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**EFFECTS OF LAND USE AND DEPTH ON CARBON SEQUESTRATION AND AGGREGATE STABILITY IN SOILS OF COASTAL PLAIN SANDS PARENT MATERIAL IN OKWUTA-ISIEKE, SOUTHEASTERN, NIGERIA**

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**ABSTRACT**

***Effect of land use and depth on carbon sequestration and aggregate stability in soils formed under coastal plain sands in Okwuta-Isieke, Southeastern Nigerian were studied. The experimental design used for the study was 3 x 3 factorial in randomized completely block design (RCBD), comprising of two factors- soil depth (at 3 levels: 0-19, 20-39, 40-100cm) and land use [ at 3 levels: planted pine forest of Pinus carribeae plantation (PPF-PCP), Managed Tree Cropland of Irvingia wombulu plantation (MTC-IWP) and continuously cultivated cropland of cassava/maize/telferia intercrop (CCC-CMI). Results showed that higher (P<0.05) mean weight diameter was observed under PPF-PCP and MTC-IWP relative to CCC-CMT. Planted pine forest and Irvingia plantation improved (p<0.05) soil aggregate stability more than arable cropland. Land use significantly (p<0.05) influenced soil organic carbon (SOC) , total nitrogen, cation exchange capacity, available P and SOC pool. Soils under PPF-PCP sequestered higher (p<0.05) amount of C, followed by MTC-IWP soil; across the soil depths. The trend showed that pine forest >Irvingiawombulu> Cassava/maize/telferiaintercrop in the amount of C sequestered. Soil conservation practices associated with CCC-CMT should be re-evaluated as this is inadequate to improve the qualities of soil with emphasis on organic matter content and aggregate stability.***

**Key word: C**oastalplain sand, land use, aggregate stability, carbon sequestration

**INTRODUCTION**

Coastal plain sands is a dominant parent material in southeastern Nigeria due to the nearness of the region to the Atlantic coastal marshes (Ibe, 2014). These coarse textured soils are usually not environmentally friendly due to excessive soil nutrient leaching and low soil organic matter (SOM) (Anikwe, 2010). According to Ojanuga (1977), soils of southeastern Nigeria are highly weathered with low cation exchange capacity resulting in very low agronomic value. Uguru et al. (2011) recorded that coastal plain sands retain low amount of SOM because of its coarse nature and rapid mineralization of SOM in the tropics.

Food and Agricultural Organization (FAO, 2017) recognized reduction of agricultural related carbon emission as a main option in the mitigation of climatic change and global warming. Lal (2004) agreed that improved agricultural practices could help in mitigating climate change by reducing emissions from agriculture and storing carbon in plant biomass and soils. All ecosystems such as forests, grasslands, croplands, plantations swamp areas and fallow lands take up atmospheric carbondioxide (CO2) in the photosynthetic process and transform it into organic products (AN et al., 2010; Awelewa and Ogban, 2017). Soil carbon sequestration potential of a given ecosystem is dependent on use, crop plant species composition, age of component species, parent material, slope, various environmental factors and management practices (Ibe, 2020 and Salako, 2013). It was also reported by early researchers that soil carbon sequestration is a function of texture, elevation, drainage and degree of tillage operation carried out on arable cropland (IUSS Working Group, WRB, 2015; Salako, 2015; Abah and Petja, 2017).

According to Hamed et al. (2019), land use and continuous cultivation can change the total amount of soil organic matter (SOM) that is stabilized through physical and chemical processes. Long-term continuous cultivation and vegetation removal deplete SOC stock leading to aggregate instability due to low biomass input. Application of fertilizer, manure and other soil amendments have been found to increase SOC. This is because these cultural and management practices increase biomass and residue productivity (Baishya, 2015). Soils under long-term forage plants and crop rotation have higher (p<0.05) SOC in a similar tropical environment. Odurukwe et al. (1995) observed that forage plants leave more residues and biomass in the soil compared to arable cropland. Yadav and Arora (2018) reported that long-term vegetation cover on soils may be the best strategy for the improvement of the accumulation of carbon.

Eibasiceuny et al. (2014) noted that even though the SOC pool forms the largest sink apart from sedimentary rocks and fossil deposit, it has remained the most vulnerable to anthropogenic disturbances. The net losses of SOC due to land use changes may occur as a result of decreased organic matter inputs and changes in litter composition, high rate of SOM decomposition and erosion (Khera and Singh, 2008; Ullasa and kumar, 2017). Substrate quality has been reported as one of the main factors affectingdecomposition (Ogunwole et al., 2014). It has also been linked to the relative abundance of specific compounds such as nitrogen, lignin and phenolic acids (Lal, 2004). Lack of nutrients, especially N could explain the low C conversion efficiency (Lal, 2005). According to Ogunwole et al. (2014), the rate of carbon accumulation in agricultural abandoned fields was controlled by the rate of nitrogen accumulation which in turn depend on atmospheric nitrogen deposition and symbiotic nitrogen fixation by legumes.

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Surface soils in the tropics have low SOC and high erosion risk because of disturbances resulting from deforestation and tillage operations (Lal, 2017, 2006 and Li et al., 2010). When agricultural land is no longer used for cultivation and allowed to revert to natural vegetation or re-planted to perennial vegetation, soil organic carbon can accumulate by processes that essentially reverse some of the effects responsible for soil organic carbon depletion (Nnaji, 2018 and Ahaiwe et al., 2010). Soil organic matter enhances soil carbon sequestration with the adoption of appropriate land use and soil management.Bhuni et al. (2016) observed high amount of variation in rates and the length of time that carbon may accumulate in the soil. This is related to vegetation, physical and biological conditions in the soil and the past history of soil organic carbon inputs and physical disturbance (Uguru et al., 2011; Lal and Okigbo, 1990).

Soil aggregate stability may be used as an indicator to express the ability of a soil to sustain mechanical breakdown (Abah and Petja, 2017). Soil aggregates are structural units within soil that control the dynamics of SOM and nutrient cycling (Salako, 2015). It is an attribute that is contingent on the shear strength of a soil, on the amounts and forms of organic matter prevalent in a soil, on the biochemical composition of plant residues and on soils functional properties like soil permeability, on vegetation cover, on root length density, on susceptibility to surface run off during heavy precipitation events, on soils structure, on soil erosion (Govers et al., 2013; FAO, 2017 and Hamed et al., 2019). Tillage practices appear to be one major activity that breaks down soil aggregation and aggregate stability. It was found out that the aggregate stability decreased due to tillage (IUSS Working Group, WRB, 2015).

The conversion of land use often results in the destruction of soil structure (Sulieman et al., 2019; Yadav and Arora, 2018). Soil organic carbon (SOC) is known to have a strong relationship with aggregate formation and stabilization (Lal and Okigbo, 1990). Macro-aggregates are sensitive to changes in land use and cultivation practices whereas microaggregate re less sensitive (Ahaiwe et al., 2010; Igwe et al., 1995 and Lal, 2017).

Quantification of the impacts of land use and soil depth on carbon stocks and aggregate stability in the study area is challenging because of the heterogeneity of soil, climate, cultural/management conditions and due to the lack of data on soil carbon pools of most common ecosystems. There are limited knowledge about SOC pool dynamics in soils under specific ecosystems in the tropical humid agro ecosystem of southeastern Nigeria. It is important to generate reliable information which is essential for developing techniques of land management systems and for recommendation of agricultural practices that promote C sequestration for sustainable agricultural and erosion control. The broad aim of this study is to assess the effect of land use and depth on carbon sequestration and aggregate stability in coastal plain sands of Okwuta-Isieke, Southeastern Nigeria. The specific objectives are to:

1. Determine the effect of land use and depth on soil organic carbon sequestration and aggregate stability.
2. Quantify SOC pool and assess their distribution across three depths (0-19, 20-39 and 40-100cm) under different land uses.

**MATERIALS AND METHODS**

**Description of the Study Area**

The study was conducted at the Forestry Research Institute of Nigeria (FRIN), Okwuta-Isieke, Abia State. The FRIN lies within latitude 05o30IN to 05o33N and longitude 07o31E to 07o35E (Fig.1). And is in the Southeastern Nigeria. The study area is shown in Figure 1.

The soil type of the area are dominantly Utisols (Acrisols) (Lekwa and White side, 1986; Igwe et al., 1995; Okpamen et al., 2013; Nuga, 2009 and Ahaiwe et al., 2010).

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Abia State generally have tropic rainforest with bimodal rainfall distribution pattern but with less intensity and clear distribution between wet and dry seasons. The tropical rainforest have average rainfall of 2500mm (NIMET, 2018 and NDBDA, 2019). The mean maximum temperature of the area is 32oC while the mean minimum is 21oC. February and March are usually the hottest months while July and September record the lowest temperature. The area has average daily sunshine of 6.25 hours with minimum and maximum hours of 0.1 and 9.9 respectively (Uguru et al., 2011; NIMET, 2008 and Odurukwe et al., 1995). Similarly, it has annual daily solar radiation of about 2.25kwh/m2/day varying between 3.5kwh/m2/day at the northern boundary (NIMET, 2008 and AbiaState Official Gazette). The relative humidity was 82% (NIMET, 2008 and 2017). Evaporation is generally high in southeastern Nigeria because of the relatively high value of insolation and temperature (NIMET, 2008 and 2017).

The vegetation of the experimental area is typical rainforest vegetation. The secondary bush which dominates the area are the remnant of the typical rainforests which are fast disappearing, some of the forest species found in the area include, oil beans (*Pentaclethra macrophyllum*), Oil palm (*Elaesis guinensis*), plantain/Banana (*Musa* spp), Raffia palm (*Raphia spp*). Grasses and brown leaf weeds that dominate the entire area include *Panicum maximum*, *Pennisetum purperium*, *Aspilla africana*. The major tuber and root crops mostly grown on ridges and mounds in the area include Cassava (*Manihot esculenta*), Yam (*Discorea* spp), Sweet potato (*Ipomoea batatas*) and Cocoyam (*Xanthomonas sagottofulium*), Maize (*Zeamays* L), Melon (*Citrusvulgris*) and vegetables such as Okra (*Hibiscus esculentus*) and Fluted pumpkin (*Telferia*spp).

**Field studies, experimental design and sample collection**

Reconnaissance study was carried out to assess the land use practices and soils at Okwuta- Isieke, Abia State, Nigeria. Through the collaboration of the staff of the Forest Research Institute of Nigeria, Okwuta-Isieke sub-station, local farmers and community leaders in the study area, soils under three land uses within the same area were selected for the study. The land uses were (i) planted pine forest of Pinus carribeae plantation (PPF-PCP) (ii) managed Tree Cropland of Irvingia wombulu plantation (MTC-IWP) and (iii) continuously cultivated cropland of cassava/maize/telferia intercrop (CCC-CMI).

The experimental design used for the study was a 3 x 3 factorial in randomized completely block design (RCBD), comprising of two factors- soil depth (at 3 levels: 0-19, 20-39, 40-100cm) and land use [at 3 levels: planted pine forest of Pinus carribeae plantation (PPF-PCP), Managed Tree Cropland of Irvingia wombulu plantation (MTC-IWP) and continuously cultivated cropland of cassava/maize/telferia intercrop (CCC-CMI).

Stratified random sampling as modified by Smith (1976) was used in the field. Three mini-pits (0.5m x 0.5m x 1m) were dug in the study area under each of the land use types (planted pine forest of Pinus carribeae plantation land use type (PPF-PCP), Managed Tree Cropland of Irvingia wombulu plantation land use type (MTC-IWP) and continuously cultivated cropland of cassava/maize/telferia intercrop land use type (CCC-CMI). Soil samples were collected from 0-19, 20-39 and 40-100cm sampling depths from each of the mini-pits. A total of 27 disturbed and 27 undisturbed soil samples were collected and used in the laboratory for the determination of soil physical and chemical properties.

**Laboratory analysis**

Particle size distribution was determined by the hydrometer method as described by Gee and Or (2002), using sodium hydroxide as the dispersing agent.

Bulk Density Measurements was obtained by the cylindrical core method as described by Blake and Hartage (1986):

Bulk Density = Mass of Oven Dry Soil (g) (1)

Volume of Bulk soil (cm3)

Aggregate size separation was performed on 100g of 4.75mm sieved soil by wet sieving air-dried soil through a series of sieves (Elliot, 1986), after submerging the soil samples in water at room temperature for 5minutes. A series of four sieve were used to obtain five different water stable aggregate (WSA) fractions as follows: >2.00mm, 1.00–2.00mm, 0.50–2.00mm, 0.25 – 0.50mm, and < 0.25mm. Materials retained on each sieve (WSA) were oven dried at 400C to constant weight.

