S/N	Temperature (^{0}C)	Average Drying Time (mins)
1	50	1545
2	60	1500
3	70	1320

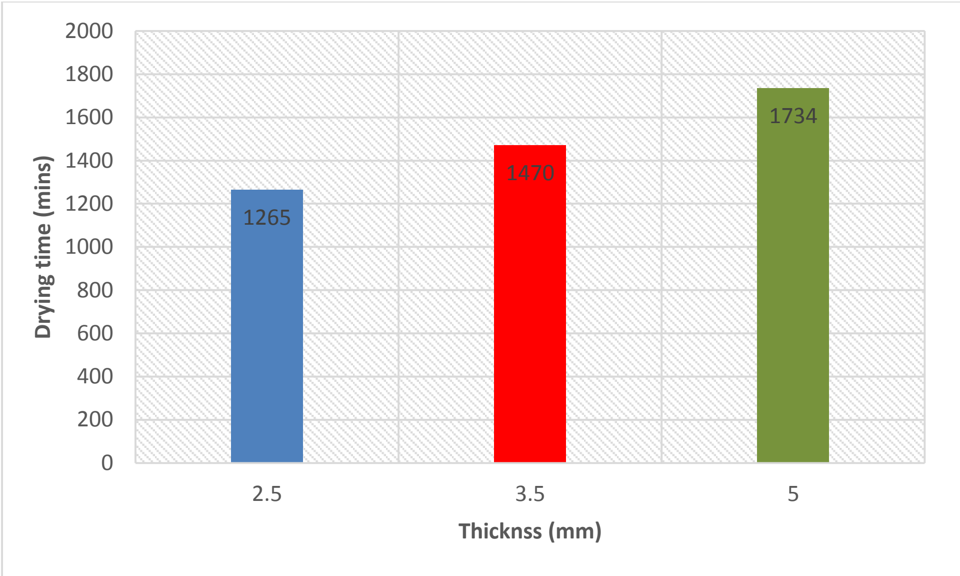

Fig. 3: Effect of thickness on the drying time of tomatoes

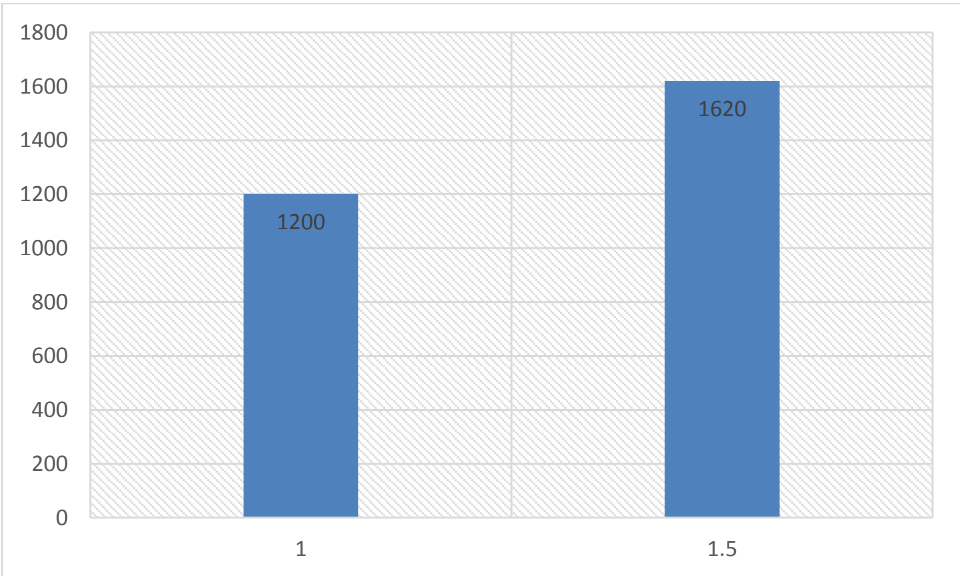

Fig. 4: Effect of temperature on the drying time of tomato at 60^{0}C and 3.5mm thick

PERFORMANCE EVALUATION OF MICROMEC MULTI-CROP THRESHER

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ABSTRACT

Threshing of grains is an important postharvest operation, which determines, to a large extent, the quality of the produce. In Nigeria, a range of imported and locally fabricated threshers are available, but information on their performance and key operational parameters is lacking. This study was carried out to evaluate the performance of a Micromec multi-crop thresher that was recently procured. The study was carried out using two types of crops namely sorghum and millet which were harvested and dried to a moisture content of 12% d/d. Threshing operations were carried out to evaluate the threshing efficiency, cleaning efficiency, scatter loss and throughput capacity. The thresher achieved 98.75% threshing efficiency, 82.64% cleaning efficiency, 10.42% scatter loss, and 192 kg/h throughput capacity for sorghum and 98.38% threshing efficiency, 76.19% cleaning efficiency, 19.05 scatter loss, and 61.76kg/h throughput capacity for millet. The results showed that thresher exhibited higher performance for sorghum threshing compared to millet. The thresher is therefore recommended for threshing sorghum.

Keywords: *Threshing, Postharvest Technology, Operational parameters,*

INTRODUCTION

Agriculture has been and will continue to be a strong part of the Nigerian economy. Agriculture contributes approximately 22% to the total GDP as of Q1 2020. It plays a vital role in the sustainment of the livelihood of Nigerians as the agricultural sector remains the largest employer in Nigeria. Employing more than 36% of the labor force (Oyaniran, 2020). However, Nigeria's agricultural sector still suffers setbacks due to low technological inputs in agricultural activities such as harvesting, threshing, and milling. Threshing is a key postharvest operation where grains are separated from harvested crops, particularly cereal grains, such as sorghum, millet, wheat, barley, and rice. It involves the mechanical removal of seeds or grains from the stalks and husks, commonly known as straw or chaff. Threshing is a crucial step in the post-harvest processing of crops, facilitating the extraction of valuable edible grains from the bulkier plant material, and preparing them for further processing or consumption (Saleh et al, 2016).

In Nigeria, threshing of grains is originally done by the use of traditional methods which involve the use of bare hands, pestle and mortar, and beating the grain out from the ears of the grain with a stick. The traditional methods of threshing are generally tedious and time-consuming, and characterized by low efficiencies and outputs (Kailashkumar, 2019). On average 1 to 3 bags of grains can be threshed by the use of traditional methods. Mechanical or power threshers have been introduced over the years to overcome those difficulties (Dauda and Adgidzi, 2002). Mechanical threshers can detach grains from harvested crops and separate the threshed grain from the chaff at high throughputs.

To achieve food security in Nigeria, appropriate mechanization must be adopted by the farmers, particularly the smallholder farmers who constitute the majority. However, agricultural production is predominantly done manually, resulting in low hectarage and poor-quality produce. Threshing is one of the key postharvest activities in grain production, which determines, to a large extent, the quality of the grain. While threshing is still largely done manually, threshers of different specifications are available in the market, including multi-threshing machines that can perform the thresh multiple crops. Information regarding the performances of threshers, such as the throughput capacity, threshing efficiency, fuel consumption, etc. is required for selection and effective utilization of the machines.

Many studies on the evaluation of threshers have been reported. For example, Singh et al. (2015) developed a multi-millet thresher and carried out a performance evaluation on the machine and reported that at a moisture content of 7.79%, feed rate of 105 kg/h and a cylindrical speed rate of 625 rpm, the maximum threshing efficiency and cleaning efficiency were measured to be 95.13% and 94.12% respectively, and concluded that the multi millet thresher is suitable for the threshing of various types of millets. Karthik et al. (2015) evaluated the performance of a multi-threshing machine for safflower at two levels of moisture content (10.89% and 12.05%), three levels of cylinder speeds (840rpm, 735rpm, and 630rpm) and three levels of feed, and observed the threshing efficiency of more than 98% and grain output of 28.84 – 72.48kg/hr. Muhammad et al. (2019) also led research on the performance evaluation of a multi-crop thresher with sorghum and maize crops respectively and detected that the machine can be best used in threshing Maize at a combination of feed rate of 40 kg/min and a speed of 950 rpm. With this combination, the mean values for output capacity, threshing efficiency, cleaning efficiency, scatter loss, and grain breakages are 676.80kg/hr, 100.00%, 74.70%, 27.8% and 1.38% respectively and the best combination for threshing of Sorghum with the machine is at the feed rate of 12 kg/min and a speed of 950 rpm. However, each specific thresher needs to be evaluated for effective utilization and maintenance.