The mass of aggregates >0.25mm was calculated by subtracting the sum of the oven dried weights of materials retained on each sieve from the air-dried weight of the original sample. The proportion of each class to the total sample weight is computed, thus:

………………………… (2)

Where; Wt = proportion of the total sample weight occurring in the corresponding size fraction.

Mi=weight of the oven dried aggregates (uncorrected for sand) in the size class fractions after sieving.

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Mt = total weight of the initial material (100g) before sieving

The mean weight diameter (MWD) was calculated from the equation:

MWD=ΣxiWi …………………….... (3)

Where; xi = mean diameter of each size fraction (mm) Wi = proportion of the total sample weight occurring in the corresponding size fraction Soil pH was determined in distilled water and potassium chloride solution at ratio 1:1 and 1:2:5 soil/water suspension using pH meter (Mclean, 1982). Soil organic carbon content was determined by Walkey and Black wet oxidation method as described by Nelson and Sommers (1982). And the SOC pool content was calculated using the following equation (Lal et al., 1998)

MgCha-1=% C x Pb x d x 104M2ha-1 (4)

100

Where:

MgCha-1=Mega-gram carbon per hectare (1Mg= 106g), % C=Percentage of C given by laboratory results, Pb (MgM-3)=Soil bulk density (Mega-gram per cubic meter) d=Depth in metres Total nitrogen content was determined by the macro kjeldahl digestion method using CuSO4 and Na2SO4 catalyst mixture (Bremmer and Mulvaney, 1982). Cation exchange capacity (CEC) was determined by the NH4OAC (Ammonium acetate) at pH 7 methods (Thomas, 1982).

**Statistical analysis**

Data collected from the study were subjected to the analyses of variance. Separation of means for significant difference was performed using the F-LSD procedure as stated by Obi (1986).

**RESULTS AND DISCUSSION**

**Effect of Land Use and Depth on Soil Properties**

**Physical properties**

The effect of land use and depth on some soil physical properties in the study area are presented in Table 1. Sand dominated other particle sizes with values >52% at all depths. Land use did not significantly (P>0.05) influence particle size distribution and bulk density. Sand particle significantly (P<0.05) decreased with depth under MTC-IWP. This shows that eluviations of clay to the subsoil is more under this land use type. Generally, soil texture is more or less permanent property of the soil and do not change easily over time (Nnaji et al. 2009), hence the non-significant influence of land use on particle size distribution. MTC-IWP land use type reduced bulk density across soil depths. This could be related to the fact that vegetations associated with land uses could affect soil structure through their secretions into the soil, dead parts, micro and macro-organisms they attract to the soil, etc. This is shown by the differences in soil bulk density values under the different land uses. This result is in agreement with the observation of Igwe et al. (1995). They noted that bulk density is a function of land use.

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| --- | --- | --- | --- | --- | --- |
| **Table 1:**Effect of land use and depth on soil physical properties in the study area | | | | | |
| Depth (cm) |  | % | | | BD (g/cm3) |
| Land use | Sand | Silt | Clay |
| 0-19 | PPF-PCP | 70.30 | 6.70 | 23.00 | 1.46 |
|  | MTC-IWP | 79.33 | 8.67 | 12.00 | 1.40 |
|  | CCC-CMT | 80.00 | 6.64 | 13.36 | 1.55 |
| Sub mean |  | 76.54 | 7.33 | 16.10 | 1.47 |
|  |  |  |  |  |  |
| 20-39 | PPF-PCP | 75.70 | 9.00 | 15.30 | 1.56 |
|  | MTC-IWP | 63.00 | 6.00 | 31.00 | 1.37 |
|  | CCC-CMT | 76.70 | 5.87 | 17.43 | 1.54 |
| Sub mean |  | 71.80 | 6.89 | 21.24 | 1.49 |
|  |  |  |  |  |  |
| 40-100 | PPF-PCP | 66.30 | 3.33 | 30.37 | 1.79 |
|  | MTC-IWP | 54.33 | 6.67 | 39.00 | 1.67 |
|  | CCC-CMT | 66.70 | 3.54 | 30.30 | 1.82 |
| Sub mean |  | 62.44 | 4.54 | 33.22 | 1.76 |
|  |  |  |  |  |  |
| Total mean |  | 70.26 | 6.24 | 23.53 | 1.57 |
| LSD(0.05) for land use |  | 5.77NS | 1.99NS | 6.39NS | 0.09NS |
| LSD(0.05) for depth |  | 7.07\* | 2.45\* | 7.83\* | 0.11\*\* |
| LSD(0.05) for interaction |  | 10.00NS | 3.46NS | 11.07NS | 0.16NS |
| \*, \*\*, = Significant at 0.01 and 0.05 alpha levels, respectively, NS= Non-signficiant BD = Bulk density, CEC = Cation Exchange Capacity, TN = Total Nitrogen, SOC = Soil Organic Carbon, P = Phosphorus, K = Potassium, PPF-PCP = Planted Pinus forest of *Pinuscarribeae* plantation, MTC-IWP = Managed tree cropland of *Irvingiawombulu* plantation, CCC\_ CMT = Continuosly cultivated Cropland of Cassava/Maize/Telferia mixed cropping | | | | | |

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**Fig. 1: Southeastern Nigeria: Study Area (Shaded)**

**Source: (Cartographic Unit, Department of Geography,**

**Abia State University, 2015)**

**Aggregate stability**

Effect of land use and depth on selected aggregated stability indices in the study area are presented in Table 2. Significant (P<0.05) influence of land use on mean weight diameter (MWD) was observed at the various soil depth, with PPF-PCP having highest MWD, followed by MTC-IWP. The results revealed that soil aggregate stability was high in PPF-PCP and MTC-IWP. This implies higher stability and resistance to erosion by these soils. Soil under CCC-CMTare unstable and could be termed, erosion risk area. The most affected areas in the soil are the subsoil (20-100cm) of the arable land. The decrease in aggregate stability status of the subsoils could be due to the decrease in SOM content down the profile. This aligns with the findings of An et al. (2010), who reported that SOM serves as a biding agent for soil aggregates and primary soil particles. Lal (2006) recorded that reduced SOM in soils due to continuous cropping and vegetation removal results in pore collapse which reduces infiltration and increases runoff and erosion and consequently may cause further soil degradation.

Significant (p=0.05) influence of land use on clay dispersion index (CDI) was observed at all depths. The CCC-CMT soils had higher CDI than PPF-PCP and MTC-IWP soils. There were also significant (p<0.05) effect of land use on clay flocculation index (CFI) and soil structural index (SI) at the various soil depths with PPF-PCP and MTC-IWP having higher CFI and SI than CCC-CMT soil. Across the study location and the three depths, PPF-PCP showed the least tendency to disperse, followed by MTC-IWP. While CCC-CMT showed the greatest tendency to disperse. The ability of the soil to resist dispersion increased with depth and clay content of the soils (Igwe and Ejiofor, 2005). The results showed that soils under PPF-PCP and MTC-IWP were statistically similar compared to soils under CCC-CMT.

The SI followed the same trend with clay content, it can be deduced that SI is a function of clay content. Bhunia et al. (2016) reported that land use and depth were among the major environmental factors that control SOM and extent of soil structural degradation. This implies that whereas PPF-PCP and MTC-IWP indicated high structurally stabilized soils, CCC-CMT indicated high risk of structural degradation. Degradation showed a decreasing trend in this order; CCC-CMT > MTC-IWP> PPF-PCP. There were significant (P<0.05) effect of land use and depth on CDI, CFI and SI. There was also significant (p<0.05) influence of interaction of land use and depth on CDI andCFI. This is in line with Lal and Okigbo (1990), who reported that soil microaggregate stability indices are dependent on depth and land use. However, Okpamen et al. (2013) also observed that most tropical soil microaggregate stability indices are dependent on parent material and mineraology.

**Chemical properties and soil organic carbon pool**

Effects of land use types and depth on soil chemical properties and soil organic carbon pool are presented in Table 3. Significant (P<0.05) effect of land use on SOC also was observed at the various soil depths with PPF-PCP having the highest SOC followed by MTC-IWP while CCC-CMT had lowest SOC. This suggests that planted pine forest and *Irvingia*plantation improved soil organic carbon across the soil depths. There was also significant effect of land use on total nitrogen (TN) at 0-19cm and 20-39cm soil depths with PPF- PCP having highest TN, followed by MTC-IWP while CCC-CMT had lowest TN. Significant (P<0.05) influence of land use on CEC was observed at the various depths with MTC-IWP having higher CEC, followed by PPF-PCP. There was significant (P<0.05) effect of land use on SOC pool at the various depths with PPF-PCP having highest SOC Pool, followed by MTC-IWP. The SOC pool in PPF-PCP and MTC-IWP were within the threshold level (≥ 120 MgCha-1) for surface (0-100cm) soil in relation to mitigating climate change and for better environmental quality control as postulated by FAO (2017). Whereas SOC pool in CCC-CMT was at the lower limit of the threshold level. This suggests that planted pine forest and Irvingia plantation improved SOC pool whereas continuous cultivation of cassava/maize/telferia intercrop depleted SOC pool.

Land use and depth significantly affected H (H2O), SOC, TN, AV. P and SOC Pool. Significant interaction between land use and depth influenced TN, AV. P and SOC Pool. This supports Lal and Okigbo (1990) who reported that SOC pool depends on land use.

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| **Table 2:** Effect of Land Use and Depth on Selected Aggregate Stability Indices in the Study Area | | | | | |
| Depth (cm) | Land use | MWD (mm) | CDI | CFI | SI% |
| 0-19 | PPF-PCP | 5.57 | 29.08 | 38.75 | 23.47 |
|  | MTC-IWP | 5.10 | 29.68 | 21.00 | 21.23 |
|  | CCC-CMT | 4.28 | 81.85 | 19.88 | 9.47 |
| Sub mean |  | 4.98 | 46.87 | 26.54 | 18.06 |
|  |  |  |  |  |  |
| 20-39 | PFP-PCP | 5.60 | 25.25 | 56.80 | 24.73 |
|  | MTC-IWP | 5.17 | 25.18 | 57.30 | 10.64 |
|  | CCC-CMT | 4.12 | 56.63 | 43.50 | 7.32 |
| Sub mean |  | 4.96 | 35.69 | 52.53 | 14.23 |
|  |  |  |  |  |  |
| 40-100 | PFP-PCP | 5.62 | 17.50 | 63.53 | 14.33 |
|  | MTC-IWP | 5.23 | 20.29 | 76.00 | 6.61 |
|  | CCC-CMT | 4.16 | 30.28 | 62.82 | 2.68 |
| **Sub mean** |  | **5.00** | **22.69** | **68.12** | **7.87** |
|  |  |  |  |  |  |
| **Total mean** |  | 4.98 | 42.64 | 49.06 | 13.39 |
|  |  |  |  |  |  |
| LSD (0.05) for land use |  | 0.13\*\* | 0.73\*\* | 1.93\*\* | 4.29\*\* |
| LSD (0.05) for depth |  | 0.16NS | 0.89\*\* | 2.39\*\* | 5.25\* |
| LSD (0.05) for interaction |  | 0.22NS | 1.26\*\* | 3.38\*\* | 7.43NS |
| \*, \*\*, \*\*\* = Significant at 0.01 and 0.05 alpha level (2 tailed), respectively, NS = Non-significant  MWD= Mean Weight Diameter, CDI = Clay Dispersion Index, CFI = Clay Flocculation Index, SI = Soil Structural Index | | | | | |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3:** Effect of land use and depth on some soil chemical properties and SOC pool in the study area | | | | | | | |
| Depth (cm) |  | % | | CmolKg-1 | |  |  |
| Land use | SOC | TN | K | CEC | AV. P (Mg/kg) | SOC Pool (MgCha-1) |
| 0-19 | PPF-PCP | 3.69 | 0.53 | 0.04 | 18.01 | 15.25 | 133.40 |
|  | MTC-IWP | 2.62 | 0.17 | 0.04 | 21.42 | 19.72 | 70.30 |
|  | CCC-CMT | 1.15 | 0.14 | 0.04 | 11.12 | 18.33 | 33.80 |
| Sub mean |  | 2.29 | 0.28 | 0.04 | 16.85 | 17.77 | 79.19 |
|  |  |  |  |  |  |  |  |
| 20-39 | PPF-PCP | 3.38 | 0.39 | 0.04 | 16.11 | 19.75 | 107.60 |
|  | MTC-IWP | 2.27 | 0.11 | 0.03 | 21.39 | 22.68 | 42.20 |
|  | CCC-CMT | 0.97 | 0.08 | 0.05 | 10.81 | 20.00 | 31.70 |
| Sub mean |  | 2.20 | 0.19 | 0.23 | 16.10 | 20.81 | 60.50 |
|  |  |  |  |  |  |  |  |
| 40-100 | PPF-PCP | 2.89 | 0.23 | 0.5 | 19.16 | 13.80 | 334.80 |
|  | MTC-IWP | 1.75 | 0.10 | 0.03 | 20.43 | 23.39 | 147.30 |
|  | CCC-CMT | 0.52 | 0.14 | 0.03 | 12.15 | 26.67 | 58.20 |
| Sub mean |  | 1.71 | 0.16 | 0.03 | 17.26 | 21.29 | 180.0 |
|  |  |  |  |  |  |  |  |
| Total mean |  | 1.50 | 0.16 | 0.10 | 16.74 | 19.96 | 106.59 |
| LSD(0.05) for land use |  | 0.20\* | 0.08\* | 0.02\* | 1.35\*\* | 1.68\*\* | 27.34\*\* |
| LSD(0.05) for depth |  | 0.25\*\* | 0.10\* | 0.02NS | 1.65NS | 2.06\* | 33.49\*\* |
| LSD(0.05) for interaction |  | 0.36NS | 0.15\* | 0.04NS | 2.34NS | 2.91\*\* | 47.36\*\* |
| \*, \*\*, \*\*\* = Significant at 0.01 and 0.05 alpha level (2 tailed), respectively, NS= Non-signficiant  Key: CEC = Cation Exchange Capacity, TN = Total Nitrogen, SOC = Soil Organic Carbon, P = Phosphorus,  K = Potassium, PPF-PCP = Planted Pinus forest of *Pinuscarribeae* plantation, MTC-IWP = Managed tree cropland  of *Irvingia* *wombulu* plantation, CCC\_ CMT = Continuosly cultivated Cropland of Cassava/Maize/Telferia  mixedcropping | | | | | | | |

**CONCLUSION**

This study showed that planted pine forest of Pinus carribeae plantation (PPF-PCP) and managed Tree Cropland of Irvingia wombulu plantation (MTC-IWP) land uses improves soil SOC pool at 0-100cm soil depth relative to continuously cultivated cropland of cassava/maize/telferia intercrop (CCC-CMI) land use. The results revealed that soil carbon sequestration depends on land use and depth. The SOC pools of soils of PPF-PCP and MTC-IWP land uses were within the threshold level and therefore met the standards in relation to mitigating climate change and for better environmental quality control. Whereas SOC Pool in soil of CCC-CMT land use was at the lower limit of the threshold level. Soil aggregate stability was higher in PPF-PCP and MTC-IWP compared to CC-CMT. There were significant effect of land use and depth on CDI, CFI and SI. Macroaggregate stability was a function of land use. While microaggregate stability and soil structural stability were dependent on both land use and depth. The soil conservation practices associated with CCC-CMT under coastal plain sands in the area should be re-evaluated. This is because it is inadequate to maintain or improve the quality of the soil. Some practices such as no-till, use of cover crops, mulching, and application of organic and inorganic amendments and reduced application of agro-chemicals should be incorporated into the soil management and cultural practices.

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**REFERENCES**

Abah R.C. and Petja, B.M. (2017). Crop suitability mapping for rice, cassava, and Yam in North Central Nigeria. *Journal of Agricultural Science*, **9 (1)**, 96-98.

Abdullahi A.C., Siwar C., Shaharudin M. and Anizan I. (2018). Carbon sequestration in soils: the opportunities and challenges. <http://dx.doi.org/10.57721> intechnopen. 79347.

Abia State Official Gazette (1992). Official Gzette of 13th November, 1992. Bulletin **52,**  Vol. 79.

Ahaiwe M.O., Nwaigbo L.C. and Ano A.O. (2010). Influence of plant prunnings on soil properties and yield of yam miniset. *Journal of Agriculture and Social Research (JASR)*, **10 (2),** 1-6.

An S.S., Mentier A., Mayer H. and Bium W.E. H. (2010). Soil aggregation, aggregate stability, organic carbon and nitrogen in different soil aggregate fractions under forest and shrub vegetation on the Locs Plateau China. *Catena*, **81,** 226-33.

Anikwe M.A. (2010). Carbon storage in soils of southeastern Nigeria under different management practices. *Carbon Balance and Management,* **55**, Pp. 7.

Awelewa A.E. and Ogban I.P. (2017). Effect of intensive vegetable cultivation on soil organic carbon storage in AkwaIbom State, Southeastern Nigeria. *British Journal of Environment and Climate Change*. ISSN:2231-4784, Vol. **5**, Issue 4.

Baishya K. (2015). Impact of agrochemcials application soil quality degradation. A Review, 2nd International Conference on Science, Technology and Management, University of Delhi (DU), Conference Centre, New Delhi (India).

Bhumia G.S., Shit P.K. and Maiti R. (2016). *Journal of the Saudi Society of Agricultural Sciences*. <http://dx.doi.org> 110.1016/j.jssas.206-02.001.

Blake G.R. and Hartage K.H. (1986). Bulk density In: Klute, A. (ed). Methods of soils analysis, Part 1: American Society of Agronomy: Madison, WISC, Pp. 363-382.

Bremmer J.M. andMulvaney G.S. (1982). Nitrogen total In: Page, A. L., Miller, R. H. and Keeney, Dr (eds) methods of soils analysis. Part 2: American Society of Agronomy, No. 9. Madison WIS. Pp. 595-624.

Cartographic Unit, Department of Geography ABSU (2015). Southeastern Nigeria: Study Area (Shaded)

Elbasiouny H., Abowaly M., Abu-Alkheir A. and Gad, A. (2014). *Catena*. **113,** 76-78.

FAO (2017). Soil organic carbon: the hidden potential. Food and Agricultural Organization of the united Nations Rome, Italy.

Gee G.W. and Or D. (2002). Particle size distribution In: methods of soil analysis part 4. Physical methods. Dane, J. H. and Troops, g. C. (eds). Soils Sc. America. Book Series. No. 5 ASA and SSA, Madison, W. L. Pp. 225-293.

Govers G., Mevckx R., Van, Oost K. and Van We Semeal B. (2013). Managing soil organic carbon for global benefits: A STAP Technical Report Global Environment Facility, Washington, D. C.

Hamed L.M.M., Fouda S. and Emara E.R. (2019). Conserving soil fertility and sustaining crop performance via soil tillage systems and crop rotation. Doi: 10.21608/ASEJSAE., **2019**, 31624.

Ibe K.O. (2014). Characterization, classification and suitability evaluation of soils for crop production along a toposequence in Ohafia, Abia State, Nigeria. M.Sc. thesis submitted to the PG School, Michael Okpara University of Agriculture, Umudike, AbiaState,Pp. 120.

Ibe K.O., (2020). Spatial analysis of soil carbon sequestration, aggregation an aggregate stability under different parent materials and land uses in southern Nigeria. PhD Dissertation submitted to the Postgraduate school, Michael Okpara University of Agriculture, Umudike, P.420.

Igwe C.A. and Ejiofor, N. (2005). Structural stability of exposed gully wall in Central Eastern Nigeria as affected by soil properties. *International Agrophysics,* **19,** 215-222.

Igwe C.A., Akanigbo F.O.R. and Mbagwu J.S.C. (1995). Physical properties of soils of southeastern Nigeria and the role of some aggregating agents in their stability. *Soil Science.* **160 (6)**, 114-12.

IUSS Working Group WRB (2015). World Reference base for soil resources 2014, update 2015 international soil classification system for naming soil and creating system for naming soil and creating legends for soil maps. *World Soil Resources Reports*. No. 106. FAO, Rome.

Khera K.L. and Singh, M.J. (2008). Soil erodibility indices under different land uses in lower Shiwaliks. *Tropical Ecology*, **49 (9),** 113-119.

Lal R. (2004). Soil C-Sequestration impacts on global climate change and food security. *Science*, **304,** 1623-1627.

Lal R. (2005). Soil carbon sequestration in natural and managed tropical forest ecosystems. *Journal of Sustainable Forestry*. Vol. 21.

Lal R. (2017). Soil organic carbon sequestration: importance and state of science. Proceedings of the global symposium on soil organic carbon. 2017 held 21-23rd March, 2017, FAO headquarters, Rome, Italy. Pp. 6-12.

Lal R. and Okigbo B.N. (1990). An assessment of soil degradation in southern Nigeria. Environment, Working Paper. World Bank, Washinton D.C. USA.

Lal R.U. (2006). Encyclopedia of soil science. 1st edition volume 1. Taylor and Francis Group, London.

Land use and depth on carbon sequestration and aggregate stability in soils of coastal plain sands parent material

Lal R., Kimbe J.M., Follet R.F. and Cole C. V. (1998). The potential of US Cropland to sequester carbon and mitigate the Greenhouse Effect. Sheeping Bear Press, Inc Chelsea, M.I.

Lekwa G. and Whiteside E.P. (1986). Coastal plain sands of southeastern Nigeria: Morphology, classification and genetic relationship. *Soil Science American Journal*, **50,** 154-160.

Li C., Li Y. and Tan L. (2010). Soil organic carbon stock and efflux in-deep soil of desert and oasis. *Environment Earth Science*, **60,** 549-557.

NDBDA (2019). Research collaboration and training reports, agricultural services, Nigeria Delta Basin Development Authourity, 21 Azikiwe Road, Port-Harcourt, NDBDA/361/vol.1/82.

Nelson P.N. and Sommers L.E. (1982). Total carbon, organic carbon and organic matter In: Page, A. L., Miller, R. H and Keeney, D. R. (Eds). Methods of soil analysis,Part 3. Chemical Methods ASA and SSSA, Madison, W. L. pp. 539-579.

NIMET (2017). Periodic publication, Port Harcourt Station, Port-Harcourt International Airport.

NIMET (2018). Nigeria climate review bulletin. No. 001, NIMET, Abuja.

Nnaji G.U. (2008). Fertility status of some soil in Isoko South Local Government Area of Delta State. Proceedings of the 42nd Annual Conference Agricultural Society of Nigeria (ASN). Ocotober, 19th 2008. Ebonyi State University, Abakaliki, Nigeria.

Nuga B.O. (2009). Classification and evaluation of the soils of Ikwuano Local Government Area, Abia State, Nigeria,. Ph.D. Thesis. Department of Agronomy, University of Ibadan, pp. 191.

Obi I.U. (1986). Statistical method of detecting differences between treatment means. SNAP Press Ltd. Enugu, Nigeria, Pp. 45.

Odurukwe S.O., Anuebunwa F.O., Iloka A.W., Udealor, A. and Ibedu M.A. (1995). Phsycial environment, fallow and multi-purpose tree and shrub species in the farming systens of southeast zone of Nigeria. A report of diagnostic survey-NRCRI, Umudike Publications.

Ogunwole J.O., Sharma B.R., McCartney M.A., Zemaadim B.E. and Leta G. (2014). Land use impact on soil physical quality and soil structure in three Highland Watersheds of Ethiopia. *Advances in Plants and Agriculture Research*, **1 (4),** 00019.

Ojanuga A.G. (!977). A study of soils and soil genesis in the southeastern upland Nigeria. Phh.D. Dissertation. University of Wisconsin, Madison, WIS USA.

Okpamen S.U., Ilori E.G., Agho I., Nkechika A., Maidoh F.U. and Okonjo P.N. (2013). Ibfluence of depths and soil ph on forms of magnesium in soils of four parent materials (rhodic pale udults, rhodictropudalfs, oxictropudalfs and aquitropossament). *Journal of Soil Science and Environmental Management,* **4 (4),** 71-76.

Salako F.K. (2015). For soil to oil the Nation: advancing the frontiers of conservation agriculture in Nigeria. The 48th Inaugural Lecturer. Federal University of Agriculture, Abeokuta, Nigeria. FUNAAB Inaugural lecturer Series No. 48 Wednesday 4th February, 2015. Pp. 168.

Salako F.K. (2003). Soil physical conditions in Nigerian savannas and biomass production. Department of Soil Science and Agricultural Mechanization, University of Agriculture, Abeokuta, Nigeria. Lecture given at the College on Soil Physics on 3-21 March, 2003.