This work was conducted to evaluate the performance of a Micromec multi-crop thresher that has not been evaluated before. The aim is to evaluate the performance of the thresher with the view to provide valuable information on the machine's overall performance and effectiveness in threshing different crops. Specifically, it will determine the throughput capacity, threshing efficiency, scatter loss and cleaning efficiency for threshing sorghum and millet as model crops.

MATERIALS AND METHODS

Materials

The materials used in this research include a Digital Weighing balance (0.01g precision), Tachometer (Model TS 6000 and sensitivity of 5V per 1000 rpm), Millt (super SOSAT), Sorghum (CRS-01), Oven (model (SM 150 temperature range 195 – 2250C), Measuring cylinder (1000ml), Digital stopwatch, and fuel (diesel).

Threshing Procedure

The prime mover will provide drive-through a V–belt that will be connected to the pulley attached with a set of beaters and blower. The hopper is the part where the grains will be introduced and moved into the threshing unit to remove grains from the ears. The cleaned grains will then be collected through grain delivery while the chaff will be blown off with a blower. The moisture content of the grain will also be determined by using oven drying in which the sample will be dried at 130°C for 18 hours and moisture content on a wet basis will be obtained from Equation 3.1 (Muhammad et al. 2019).

Performance Evaluation

To evaluate the performance of the Micromec multi-thresher, the following parameters were evaluated:

Threshing efficiency, Te (%)

It is the ratio of threshed grain received from all outlets concerning total grain input expressed as a percentage by weight. it is expressed as Equation 1:

$$\text{Te} = (100 - \frac{QU}{QT}) \qquad 1$$

Where: Qt = Weight of total mixture of grain and chaff received at the grain outlet (kg),

Qu = Quantity of unthreshed grains in sample (kg)

Cleaning efficiency CE (%)

Clean grain received at the main grain outlet concerning total grain mixture received at the main outlet expressed as a percentage by weight. It was determined according to Equation 2.

$$\text{CE} = (\frac{\text{QU}-\text{WC}}{QU})100 \qquad 2$$

Where: $CE = cleaning\ efficiency$, %,

QU = Quantity of unthreshed grains in sample (kg),

WC = weight of chaff (kg)

Scatter Loss SL (%)

The scatter loss is determined according to Equation 3.

SL (%) $SL = (\frac{Ql}{Qt})100$ 3

Where Ql = Quantity of grains scattered around the thresher after the threshing operation (kg),

Qt = Total quantity of grain in the sample (kg)

Throughput capacity, Tc (kg/hr)

The throughput capacity was calculated using Equation 4.

$Tc = (\frac{Qs}{T})$ 4

Where: Qs = Quantity of threshed grain collected after a threshing operation (kg)

T = Time taken for a complete threshing operation (h).

RESULT AND DISCUSSION

Threshing efficiency (TE) (%)

The threshing efficiency of the Micromec multi-crop for threshing sorghum and millet was evaluated. The threshing efficiencies were 98.75% and 98.38% respectively shown in Fig. 1. This showed that the thresher has a slightly higher efficiency for threshing sorghum compared to millet. However, the threshing efficiencies are within the range of efficiencies commonly reported for multi-crop threshers. For example, Abhishek and Stevens (2016) found the maximum threshing efficiency to be 98.89% in their study of high-capacity multi-crop thresher. This is significantly higher than the 79.86% achieved for sorghum in the Micromec multi-crop thresher. Another study on the modification and testing of a replaceable drum multi-crop thresher, as reported by Hussen *et al* (2015) reported threshing efficiencies ranging from 98.3 to 99.9% for different crops, which are still close to the values observed in our studies. Mechanical threshers have high threshing efficiencies compared to manual threshing methods. However, factors such as cylinder speed, feed rate, and concave clearance can significantly impact the performance of mechanical threshers. Thus, optimization of these variables could potentially improve the efficiency of the Micromec multi-crop thresher.