Sulieman M.M. and Algarni, A.M. (2019). Soil Organic carbon mapping and prediction based on depth intervals using Kriging technique: A Case of Study in Alluvial Soil from Sudan. *Eurasian Journal of Soil Science*, **8 (1),** 44-53.

Thomas G.W. (1982). Exchangeable cations. In: Page, A.L. (Ed). Methods of soil analysis, Part 2. American Society of Agronomy and Soil Science Society of America, Madison Wiscousin, Pp. **139**.165.

Uguru, M. I., Balyevi, K. P. and Aba, S. C. (2011). Indicators of climate change in the derived savannah rich of Nsukka, Southeasetrn Nigeria. *Journal of Soil Science*, 18:175-182.

Ullasa, M. Y. and Kumar, M. D. (2017). Spatial distribution of organic carbon in selected gardens of Karnataka. Society for advancement of human and natural. International Journal of farm Sciences, **7 (3),** 28-33.

Yadav A.S. and Arora S. (2018). Crop residue management in diverse agroecosystems for improving soil health- An overview. *Journal of Soil and Water Conservation*, **17 (4),** 387-392.

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**Evaluation of white yam performance under different sett sizes and time of immersion in water**

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**ABSTRACT**

***A field experiment was conducted to study the effect of sett sizes and time of sett immersion in water on growth and yield of white yam in an ultisol at Umudike, South eastern Nigeria during 2016 and 2017 cropping seasons. The experiment was laid out as a 5 X 4 factorial in randomized complete block design (RCBD) with three replications. Five sett sizes (40; 50; 60; 70g setts and 70g whole seed yam) were combined with four periods of sett immersion in water (0, 12, 24 and 36hrs) to give 20 treatment combinations. In both years, crop establishment was significantly increased by the 70g whole tuber while the 60g sett increased shoot dry matter. The highest tuber yield was obtained from 60g sett. Increasing the time of sett immersion in water to 12 hours increased crop establishment up to 40 -80% and shoot dry matter by 66 – 90% but increasing the time of immersion reduced leaf area index. Time of sett immersion in water did not affect tuber yield but interactions were significant on yield in both cropping seasons. On average, the highest tuber yield was obtained from 60g sett under no immersion in water.***

**Key words*:*** *Dioscorea rotundata,* sett size, immersion in water, tuber yield

**INTRODUCTION**

Yam (*Dioscorea* spp) is an important food crop which is grown throughout the tropics (Andres *et al,* 2017). Among the most important species, white yam (*Dioscorea rotundata*) is believed to have originated in West Africa around the eastern banks of the river Niger, where it is still the preferred food crop (Coursey, 1967; Hahn *et al*, 1987). The crop has underground structures comprising the fibrous root system and thick storage organs or tuber in which starch is deposited. The tuber is a good source of industrial starch and contains pharmalogically active substances such as dioscorine, saponin and sapogenin (Eka, 1985). Usually, the yam tuber is eaten in boiled or roasted forms and can be processed into pounded yam, fried yam slices, yam chips, flakes and flour.

One of the technologies aimed at reducing the total cost of yam production and generating planting materials is the minisett technique, but the problem associated with this method is the difficulty in obtaining the recommended 25g cut sett (Ikeorgu, 2003), which is also more prone to desiccation than bigger setts. The use of bigger sett sizes or the technique of sett size is based on the principle that any section of the tuber is capable of sprouting provided it has a covering portion of the skin or a viable meristematic region found beneath the skin (Onwueme, 1978, Ile *et al,* 2006). For some white yam cultivars, an increase in sett size can enhance their sprouting potential and yield but agroecological conditions, temperature and relative humidity also play a determining role (Ayankanmi *et al*, 2005; Igwilo, 2009, Hamadina and Asiedu, 2015). Although Ikeorgu (2003) did not obtain significant yield differences with varying minituber sizes, Igbokwe *et al* (1988) and Law-Ogbomo *et al* (2014) found yield increases as sett size increased.

Moisture stress may not prevent sprouting entirely but may inhibit bud elongation on the yam tuber (Onwueme, 1975), thereby influencing crop establishment and growth. Priming or the use of water to stimulate shoot initiation in dry seeds and cure dormancy is a form of seed planting preparation in which seeds are presoaked before planting or observed for germination (Khan, 1992, Ileleji et at, 2015; Asonye and Hamadina, 2018). Priming prior to planting is a process of hydrating or planting materials in order to increase germination or sprouting, ensure more uniform emergence under a wide range of field environments and improve vigour (Modi, 2005). Hydro priming (hydration of seed with water only) is an approach used to increase the percent and rate of germination and increase the uniformity of stand establishment under stress conditions especially in dry areas (Clark *et al*, 2001; Mavi et al, 2006; Berchie *et al*, 2010) although Barker et al (1999) found no such advantage by soaking tubers in water on sprouting. McDonald *et al* (2006) noted that seed priming enhances seedling growth by controlling inhibitory conditions and reducing the effects of vagaries of weather. The water imbibed by the planting material activates enzymes and facilitates metabolism of stored starch and protein (Kikuchi *et al*, 2006) and thus, water imbibition is the most important event for ensuring nutrient supply to the embryo and to generate energy for the commencement of seedling growth (Abebe and Modi, 2009). Yam is usually planted during the period of moisture stress in the dry season or at the commencement of the rainy season, but the effect of priming yam tubers and setts on the crop is little known. The objective of this study was to examine the effect of sett size and time of sett immersion in water on growth and yield of white yam in southeastern Nigeria.

Evaluation of white yam performance under different sett sizes and time of immersion in water

**MATERIALS AND METHODS**

Field experiments were conducted at the National Root Crop Research Institute (NRCRI), Umudike, south eastern Nigeria under rainfed conditions. The location is situated at latitude 5029'N, longitude 7033'E and at the altitude of 122m above sea level. The soil of the experimental site is an ultisol and was texturally loamy sand in 2016 and sandy clay loam in 2017. The soil had pH (water) 5.1, 1.62% 0M, 0.08%N, 34.2mg/kg P and 0.11 cmol/kg K in 2016 and 4.8 pH (water) 1.66% om, 0.095%N, 21.0mg/kg P and 0.30 cmol/kg K in 2017. The total annual rainfall was 2322.7mm in 2016 and 2079.8mm in 2017 while the mean maximum temperature was 31.60C in 2016 and 32.10C in 2017.

In each cropping season, the land which was previously under one year fallow was slashed, ploughed and harrowed using disc plough and harrow. The land was ridged1m apart after harrowing. The experiment was a 5 X 4 factorial, laid out in a randomized complete design with three replications. Treatments comprised all combinations of five sett sizes (40g, 50g, 60g, 70g cut setts and 70g whole seed yam) and four periods of sett immersion in water (0, 12, 24 and 36 hours). Each plot measured 4 X 3m (12m2).

The setts of the white yam cultivar Yandu were planted on the crest of the ridges on 10 April 2016 and 11 April 2017 at a spacing of 1m X 0.3m. This gave a plant population of 33,333 plants/ha. Hoe weeding was carried out at 4, 8 and 12 WAP. Fertilizer NPK (15:15:15) was applied at 400kg/ha at 8 WAP by banding. Pyramidal staking method (2m stake) was done and the vines were periodically trained to the stakes in a clockwise direction. Records were taken on the following: percent establishment at 4, 8, and 12 WAP; leaf area index (LAI) and shoot dry matter (g/plant) at 5MAP and number of tubers/plant tuber weight (kg) and tuber yield (t/ha). Percent crop establishment was estimated as percent of stands with vines greater then 10cm above soil level. Leaf area (cm2) per plant was obtained using the grid method, where 20 leaves were collected randomly from the base, middle and top of the plant, after which, they were traced on a graph sheet and their dimensions taken. Leaf area was calculated using the formula: Y = a + bx (Y = 0.46 + 0.194x) where Y = total leaf area/plant, a = intercept, b = slope and x = length X width of the leaf X number of leaves/plant. Leaf area index was determined using the formula: LAI = LA/P, where LA = total leaf area and P = land area. The data collected were subjected to analysis of variance (ANOVA) according to the procedures for a factorial in randomized complete block design using GenStat (2007) statistical package (GenStat Discovery Edition 3).

**RESULTS**

At 4 and 8 WAP, the 70g whole tuber had significantly higher percent establishment than the setts regardless of size in both 2016 and 2017 cropping seasons (Fig 1a, b). Among the sett sizes in 2016, the smaller 40g sett had higher percent establishment than the 50g sett at 4 WAP and the 70g sett at 8 WAP. Similarly, in 2017, the 40g sett had significantly higher percent establishment than the 60g sett at 4 WAP and the 50g sett at 8 WAP. Except at 12 WAP, the 70g whole tuber consistently had higher percent establishment than the 70g sett, in both years. Across sampling dates and both years, establishment was 15-16 percent higher in 70g whole tuber than in the setts. In all instances, percent establishment was significantly higher when the setts were immersed in water for 12 hours than when not (control) or when immersed in water for longer periods of 24 and 36 hours in both years (Fig. 2a, b). Averaged across sampling dates and years, increasing the 12 hours increased crop establishment by 40 – 80 percent compared to other times of sett immersion in water. Leaf area index in 2016 cropping season was increased significantly by planting 70g sett or whole tuber than the smallest 40g sett (Table 1). In 2017, however, the 50g and 70g sett weights produced significantly higher leaf area index than the 70g whole tuber and other sett sizes. Generally, leaf area index decreased with increase in time of sett immersion in water in both years but, significant differences were established in 2017 only. Leaf area index in 2017 was higher in the no immersion control than when sett was immersed in water for 24 or 36 hours. Sett size X time of immersion in water interaction effects were significant on leaf area index in 2016. Leaf area index in 2016 was highest in the 70g sett or whole tuber and the control (no immersion).



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In both cropping seasons, shoot dry matter increased significantly with increase in sett size up to 60g, beyond which decline in dry matter occurred (Table 2). On average, increasing the sett weight above 60g resulted in 11.4% and 28.0% reductions in shoot dry matter for the 70g cut sett and 70g whole tuber respectively. Generally, the 70g cut sett produced significantly higher shoot dry matter than the 70g whole tuber. Similarly, immersing sett in water for 12 hours remarkably increased by 60 to 90 percent dry matter accumulation in the shoot than other times of immersion in water or the control in both years. Interactions were significant. In all instances, the 60g sett immersed in water for 12 hours had higher shoot dry matter than other sett sizes and times of immersion in water.

In 2016, there were no statistical differences in the number of tubers harvested per plant (Table 3). However, in 2017, the smaller 40g sett had significantly higher number of tubers than the bigger 50, 60 or 70g setts, which gave similar results. The 70g whole tuber did not differ from 70g sett, but had lower number of tubers than 40 and 60g setts. On the other hand, in 2016, the trend was for a depression in number of tubers with immersion of sett in water, but significant differences were established when setts were immersed in water for 12 or 24 hours compared to the control (no immersion in water). There were no differences in number of tubers in 2017 with time of immersion of sett in water, although, values appeared lower when setts were immersed in water than when not. Interactions were significant in 2017, with the 60g sett under no immersion in water (control) producing the highest number of tubers while, the 40g sett regardless of time of sett immersion in water produced the lowest number of tubers.

Unlike the results obtained for number of tubers, tuber weight increased significantly with sett size up to 70g setts in 2016 (Table 4). The 70g whole tuber had lower weight of tubers than the 70g sett. Also, tuber weight in 2017 showed similar trend but, no significant differences occurred between the sett sizes. There was no clear trend for time of immersion in water in 2017, as setts immersed in water for 12 or 36 hours produced significantly higher tuber weight than the control or with immersion in water for 24 hours. Interactions were significant in 2017, with the 60g sett and the control or the 70g sett immersed in water for 12 hours, producing the highest tuber weight.

On average, white yam yield was greater in 2016 than in 2017 (Table 5). In both years, tuber yield followed similar trends but, it was only in 2017 that significant differences occurred with sett size. Tuber yield in 2017 increased significantly with the 60g sett compared with the smaller 40g sett. There were no yield differences between the bigger setts of 50, 60 and 70g. Increasing the sett size from 60 to 70g seemed to depress tuber yield, although no statistical significance was established.

Evaluation of white yam performance under different sett sizes and time of immersion in water



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 1:** Effect of sett size and Time of sett immersion in water on leafarea index of Yandu White yam cultivar at 5WAP | | | | | |
|  | Time of Immersion in water (Hours) | | | | |
| Sett size (g) | 0 | 12 | 24 | 36 | Mean |
| **2016** | | | | | |
| 40 | 0.34 | 0.25 | 0.27 | 0.64 | 0.38 |
| 50 | 0.63 | 0.65 | 0.40 | 0.46 | 0.54 |
| 60 | 0.36 | 0.64 | 0.63 | 0.39 | 0.50 |
| 70 (Cut) | 0.74 | 0.53 | 0.66 | 0.42 | 0.59 |
| 70 (Whole) | 0.81 | 0.59 | 0.38 | 0.51 | 0.57 |
| **Mean** | **0.58** | **0.53** | **0.47** | **0.49** |  |
| **2017** | | | | | |
| 40 | 0.33 | 0.22 | 0.28 | 0.67 | 0.37 |
| 50 | 0.92 | 0.71 | 0.67 | 0.64 | 0.74 |
| 60 | 0.54 | 0.64 | 0.41 | 0.36 | 0.49 |
| 70 (Cut) | 0.92 | 0.74 | 0.67 | 0.41 | 0.68 |
| 70 (Whole) | 0.77 | 0.36 | 0.31 | 0.41 | 0.46 |
| **Mean** | **0.70** | **0.53** | **0.47** | **0.49** |  |
|  |  |  |  | **2016** | **2017** |
| LSD(0.05) for sett size (S) means = | | | | 0.16 | 0.20 |
| LSD(0.05) for Time (T) of immersion in water means = | | | | NS | 0.18 |
| LSD(0.05) for S X T means = | | | | 0.31 | NS |

Time of sett immersion in water did not significantly influence tuber yield in both 2016 and 2017 cropping seasons. Interactions were significant. In 2016, the highest tuber yields (44.4 – 52.6t/ha) were mostly obtained from all sett sizes (except 70g cut sett) or 70g whole seed yam and no immersion in water, while in 2017, the 60g sett with zero immersion in water had the highest tuber yield of 40.6t/ha.



**DISCUSSION**

Crop establishment in white yam was consistently enhanced by the use of whole tubers than by the use of cut tuber portions. The better establishment of 70g whole tuber may be due to the presence of apical dominance conferred by the primary nodal complex (PNC) or corm-like structure attached to the head region of the tuber (Degras, 1993). The corm-like structure is known to have greater tendency to produce sprouts or shoot than non-corn possessing setts from other regions (Onwueme, 1975; Wilson *et al.*, 1998) due to its faster ability to complete the *de novo* formation of primary modal complex (PNC), which is the origin of yam roots, sprout or shoot and tubers (Hamadina, 2012l Awologbi and Hamadina, 2016). The greater tendency of whole tubers to produce sprouts is coupled with their undisturbed (by the cutting process, which creates surface for swift moisture loss) nature to enable early and better interaction with factors of the growing environment that promote vine or shoot elongation.

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|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 2:** Effect of sett size and Time of sett immersion in water on shoot dry matter (g/plant) of Yandu White yam cultivar at 5WAP | | | | | |
|  | Time of Immersion in water (Hours) | | | | |
|  | | | | |
| Sett size (g) | 0 | 12 | 24 | 36 | Mean |
| 2016 | | | | | |
| 40 | 21.00 | 56.70 | 26.70 | 28.30 | 28.20 |
| 50 | 32.70 | 52.70 | 31.70 | 30.00 | 36.80 |
| 60 | 35.70 | 74.70 | 37.70 | 28.00 | 44.00 |
| 70 (Cut) | 27.70 | 55.00 | 44.30 | 28.30 | 38.80 |
| 70 (Whole) | 26.70 | 36.00 | 25.00 | 38.30 | 31.50 |
| Mean | 28.76 | 55.02 | 33.08 | 30.58 |  |
| 2017 | | | | | |
| 40 | 21.00 | 58.00 | 27.00 | 28.00 | 37.60 |
| 50 | 33.00 | 53.00 | 32.00 | 30.00 | 45.00 |
| 60 | 36.00 | 73.00 | 38.00 | 28.00 | 62.30 |
| 70 (Cut) | 28.00 | 55.00 | 44.30 | 28.30 | 46.80 |
| 70 (Whole) | 27.00 | 36.00 | 25.10 | 66.00 | 38.30 |
| Mean | 29.00 | 55.00 | 33.28 | 30.52 |  |
|  |  |  |  | 2016 | 2017 |
| LSD(0.05) for sett size (S) means = | | | | 5.00 | 5.00 |
| LSD(0.05) for Time (T) of immersion in water means = | | | | 4.50 | 4.50 |
| LSD(0.05) for S X T means = | | | | 10.00 | 10.00 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 3:** Effect of sett size and Time of sett immersion in water on number of tubers/plant of Yandu White yam cultivar | | | | | |
|  | Time of Immersion in water (Hours) | | | | |
| Sett size (g) | 0 | 12 | 24 | 36 | Mean |
| 2016 | | | | | |
| 40 | 1.75 | 1.23 | 1.42 | 1.11 | 1.45 |
| 50 | 2.12 | 2.37 | 1.48 | 1.55 | 1.65 |
| 60 | 1.77 | 1.27 | 1.64 | 1.40 | 1.65 |
| 70 (Cut) | 1.91 | 1.51 | 1.62 | 1.21 | 1.71 |
| 70 (Whole) | 1.64 | 1.61 | 1.45 | 1.41 | 1.53 |
| Mean | 1.84 | 1.41 | 1.52 | 1.62 |  |
| 2017 | | | | | |
| 40 | 1.19 | 1.14 | 1.24 | 1.11 | 1.67 |
| 50 | 1.27 | 1.24 | 1.22 | 1.55 | 1.32 |
| 60 | 1.76 | 1.10 | 1.46 | 1.40 | 1.43 |
| 70 (Cut) | 1.45 | 1.21 | 1.18 | 1.21 | 1.26 |
| 70 (Whole) | 1.26 | 1.37 | 1.21 | 1.07 | 1.23 |
| Mean | 1.38 | 1.21 | 1.26 | 1.27 |  |
|  |  |  |  | 2016 | 2017 |
| LSD(0.05) for sett size (S) means = | | | | NS | 0.17 |
| LSD(0.05) for Time (T) of immersion in water means = | | | | 0.25 | NS |
| LSD(0.05) for S X T means = | | | | NS | 0.33 |

The 40 to 80 percent increase in crop establishment associated with immersion of setts in water for 12 hours rather than for the control (no immersion) or more hours of immersion, and the generally better (15-26 percent) establishment recorded by whole tuber indicate that the tuber skin constricts movement of water into the tuber and that the tuber has enough moisture to support vine growth. Shoot dry matter and tuber yield were however dependent on sett size. The greater accumulation of dry matter of shoot at 60g sett weight indicates that bigger setts resulted in larger crop canopy relative to that from smaller setts, even when the smaller 40g sett showed higher initial crop establishment at 4 and 8 WAP. Similar differences in crop growth have been reported in cassava (Okeke, 1994; Eke-Okoro *et al.*, 2001), yam (Ekpe et al, 2005; Ikeorgu, 2003), cocoyam (Ndaeyo *et al.* 2013), and sweet potato (Law-Ogbomo *et al,* 2014) with different stake or sett sizes.

Similar to the effect on crop growth, tuber yield increased significantly on average, as sett size increased to a maximum of 60g (2t/ha), but, beyond this, further yield advantages did not occur. The yield differences between the sett sizes were attributable to differences in food reserves in favour of bigger sett sizes as reported by Okeke (1994). In this study, mean tuber weight increased with sett size such that the values obtained for 40, 50, 60 and 70g setts were 553g, 580g, 608g and 761g respectively. Ikeorgu and Igbokwe (1999) reported that growing sett weight below 25g produced mostly minitubers and seed yams not exceeding 200g, whereas 26 – 50g sett weight could produce about 45% seed yams of 200 – 500g, while using sett weight of 51 – 75g, produced over 86% seed yams of 200 – 1000g. Igwilo (1988) observed that growth of tubers is positively geotropic and larger setts tend to produce larger tubers, which encounter greater soil resistance to penetration, and as a consequence, smaller setts give higher yield than bigger setts. The bigger 70g whole tuber which gave higher establishment and the 70g sett did not improve tuber yield over the smaller 60 and 50g setts. The results of this investigation would therefore favour the use of 60g or 50g setts for seed yam production. Although, immersing the white yam setts in water for 12 hours enhanced crop establishment and accumulation of dry matter in the shoot, it did not improve tuber yield. The higher leaf area index associated with the control or setts that were not immersed in water was an indication of greater photosynthetic activity which slightly increased tuber yield, on average, as yield reductions obtained when setts were immersed in water for 12, 24 and 36 hours were 20%, 24% and 16% respectively. The decreasing trend of leaf area index with increased period of immersion in water suggests adverse effect on leaf development and a reduction in the photosynthetic activity of leaves. Consequently, there was no effect on yield or even the tendency to depress yield following immersion of sett in water.

Evaluation of white yam performance under different sett sizes and time of immersion in water

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 4:** Effect of sett size and Time of sett immersion in water on tuberweight (kg/plant) of Yandu White yam | | | | | |
|  | Time of Immersion in water (Hours) | | | | |
| Sett size (g) | 0 | 12 | 24 | 36 | Mean |
| 2016 | | | | | |
| 40 | 0.82 | 0.63 | 0.67 | 0.56 | 0.67 |
| 50 | 0.50 | 0.93 | 0.70 | 0.63 | 0.71 |
| 60 | 0.74 | 0.63 | 0.69 | 0.76 | 0.70 |
| 70 (Cut) | 1.34 | 0.79 | 0.89 | 1.04 | 1.01 |
| 70 (Whole) | 0.76 | 0.74 | 0.61 | 0.82 | 0.73 |
| Mean | 0.852 | 0.74 | 0.71 | 0.76 |  |
| 2017 | | | | | |
| 40 | 0.42 | 0.54 | 0.43 | 0.33 | 0.43 |
| 50 | 0.41 | 0.45 | 0.44 | 0.46 | 0.44 |
| 60 | 0.68 | 0.49 | 0.35 | 0.49 | 0.50 |
| 70 (Cut) | 0.45 | 0.63 | 0.45 | 0.46 | 0.50 |
| 70 (Whole) | 0.39 | 0.52 | 0.48 | 0.51 | 0.47 |
| Mean | 0.47 | 0.53 | 0.43 | 0.45 |  |
|  |  |  |  | 2016 | 2017 |
| LSD(0.05) for sett size (S) means = | | | | 0.17 | NS |
| LSD(0.05) for Time (T) of immersion in water means = | | | | NS | 0.07 |
| LSD(0.05) for S X T means = | | | | NS | 0.16 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| T**able 5:** Effect of sett size and Time of sett immersion in water on tuber yield (t/ha) of Yandu White yam cultivar | | | | | |
|  | **Time of Immersion in water (Hours)** | | | | |
| **Sett size (g)** | **0** | **12** | **24** | **36** | **Mean** |
| **2016** | | | | | |
| 40 | 47.90 | 27.20 | 33.00 | 22.70 | 22.70 |
| 50 | 44.40 | 43.10 | 35.20 | 35.00 | 39.40 |
| 60 | 45.60 | 27.00 | 38.80 | 49.20 | 40.20 |
| 70 (Cut) | 33.30 | 38.70 | 48.30 | 62.70 | 45.80 |
| 70 (Whole) | 52.60 | 39.80 | 30.00 | 26.40 | 37.20 |
| **Mean** | **44.80** | **35.20** | **37.00** | **39.20** | **39.10** |
| **2017** | | | | | |
| 40 | 17.40 | 20.90 | 17.90 | 12.60 | 17.20 |
| 50 | 18.00 | 19.10 | 18.40 | 23.90 | 19.80 |
| 60 | 40.60 | 18.20 | 16.70 | 24.00 | 24.90 |
| 70 (Cut) | 22.90 | 25.90 | 17.90 | 19.20 | 21.50 |
| 70 (Whole) | 17.70 | 23.80 | 19.60 | 18.30 | 19.80 |
| **Mean** | **23.30** | **21.60** | **18.10** | **19.60** | **20.60** |
|  |  |  |  | **2016** | **2017** |
| LSD(0.05) for sett size (S) means = | | | | NS | 5.50 |
| LSD(0.05) for Time (T) of immersion in water means = | | | | NS | NS |
| LSD(0.05) for S X T means = | | | | 22.60 | 10.90 |
| LSD(0.05) for Year means = | | | | 3.80 |  |

Lebot (2009) reported that the moisture content of yam tubers at sprouting time is sufficient to initiate root growth and that, plant development depends almost exclusively on tuber reserves for nutrients and moisture until the initial stem emerging from the corm produces leaves. This probably explains the lack of effect of immersion of setts in water on tuber yield. Overall, immersion of whole yam tubers or setts in water before planting proved to be unnecessary, as it tended to depress tuber yields. In general, time of sett immersion in water did not affect tuber yield significantly, probably because of the fairly high moisture content in the yam tuber.