Cleaning efficiency (CE) (%)

The cleaning efficiency indicates the ability of the thresher to separate grains from chaff and other impurities. The cleaning efficiencies for the sorghum and millet were 82.64% and 76.19% respectively as shown in Fig. 2. The cleaning efficiency is higher for sorghum threshing compared to millet threshing. However, both cleaning efficiencies indicate that the threshed grains would contain some chaff. This suggests that the threshing and separation mechanism in the Micromec machine is not fully optimized for the complete separation of grain and chaff. According to Ugwu and Omirufyi (2016), the grain is separated from the chaff before to entering the grinding chamber using a blower. This implies that attaining superior grain separation requires careful consideration in the design of the threshing and separation system. This could be due to factors such as inadequate airflow, improper sieve settings, or suboptimal threshing drum design. When comparing these results with some previous studies, higher cleaning efficiencies have been reported, resulting in better separation of grain and chaff. Those threshers may have superior design features, such as adjustable sieves, multiple cleaning stages, or advanced airflow systems, leading to higher cleaning efficiencies and cleaner grain output. To enhance the cleaning efficiency of the Micromec multi-crop threshing machine, there is a need to optimize the airflow distribution, adjust sieve settings for different crop types, and possibly incorporate additional cleaning stages for improved separation.

Scatter Loss (SL) (%)

Fig. 3 depicts the results of the scatter loss evaluation. The scatter loss for sorghum threshing was 10.42% while that of millet threshing was 19.05% for millet. Scatter loss is an estimation of the amount of grains lost during the threshing process. A lower scatter loss percentage indicates a more efficient threshing process with less grain wastage. The results indicate that more grains are lost in millet threshing compared to sorghum threshing. Typically, lower scatter losses are desirable as they indicate better performance and less grain wastage. Thus, the scatter loss in both cases is considered to be high compared to many previous studies where scatter losses were mostly below 1%.

Throughput capacity (TC) (kg/hr)

The throughput, which is the quantity of grains threshed per unit of time, was evaluated for both sorghum and millet. The throughput capacities were found to be 180 kg/hr for sorghum and 65.63 kg/hr for millet (Fig. 4). The throughput capacity for sorghum was about 3 times higher than millet. Throughput capacity is an important parameter for the application of a thresher, and high throughputs are desirable for practical applications. However, several factors, including the feed rate, cylinder speed, and grain properties will affect the throughput of the thresher.

CONCLUSION

The performance evaluation was carried out on the Micromec multi-crop thresher. It can be seen that the cleaning efficiency, threshing efficiency, and throughput capacity are higher for sorghum threshing compared to the millet. This indicates that the Micromec multi-crop thresher is more suitable for sorghum threshing. However, the scatter loss in both cases is higher than is normally reported in the literature. It is recommended that the cleaning efficiency of the Micromec multi-crop thresher be optimized by improving the airflow distribution and introducing additional cleaning stages for improved separation.

REFERENCES

Dauda S.M. and D. Adgidzi (2002). Development of Indigenous rice Thresher in Nigeria. *Arid Zone Journal of Engineering, Technology and Environment*, 2:1-9

Kailashkumar, B. (2019) Study of Different Kinds of Threshers & Factors Influencing threshing of Crops: A Review. *International Journal for Scientific Research & Development*, 6 (12): 2321-0613

Karthik, S.K. Kumar, S. and Basavaraj (2015). Development And Performance Evaluation of Multi Crop Thresher, *International Journal of Agricultural Science and Research*, 5(5): 313-322.

Kumar, D, Kumar A., Khan, K and Singh, U.V. (2016). Performance Evaluation of Power Thresher for Wheat Crop. *International Journal of Agricultural Science and Research (IJASR)*, 6 (4): 195-204

Singh, K. P., Poddar, R. R., Agrawal, K. N., Hota, S and Singh, M.K. (2015): Development and evaluation of multi millet thresher. *Journal of Applied and Natural Science* 7 (2): 939 – 948.

Muhammad, M., Dangora N.D. and Ajeigbe, A.H. (2019). Performance Evaluation of ICRISAT IK00006 Multi-Crop Thresher. Nigeria *Journal of Engineering Science and Technology Research*, 5(2):55-61.