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**CONCLUSION**

White yam (yandu) crop establishment was consistently and significantly higher with the use of 70g whole tuber than with the use of setts, regardless of sett size. The 60g sett, however, produced higher dry matter in the shoot and higher tuber yield than the 70g whole tuber. The highest tuber yield was obtained from 60g sett, although 50g sett weight gave similar results. Increasing the time of sett immersion in water decreased white yam leaf area index, but increasing the time of immersion to 12 hours significantly increased crop establishment and shoot dry matter on average. Time of immersion of sett in water had no effect on tuber yield.

**REFERENCES**

Abebe A.T. and A.T. Modi (2009). Hydro primary in dry bean (*Phaseolus vulgaris L*.). Res. J. Seed Sci. **2,** 23-31

Andres C., Ade Oluwa O.O. and Bhullar. G.S. (2017). Yams (*Dioscoreaspp*): Encyclopedia of Applied Plant Sciences **3**, 435-441.

Asonye P.C. and Hamadina, E.I. (2018). Germinating *Allanblackia floribunda* seeds with slightly thickened seed coat using water. Scholars Academic Journal of Biosciences. **6 (4),** 373-377.

Awologbi E. and Hamadina E.I. (2016). Early induction of sprouting on seed tubers of yam soon after tuber initiation in a hydroponics system. Experimental Agriculture **52 (3),** 405-417.

Ayankanmi T., Shiwachi H. and Asiedu R. (2005). Sprouting and yield of yam (*Dioscoreaspp*) minisetts in relation to sett size, soil moisture and agroecology. Tropical Science **45,** 23-27.

Barker D., Keatinge J.D.H. and Asiedu R. (1999). The potential of physical mean for the manipulation of yam tuber dormancy. Tropical Science **39 (4),** 204-213

Berchie J.N., H. Adu-Dpagh J. Sarkodie-Addo, E. Asare, A. Agyemang, S. Addy and J. Donkoh (2010). Effect of seed priming on seedling emergence and establishment of four Bambara groundnut (*Vigna subterranean L. verdc*) Landraces, J, Agron., **9,** 180-183.

Clark L.J., W.E. Whalley J. Ellis-Jones, K, Dent, and H.R. Rowse*et al* (2001). On far, seed priming in Maize: A physiological evaluation. Proceeding of the 7th Eastern and South Africa Regional Maize Conference, February, 11-15, Kenya. Pp: 268-273.

Coursey D.G. (1967). Yams. Longmans, Green and Company Limited, London 230 pp.

Dagras L.M. (1993). The yam. A Tropical Root Crop. Macmillan Press Ltd. London.

Eka, O.U. (1985). The chemical composition of yam tubers. In G. Osuji (Ed.): Advances in yam Research, Nigeria: Frontline Publisher, Enugu.

Eke-Okoro O.N., Okereke, O.U., Okeke J.E. (2001). Effect of stake sizes on some growth indices and yield of three cassava cultivars. J. Agric. Sci. (Cambridge): **113,** 419-426.

Ekpe E.O., Chinaka, C.C., Otto Ndaeyo N.U., Okoro E.A. and Emah V.E. (2005). Comparative Evaluation of Bulbils and sett sizes on growth pattern and yield of water yam (*Dioscoreaalata L*.) Nigerian Journal of Agriculture, Food and Environment, **2 (1),** 42-46.

GenStat Discovery Edition 3 (2007). Lawes Agricultural Trust (Rothamsted Experimental Station), UK P. 324.

Hahn S.K., D.S.O. Osiru M.O. Akoroda and J.A. Otoo (1987). Yam production and its future propects. Outlook on Agriculture **16**, 105-110.

Hamadina E.I. (2012). Origin of vines, feeder roots and tubers in Yam: The tuber head or the Primary Nodal complex? Nigerian Journal of Agricultures, Food and Environment **8 (1),** 67-72.

Hamadina E.I. and Asiedu R. (2015). Effect of provenance and storage agroecology on duration of yam tuber dormancy. Agriculture, Forestry and Fisheries **4 (3),** 95-100.

Igbokwe M.C., Okoli, O.O., Ene, L.S.O. and Obasi, M. (1988). Advances in vegetative propagation of yams: Effect of size of minisett and area periderm from *D alata* and *D rotundata* on yield of seed yams in the rainforest zone of Nigeria. Nigerian Agricultural Journal **23,** 144-152.

Igwilo N.O. (1988). Field performance of yam grown from minisetts and seed yams: 1. Fresh tuber yield. Nigerian Agricultural Journal **23,** 11-16.

Igwilo N.O. (2009). Effect of sett size on the yield of two yam varieties grown in the dry season and rainy season. Nigerian Agricultural Journal **40,** 93-99.

Ikeorgu J.E.G. (2003). Effect of sett size and spacing of mini tubers on yield of three selected yam cultivars in the humid tropics of

Nigeria. Nigerian Agricultural Journal **34**, 58-62,

Ikeorgu J.E.G. and Igbokwe M.C. (1999). Effects of various sizes of mini tubers on seed yam size and yield. Annual Report, National Root Crops Research Institute (NRCRI), Umudike pp 36-40.

Ile E.I., Craufurd P.O., Battey N.H. and Asiedu R. (2006). Phases of tuber dormancy in yam. Annals of Botany **97,** 497-504.

Evaluation of white yam performance under different sett sizes and time of immersion in water

Ileleji F.O., Hamadina E.I. and Orluchukwu J.A. (2015). Germination of *Allanblackia floribunda* seeds: The effect of soak duration in fluridone on germination and seedling growth. Agriculture, Forestry and Fisheries **4 (3),** 142-147

Khan A.A. (1992). Preplant physiological conditioning. Hort Rev. 13:131-181.

Law-Ogbomo K.E., Osaigboro A.U., Asekunle A.T. and Nwaoguala, C.N.C. (2014). The influence of sett size on growth and fresh tuber yield of *Ipomeabatatas L*. Journal of Applied Agricultural Research **6,** 259-264.

Lebot V, (2009), Tropical Root and Tuber crops: cassava sweet potato, yams and Aroids. Crop production science in Horticulture no 17, CABI Publishing UK, 413 P. a book summarizing the available information regarding the origin, taxonomy, breeding, physiology, agronomy, pathology and processing of cassava, sweet potato, yams and Aroids,

Mavi K.,S. Ermis and L. Demire (2006). The effect of priming on Tomato root stock seeds in rlation to seedling growth. Asian J. Plant Sci. **5,** 940-947.

McDonald M.B., Sullivan J. and Lauer M.J. (2006). The pathway of water uptake on maile seed. Ohio State University, Columbus, USA.

Modi A.T. (2005). Assessment of pepper seed performance using dessication sensitivity. Seed Sci. Technol. 33:19-30.

Ndaeyo N.U., Udeme K.U., Ikeh A.O., Akpan E.A, Udoh E.I and Akata O.R (2013). Effect of sett weight on the growth and yield of some cocoyam species in Uyo, south eastern Nigerian. Nigerian Journal of Crop Science **1,** 47-53.

Okeke J.E. (1994). Productivity and yield stability in cassava as affected by stake weight. Journal of Agricultural Sciences **122,** 61-66.

Onwueme I.C. (1975). Tuber formation in yam: Effect of moisture stress and contribution of the parent sett. Journal of Agricultural Sciences **85 (2),** 267-269.

Onwueme I.C. (1978). The Tropical Tuber Crops, yams, cassava, sweet potato and cocoyams, John Wity and Sons. New York, 234pp.

Wilson L.A., Wickham I.D. and Ferguson T. (1998). Alternative manifestations in origin, form and function of the primary nodal complex of yams: a review. Tropical Agriculture (Trinidad) **75 (1),** 77-83.

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**GENETIC DIVERSITY STUDY IN OKRA (*ABELMOSCU SSPP*) ACCESSIONS**

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**ABSTRACT**

***Genetic variation is regarded as the basic material for selection and improvement of any crop breeding program.The present investigation was carried out to determine the genetic variability in pod yield and yield characters in 52 okra accessions. The accessions were grown in a Randomized Complete Block Design with three replications in the 2018 cropping season at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi,(07041'N, 08037'E, 106.4m asl). Data were collected on growth, pod and seed characters and were subjected to Principal component and cluster analysis. The principal component analysis revealed that different characters contributed differently to the total variation. In the ten principal components, the result showed that the first five principal component were loaded by plant height, one hundred seed weight, pod weight, number of leaves/plant, number of branches/plant, number of seeds/pod, pod yield, days of flowering, Days to harvestable pods and pod girth. This means that these characters were largely responsible for the variation among the 52 okra accession studied. The dendrogram indicated that the accessions were grouped into 10 distinct clusters, suggesting the degree of resemblance within members of the same clusters and dissimilarity between members of different clusters.***

**Key words:** Genetic diversity, accession, genetic variability, germplasm

**INTRODUCTION**

Okra (*Abelmoschu sspp*) belonging to the family malvaceae, is a widely cultivated vegetable which can be found in almost every market in Africa because the leaves, buds, pods, and flowers are consumed (Vineeta*eta*l, 2017). The two major cultivated okra types have been classified as *Abelmoschusesculentus* which originated from Asia and *Abelmoschus Callai* which originated from West Africa (Martin *etal*, 1981). The nutritive value of okra varies in different cultivars and depending upon the agro-climatic conditions. The development of improved varieties of crops involves the incorporation of specific genes governing desired traits, such as abiotic stress tolerance, pest and diseases resistance, stability in yield, adaptability to the environment, yield improvement among others. Thus the superiority of hybrids resulting from selection for desired traits depends to a large extent on the genetic diversity of the initial population ( Germplasm) (Adekoya, 2008).

Genetic diversity represents the variability present among different genotypes of a species. It comes into play either as a result of geographical separation or due to genetic barriers to crossability (Singh, 2010). Genetic diversity plays an important role in plant breeding due to hybrids between lines of diverse origin which on a general note display a greater heterosis than those between closely related species.

In a self pollinated crop like okra, Germplasm often exist in the form of homozygous genotypes which could be released as varieties in the short run. However, for a long term improvement, diverse genotypes are needed as parental stock for the development of improved varieties. Thus, it is important to classify the range of variability among accessions to facilitate the maintenance and further acquisition of germplasm resources. Thus, information concerning the genetic diversity within crop species is essential for a rational use of genetic resources.

Genetic variability in pod yield and its components is quiet critical among okra accessions (Ariyo, 1990, Adekoya, 2008). It is therefore, important to determine the underlying sources of genetic variability in okra pod yield and yield component characters in newly collected accessions to estimate the variation inherent in the population of the okra germplasm to pave way for its selection and subsequent improvement.

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Therefore, the objective of this study was to estimate the extent of genetic variability present among the okra accessions and classify them into various groups based on their performance.

**MATERIALS AND METHODS**

The present research took place at the Teaching and Research Farm of the University of Agriculture,Makurdi-Nigeria. (07041'N, 08037'E, 106.4m asl) The experimental materials (Okra accessions) were collected from the National Centre for Genetic Resources and Biotechnology (NAGRAB) Ibadan and some local accessions from farmers in Benue, Nasarawa, Plateau, Kebbi and Borno States of Nigeria and were code named according to their locations of collection (Table 1).In all, fifty two (52) Okra accessions were used for the study. The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replicates in the 2018 cropping season. A spacing of 60cm by 40cm was employed with a distance of O.5m and 1m between plots and blocks respectively. Two seeds were planted per hole and later thinned to one seedling per hole. Weeding was done manually and insect pests were controlled using cypermethrine at the rate of 4mls/litre of water. Data were recorded on five (5) plants randomly selected in the middle ridges in each plot. These includes plant height, number of branches per plant, number of leaves/plant, Days to first and fifty percent flowering, Days to harvestable pods, pod length, pod girth, fresh pod weight, number of seeds per pod and 100 seed weight.

Means of these data were computed and subjected to analysis of variance and significant treatment means were separated using least significant difference (LSD) (Obi, 2002). The data were also subjected to Principal Component analysis (PCA) to determine the pattern of variation and the major traits contributing to the delineation.Principal components with Eigen values above one were considered significant in determining the agro-morphological variability in the accessions and the component loadings greater than0.30 were considered to be meaningful (Hair *et al*,1998).A cluster analysis was also carried out based on Euclidean distance matrix in a hierachial way to determine the diversity and similarity of the accessions from diverse background.

**RESULT AND DISCUSSION**

The analysis of variance for the accessions used for the study showed that the means for all the traits considered (Table 2) differed significantly (0.05).The result of the principal component analysis for the 52 okra accessions is presented in Table 3. Five (5) of the ten (10) principal components had variances of 32.00, 23.00, 12.00, 10.00 and 8.00 which accounted for the total variation that gave a cumulative percentage variance of 85.90%. The first principal component (PC1) was largely loaded by days to fifty percent flowering (0.455),days to harvestable pods (0.455), days to first flowering (0.447), plant height (0.215), PC2 was loaded by number of pods per plant (0.465), number of branches/plant(0.46) pod yield (0.436) and number of leaves/plant (0.38), PC3 was largely loaded by plant height (0.432), pod weight (0.412),pod girth (0.379), and pod length (0.337).Similarly, PC4 was loaded largely by pod girth (0.603), number of leaves/plant (0.364), number of seeds/plant (0.296) and number of branches/plant (0.247)while PC5 was loaded largely by pod girth (0.287), days to first flowering (1.52), days to harvestable pods (0.151) and days to fifty percent flowering (0.150) and days to harvestable pods (0.151).

Thus, the result of the principal component analysis revealed that different characters contributed differently to the total variation as indicated by their Eigen values as well as their weights and loadings on different principal axis. This confirmed the pattern of variation among the studied accessions of okra. The characters that contributed most to the variation within a group of entries were equally identified. It revealed that the first 5 PC accounted for 85.90% of the total variation. Findings from this study were in agreement with the report of Adekoya*etal*, (2011), who reported 79.93% variation accounted for by the first four principal components in their study on 20 okra accessions. Adebisi (2004) equally reported similar results in his work on sesame. Abubakar*etal*, (2018), reported 9 components from the thirty five pearl millet accessions/ land races collected from northern Nigeria.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1:** Common Features and Sources of Okra Accessions used in the Study. | | | | | | | |
| Accessions’ | Source | Species | Height | Stem | Leaf vein color | Pod color | Pod surface |
| Name/Code |  |  |  | color |  |  |  |
| 293 | NACGRAB | *A. caillei* | Tall | Pale green | Brown | Green | Hairy |
| 297 | ״ | *A. esculentus* | Short | Red | Red | Red | Smooth |
| 298 | ״ | *A. caillei* | Tall | Red | Red | Green | Hairy |
| 301 | ״ | *A. esculentus* | Sshort | Red | Red | Red | Smooth |
| 302 | ״ | *A. caillei* | Tall | Red | Red | Red | Hairy |
| 303 | ״ | *A. caillei* | Tall | Black | Black | Black | Hairy |
| 304 | ״ | *A. caillei* | Tall | Red | Red | Green | Smooth |
| 322 | ״ | *A. esculentus* | Short | Green | Green | Green | Smooth |
| 326 | ״ | *A. esculentus* | Short | Red | Red | Green | Smooth |
| 328-B | ״ | *A. caillei* | Tall | Red | Red | Green | Smooth |
| 332 | ״ | *A. caillei* | Tall | Red | Red | Green | Hairy |
| 333 | ״ | *A. caillei* | Tall | Green | Red | Light green | Smooth |
| 335 | ״ | *A.caillei* | Tall | Red | Red | Red | Smooth |
| 342-A | ״ | *A. esculentus* | Short |  |  |  |  |
| 342-B | ״ | *A. caillei* | Tall | Pale green | Brown | Green | Smooth |
| 343-A | ״ | *A. caillei* | Tall | Red | Red | Green | Hairy |
| 345 | ״ | *A. caillei* | Tall | Red | Red | Red | Smooth |
| 346-A | ״ | *A. caillei* | Tall | Pale green | Brown | Green | Smooth |
| 346-B | ״ | *A. caillei* | Tall | Pale green | Brown | Green | Smooth |
| 348 | ״ | *A. caillei* | Tall | Red | Red | Green | Smooth |
| 349 | ״ | *A. esculentus* | Shot | Red | Red | Green | Smooth |
| 350 | ״ | *A. caillei* | Tall | Red | Red | Green | Hairy |
| 356-A | ״ | *A. esculentus* | Short | Pale green | Brown | Green | Smooth |
| 356-B | ״ |  |  | Red | Red | Green | Smooths |
| 359 | ״ | *A. caillei* | Tall | Red | Red | Red | Smooth |
| 361 | ״ | *A. esculentus* | Short | Pale green | Green | Green | Smooth |
| 371 | ״ | *A. caillei* | Tall | Pale green | Green |  |  |
| 372 | ״ | *A. esculentus* | Short | Green | Red | Green | Hairy |
| 376 | ״ | *A. esculentus* | Short | Black | Black | Green | Smooth |
| 380 | ״ | *A. caillei* | Tall | Red | Red | Green | Hairy |
| 394 | ״ | *A. esculentus* | Short | Red | Red | Red | Hairy |
| 396 | ״ | *A. caillei* | Tall | Green | Green | Green | Smooth |
| 452 | ״ | *A. caillei* | Tall | Pale green | Brown | Green | Smooth |
| 454 | ״ | *A. esculentus* | Short | Red | Red | Green | Smooth |
| 463 | ״ |  | Tall | Red | Red | Green | Smooth |
| 466 | ״ | *A. esculentus* | Short | Green | Green | Green | Smooth |
| 467 | ״ | *A. esculentus* | Short | Red | Red | Red | Hairy |
| 469 | ״ | *A. esculentus* | Short | Red | Red | Red | Smooth |
| 490 | ״ | *A. caillei* | Tall | Green | Green | Green | Hairy |
| 507 | ״ | *A. caillei* | Tall | Red | Red | Green | Smooth |
| 514 | ״ | *A. caillei* | Tall | Brown | Brown | Green | Hairy |
| 6502347 |  | *A. caillei* | Tall | Pale green | Brown | Green | Smooth |
| ABJ | Abuja FCT | Local | Tall | Red | Red | Red | Smooth |
| AWE | Awe, Nassarawa State | Local | Short | Green | Green | Green | Smooth |
| BASS | Bassa, Plateau State | Local | Tall | Pale green | Green | Red | Smooth |
| BIU | Biu, Borno State | Local | Short | Red | Red | Green | Smooth |
| J.SOUTH | Jos south, plateau state | Local | Tall | Red | Red | Red | Smooth |
| LAF. | Lafia, Nassarawa state | Local | Short | Black | Black | Green | Smooth |
| MKD | Makurdi, Benue state | Local | Tall | Pale green | Green | Green | Hairy |
| OJU | Oju, Benue state | Local | Tall | Black | Black | Green | Hairy |
| YAW | Yawuri, Kebbi state | Local | Short | Red | Red | Green | Smooth |
| ZURu | Zuru, Kebbi state | Local | Short | Red | Red | Green | Hairy |

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**Cluster Analysis**

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The variation among the 52 okra accessions were assessed based on 13 quantitative traits using cluster analysis as presented in Table 4. Based on their morphological similarities, the okra accessions were clustered into ten (10) groups. Cluster i,ii,iii, iv and v consist of 8,6,5,3 and 2 members respectively, while cluster vi,vii,viii,ix and x consist of 3,6,12,3 and 4 members, in that order. Based on thedendrgram grouping, the accessions that clustered into a particular group were highly similar with one another and quite distinct from those in other clusters (Figure 1). Thus, grouping of the accessions into ten clusters with each cluster containing accessions from different sources revealed that there was no association between pattern of clustering and sources of accessions used as the clustering pattern/membership of the accessions showed that clusters 1,2,3 and 6 consist of Okra accessions collected from NAGRAB only, while clusters 4,5,7,9,8 and 10 involves those collected form NAGRAB and farmers (Table 4). Thus, clustering of accessions into groups may be attributed to genetic and /or other factors. The inter cluster distances between the different clusters of okra accessions suggest wide genetic diversity among the okra accessions of different groups.Other researchers (Osawaru*eta,l* 2013, Shyam (2013) had reported six clusters from 53 okra accessions and four clusters from 34 Okra accessions respectively.The authors also posited that there were no correlation between ecological habitat and the diversity expressed among the accessions in their study.

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**Figure 1:Dendrogram from Cluster Analysis of Fifty two Accessions of Okra**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2:** Analysis of variance (ANOVA) for the 52 Okra Accessions | | | | | | | | | | | | | | |
| **SOV** | **DF** | **PHT(cm)** | **NOL/P** | **NOB/P** | **DFF** | **DTFF** | **DHP** | **NPP/P** | **PL(cm)** | **PG(cm)** | **PWT(g)** | **NSP/P** | **HSWT(g)** | **PY(g)** |
| ACC | 51 | 10056.9\*\* | 292.69\*\* | 17.17\*\* | 1130.16\*\* | 992.39\*\* | 1144.54\*\* | 75.12\*\* | 7.16\*\* | 0.16\*\* | 184.73\*\* | 775.24\*\* | 0.86\*\* | 54927.80\*\* |
| REP | 2 | 5.33 | 10.74 | 1.86 | 3.56 | 6.74 | 12.03 | 0.18 | 0.33 | 0.27 | 10.26 | 1.26 | 0.23 | 301.19 |
| ERROR | 102.4 | 3.93 | 3.79 | 1.47 | 10.73 | 12.53 | 13.11 | 0.47 | 0.24 | 0.17 | 1.47 | 3.07 | 0.19 | 605.00 |
| PHT=Plant height, NOL/p=number of leaves/plant, NOB/P=number of branches/plant, DFF=days to first flowering, DTFF=days to fifty percent flowering, DHP=days to harvestable pods, NPP/P=number of pods/plant, PL=Pod length, PG=Pod girth, PWT=Pod weight, NSP/P=number of seeds/pod, HSWT=hundred seed weight, PY=Pod Yield. | | | | | | | | | | | | | | |

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| --- | --- | --- | --- | --- | --- |
| **Table 3:** Principal component Analysis showing contribution, Eigen values and percent total variance accounted for by the first 5 principal components axes of each character for the 52 Okra accessions: | | | | | |
| Variable | PC1 | PC2 | PC3 | PC4 | PC5 |
| PHT | 0.215 | -0.147 | 0.432 | 0.020 | -0.272 |
| NOL/P | 0.132 | 0.380 | -0.289 | 0.364 | -0.307 |
| NOB/P | 0.056 | 0.460 | -0.266 | 0.247 | -0.295 |
| DFF | 0.447 | 0.093 | 0.153 | -0.90 | 0.152 |
| DTFF | 0.455 | 0.080 | 0.157 | -0.046 | 0.150 |
| DHP | 0.455 | 0.091 | 0.159 | -0.077 | 0.151 |
| NP/P | 0.0362 | 0.465 | 0.140 | -0.408 | -0.148 |
| PL | -0.362 | 0.044 | 0.337 | -0.156 | -0.148 |
| PG | 0.054 | 0.189 | 0.379 | 0.603 | 0.287 |
| PWT | -0.346 | 0.108 | 0.412 | 0.279 | 0.013 |
| NSP/P | 0.095 | -0.299 | 0.169 | 0.296 | -0.411 |
| HSWT | 0.174 | -0.232 | 0.115 | -0.088 | -0.608 |
| PY | -0.158 | 0.436 | 0.311 | -0.250 | -0.171 |
| Eigenvalues | 4.00 | 2.90 | 1.55 | 1.33 | 1.12 |
| Variance | 32.00 | 23.00 | 12.00 | 10.00 | 8.00 |
| Cumulative Variance | 32.00 | 55.10 | 67.10 | 77.30 | 85.90 |
| PHT=Plantheight,NOL/P=numberofleaves/plant,NOB/P=number of branches/plant,DFF=daystofirstflowering,DTFF=daystofiftypercent flowering,DHP=days to harvestable pods, NP/P=numberofpods/plant,PL=Podlength,PG=Podgirth,PWT=Pod weight, NSP/P=number of seeds/pod,HSWT=hundred seed weight,PY=Pod Yield. | | | | | |

Genetic diversity study nn okra (*Abelmoscusspp*) ccessions

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| **Table 4:** Clustering Pattern of 52 okra Accessions | | |
| Cluster | No. of members | Members |
| I | 8 | 293, 298, 332, 514, 350, 380, 490, 343-A |
| II | 6 | 322, 346,-A, 346-B, 335, 345, 371 |
| III | 5 | 302. 452, 326, 348, 372 |
| IV | 3 | 376, 454, Bassa |
| V | 2 | 361, OJU |
| VI | 3 | 304, 333, 328-B |
| VII | 6 | 297, 349, 356-B, Makurdi, 359, 396 |
| VIII | 12 | 342-A, 466, 6502347, Jos, 356-A, Biu, Yawuri, 394, 467, 469, 507 Abuja |
| IX | 3 | 301, Awe, Lafia. |
| X | 4 | 303, 342-b, 463, Zuru |

**CONCLUSION**

The classification of the okra accessions into distinct groups indicates that hybridization is possible between the accessions such that maximum heterosis could be achieved. Among the characters that had significant contribution to the total variation in the first 5 principal components included plant height at harvest, number branches/plant, number of leaves/plant, days of first and fifty percent flowering, pod weight, number of seeds/pod, one hundred seed weight and pod yield/ plant. These characters could be included in the okra improvement programme for pod yield and yield characters.