Oyaniran, T. (2020). Current State of Nigeria Agriculture and Agribusiness Sector. AfCFTA Workshop.https://www.pwc.com/ng/en/assets/pdf/afcfta-agribusiness-current-state-nigeria-agriculture-sector.pdf

Sale, N. A., Muhammed, U. S., Dalha, I. B. and Idris S. I. (2016). An improved IAR sorghum thresher. *Agricultural Engineering International: CIGR Journal*, 18(3):119-126

Yusuf, T. (2016). Performance Evaluation of a Sorghum Thresher for Fueling New Cycles of Success in the Threshing of Sorghum Crops in Northern Nigeria: *NSUK Journal of Science & Technology*, 6(2):177 -183

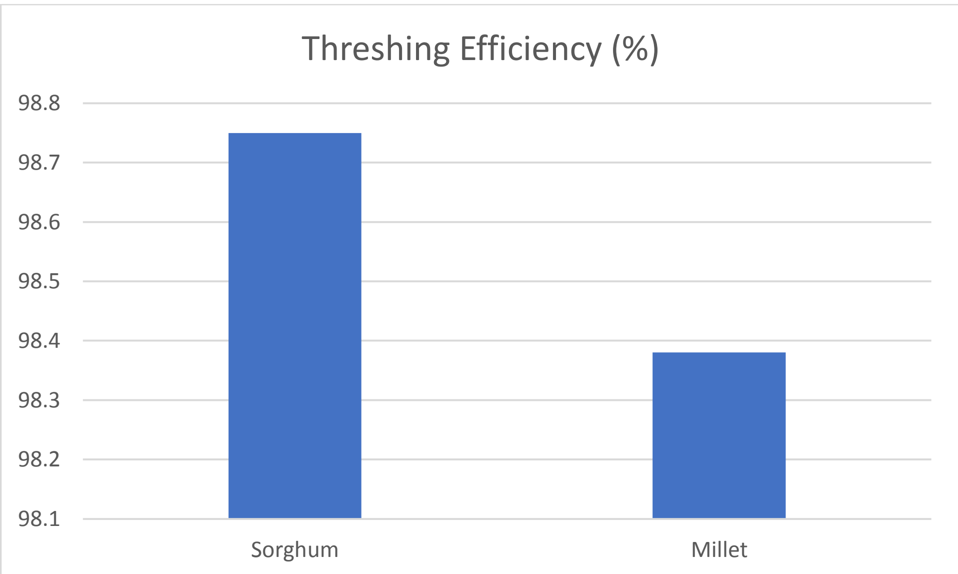

Fig. 1 Threshing Efficiency of the Micromec multi-crop thresher

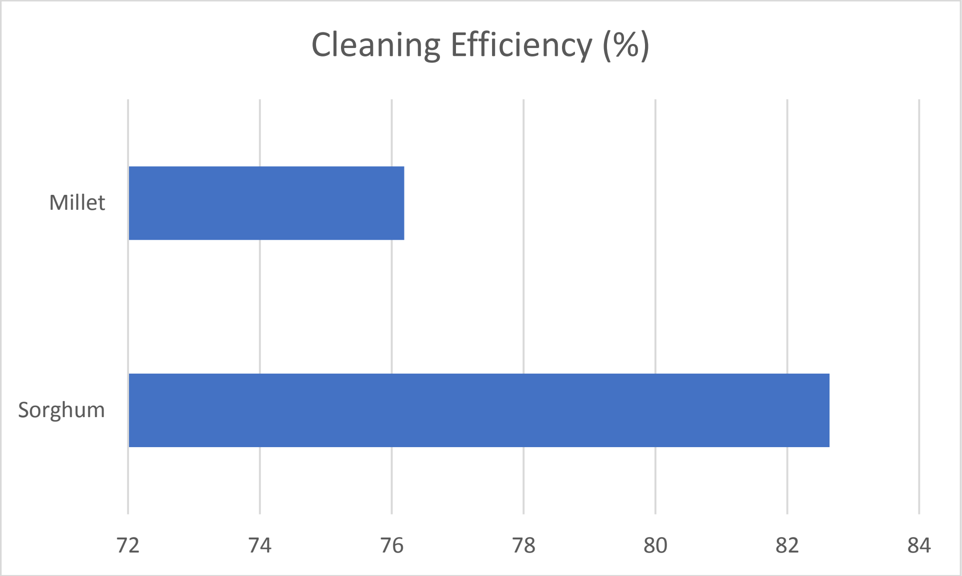

Fig. 2. Cleaning Efficiency of the Micromec multi-crop thresher

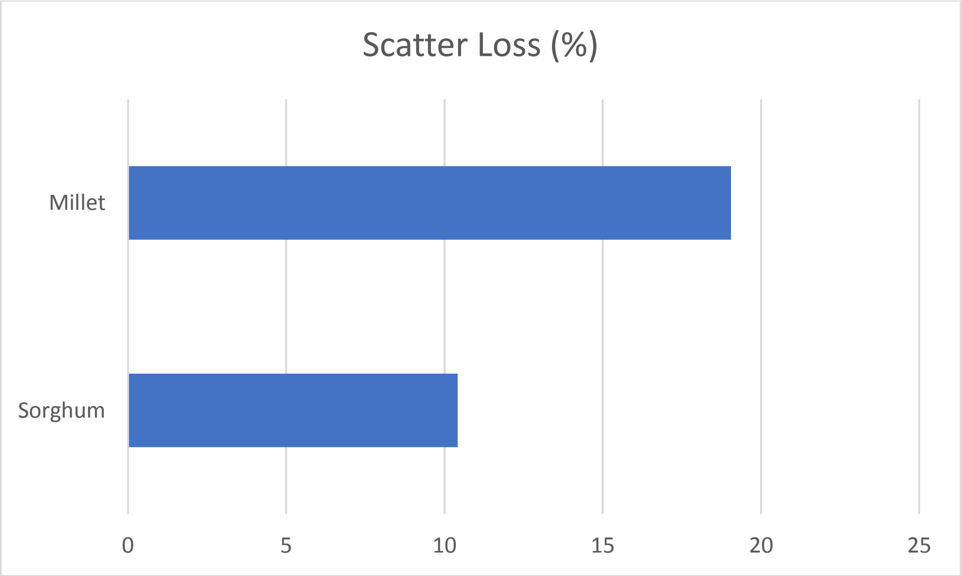

Fig. 3. Scatter Loss of the Micromec multi-crop thresher

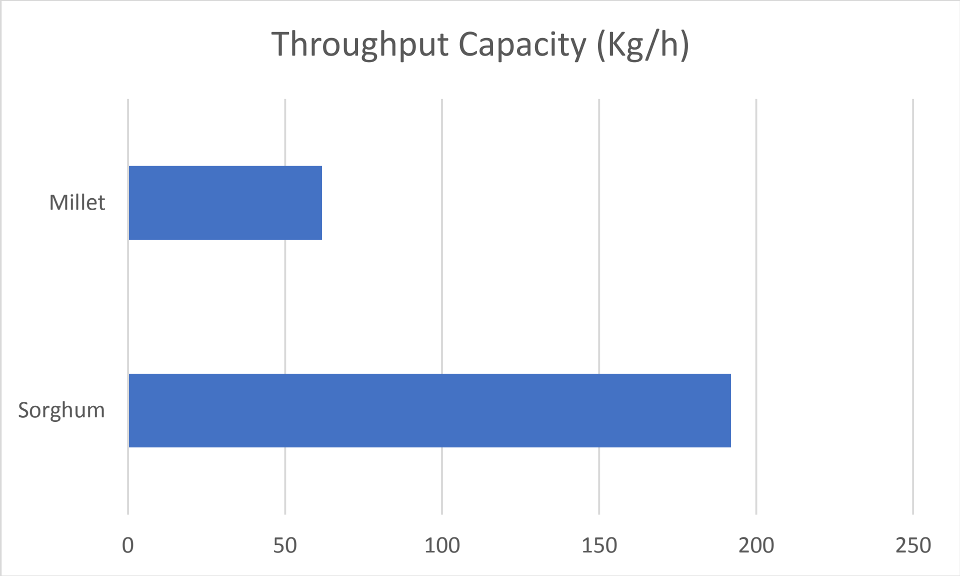

Fig. 4. Throughput of the Micromec multi-crop thresher


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