**REFERENCES**

Abubakar A.F., A.O Adebola M.O, Olayemi I.K. and Dauda O.A.Y.

(2018) .Variability study in pearl millet (*PennisetunGlaucum*. L.) land races from Northern Nigeria.Proceedings of the 42ND Annual National Conference of the Genetics Society of Nigeria, held at Nigeria Defense Academy Kaduna from 9th-13th December. PP.290-300.

Abubakar A., Falusi A.O., Adebola M.O, Olayemi I.K and Dauda O.A.Y (2018).Variability study in pearl millet (*PennisetumGlaucum* L) land races from Northern Nigeria.Proceedings of the 42ND Annual National Conference of the Genetics Society of Nigeria, held at Nigeria Defense Academy Kaduna from 9th-13th December. PP. 290-300.

Adebisis M.A. (2004).Variation, stability and correlation studies in seed quality yield components of sesame (*SesamumIndicum* L.) Ph.D, thesis from Departmentof Plant Breeding and Seed Technology, University of Agriculture,Abeakuta. 122 PP.

Adekoya M.A, (2008).Evaluation of variation, inter character correlation and performance of okra ( *Abelmoschusesculentus* (L.) Moench).Master of Agriculture thesis, Department of Plant Breeding and seed technology, University of Agriculture, Abeakuta. 114 PP.

Adekoya M.A, Adebisi M.A., Abdul-Rafiu A.M, Ariyo O.J and Ayo- Vaugham, M.A. (2011). Multivariate analysis of genetic variability in pod and seed yield characters of Okra (*Abelmoschusesculentus* (L) Moench) grown in different cropping seasons. *Nigeria J. of genetics*. **25,** PP30-46.

Ariyo O.J (1990).Effectiveness and relative discriminatory abilities of techniques measuring genotype X environment interaction and stability in Okra (*Abelmoschusesculentus* (L.) Moench)*Euphytica*, **47,** 99-105.

Hair, J.F, Anderson, J.R, Tathan, R.E. and black W.C (1998). *Multivariate data analysis, 5th ed. Prentice-hall international, inc. London.*

Martin, F.W, Rhodes, A.M,Manuel, O and Diaz, O.I (1981). Variation in Okra.*Euphitica*. **30,** 699-705.

Jibung G.G., Vange T., Msaakpa T.S. and Okoh J.

Obi U.I. (2002) Statistical methods of Detecting Differences between Treatment means and research methodology. Issues in laboratory and field experiments. Second Edition, Published in Nigeria by express publishers limited, 3 Obollo Road, Nsukka Nigeria. 117pp.

Osawaru M.E, Ogwu M.C. and Dania –Ogbe F.M (2013). morphological assessment of the genetic variability among 53 accessions of West African okra (*AbelmoschusCallai* (A. Chev.) Stevels) from South Western Nigeria.*Nigerian Journal of Basic and Applied science* **21 (3),** 227-238.

Shyam C.H, (2013).Genetic variability analysis in okra using morphological marker. Unpublished Masters’ degree thesis. SHER-E-BANGLA Agricultural University, Dhaka.PP.1-86.

Singh, B.D. (2010). *Plant breeding, principles and methods*.Kalyani publishers Ludhiana Kolkata. PP 361-363.

Vineeta P.,Arvind K. and Durvesh K. S, (2017). Evaluation of Quantitative Characters of Okra (*Abelmoschussesculentus* (L.) Moench) genotypes.*Current Journal of Applied Science and Technology*. **24 (5),** 1-6.

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**SYNERGISTIC HORMESIS OF COMBINED GAMMA RAYS DOSES AND COLCHICINE CONCENTRATIONS IN DESIGNING HIGH YIELDING GENOTYPES OF FONIO (*DIGITARIA EXILIS* [KIPPIST] STAPF.)**

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**ABSTRACT**

***A research was conducted to study the synergistic hormesis of low dose of gamma rays in combination with low colchicine concentration in developing high yielding fonio (Digitaria exilis) genotypes with good seeds quality and high genetic variability. Seeds of five different accessions of fonio were irradiated with four different doses of gamma rays (100 Gy, 200 Gy, 400 Gy and 500 Gy) and then treated with four corresponding colchicine concentrations (0.1 mM, 0.5 mM, 1.0 mM and 2.0 mM). The experiment was conducted during 2014 to 2017 wet seasons and was laid out in Randomized Completely Block Design with three replications for four generations. The result obtained from the M4 generation revealed highly significant difference (P≤0.01) in the effects of different treatments for all the selected agronomic traits of fonio indicating the presence of induced variability among the accessions. The result revealed that, the synergistic effect of low gamma rays and colchicine doses developed early maturing high yielding genotypes of fonio with larger grain sizes and high genetic variability. The LD50 value was genotype dependent and was fixed at 137 Gy+mM. The results for the estimation of genetic parameters revealed higher PCV and GCV values and that PCV values were slightly greater than GCV values for all the traits studied. However, moderate to high heritability among the mutants’ traits indicates that the traits are primarily under genetic control. While, the predominance of moderate heritability estimates and high GAM in most of the traits revealed additive gene effects induced by the mutagens in controlling such traits indicating that selection for improvement might be effective.***

**Key words:** Colchicine, fonio, gamma rays, hormesis

**INTRODUCTION**

Fonio (*Digitaria exilis* [Kippist] Stapf.) is popularly known as Acha (Jideani, 1999; Gyang and Wuyep, 2005). It is one of the world’s fastest maturing cereals producing grains just 42 to 56 days after sowing for the extra early genotypes (Ibrahim, 2001). The late genotypes take up to 150 days to grow (CIRAD, 2004). Fonio is grown in commercial quantity in various parts of Nigeria (Maji *et al*., 2005; Chukwu and Abdulkadir, 2008). It is a rich source of energy and the best tasting and nutritious of all grains (Vietmeyer *et al*., 1996). Fonio grains are rich in methionine and cystine; which are the two vital amino acids almost deficient in sorghum, rice, wheat or barley (Barikmo and Ouattara, 2004). It is a useful diet for diabetic patients (Balde *et al*., 2008; Jideani and Jideani, 2011) due to its low carbohydrate contents and for delivering women due to its anti-clotting potential after delivery (Adoukonou-Sagbaja *et al*., 2006). Its porridge is also recommended for breast-feeding women to stimulate milk production (Vodouhe *et al*., 2003).

Despite the nutraceutical and pharmaceutical importance of fonio, it is still unimproved and its cultivation is not beyond subsistence level in Nigeria (Philip, 2011) due to low yields (Dachi and Barko, 2003; Maji *et al*., 2003; Ukwungwu *et al*., 2003; Kuta *et al*., 2005) and very small grain size of about 0.4–0.5 mm (Sulaiman *et al*., 2015). Research efforts to improve fonio are still at a low level. In consequence, the crop remains primitive facing diverse agronomical and technological problems; to the extent that, fonio cultivation relies only on traditional landraces which are, despites their adaptability to marginal farming system are less productive (Vietmeyer *et al*., 1996). Lack of information on the inheritance of agronomic traits also makes fonio germplasm analyses to depend on phenotypic traits that could easily be influence by the environment. Most of the researches (Aliero, 2000; Olorunmaiye and Aliero, 2000; Aliero and Morakinyo, 2001; Aliero and Morakinyo, 2005) were centered upon germplasm collection and morpho-agronomic characterization with the objective of broadening the crop gene pool. In order to bring fonio to prominence, extensive researches are needed to provide adequate information that can support and revive its mass cultivation (Philip and Isaac, 2012). This indicates the need to enhance the productivity of this crop by developing high yielding genotypes with larger grain size and high genetic variability possessing good grain quality. Induced mutagenesis is one of the tools used to enhance genetic variability in crops and facilitate development of improved varieties at a faster rate (Maluszynski, 1990). However, most studies have been conducted and designed to evaluate the biological response to high doses of radiation, while in relatively few studies have used low doses to stimulate physiological processes although the ionizing radiation hormesis has been widely supported (Luckey, 1980). Hormesis, which is the excitation or stimulation by small doses of any agent in any system (Luckey, 2003) has been well documented as beneficial in the improvement of plant species of agricultural importance (Zaka *et al*., 2004; Kim *et al*., 2005). Although little is known about the basic nature of this phenomenon, Vaiserman (2010) had indicated the possible correlation between the hormesis and epigenetic effects. The application of low-dose ionizing radiation produce in coniferous species hormetics radio-stimulants effects through genetic and epigenetic changes that manifest as adaptive responses (Iglesias-Andreu *et al*., 2015). Therefore, this study aimed at designing high yielding genotypes of fonio using synergistic hormesis of gamma rays and colchicine.

Synergistic hormesis of combined gamma rays doses and colchicine concentrations in designing highyielding genotypes of fonio

**MATERIALS AND METHODS**

The research was conducted at the Botanical Garden of the Department of Botany, Ahmadu Bello University, Zaria (Lat 11o 11ꞌ N; Long 7o 38ꞌE) during 2014 to 2017 wet seasons.

**Treatment and experimental design**

Seeds of five fonio accessions: Dinat, Jakah, Jiw 1, Jiw 2 and Nkpowas were obtained from the National Cereal Research Institute, Badeggi, Niger State, Nigeria. The seeds were first exposed to 60Co gamma rays at four different doses (100 Gy, 200 Gy, 400 Gy and 500 Gy) at the Plant Breeding and Molecular Biology Laboratory, International Atomic Energy Agency (IAEA), Vienna, Austria. The irradiated seeds were then soaked in four corresponding colchicine concentrations (0.1mM, 0.5mM, 1.0mM and 2.0mM) for four hours after which the treated seeds were washed thoroughly in running tap water, allowed to dry over-night on Whatman No 1. filter paper at 27 oC. The control was soaked in distilled water. The treated seeds of all the accessions were sown along with respective controls to rise the M1 generation. The field was laid out in a Randomized Completely Block Design (RCBD) with three replications and plots were spaced 10 m x 5 m. The seeds were sown at 20 cm intra row and 40 cm inter row spacing. All the recommended agronomic and cultural practices such as sowing, fertilizer application, weeding and thinning as well as harvesting were carried out according to the procedures described by National Agricultural Extension Research and Liason Services (NAERLS) Crops Production Guide (2012) for millets.

Seeds harvested from individual M1 plants were advanced to M4 generation via M2 and M3 generations. Ten progenies from each accession in each replication of the M2 generation which showed significant deviation in mean values for tiller number, number of spikes, spikes length and number of seeds/spikelets in the positive direction from the mean values of control were selected as described by Singh (2011), Wani *et al*. (2013) and Chahal and Gosal (2014). Combined Lethal dose and concentration were determined for each treatment in the first mutant generation from random selection of mutants.

**Data analyses**

Multivariate Analysis of variance (MANOVA) was used to analyze quantitative traits using SAS (2008) Version 9.1 with Duncan’s multiple range tests (DMRT) used to separate the significant

means. Probit analysis (Finney, 1978) was carried out to determine the lethal dose (LD50) and lethal concentration (LC50). The Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated as described by Syukur *et al*. (2012):

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σ2G = [(MSG) – (MSE)] /

r σ2P  = [σ2G + (σ2E/r)].

Where: σ2G = Genotypic variance; σ2P = Phenotypic variance; σ2E = environmental variance (error mean square from the analysis of variance); MSG = mean square of genotypes; MSE = error mean square; r = number of replications.

GCV (%) = √(σ2G) x 100 x

PCV (%) = √(σ2P) x100 x

Where: σ2G = Genotypic variance; σ2P = Phenotypic variance; x is grand mean of a character. The Broad Sense Heritability (H2), Genetic Advance (GA) and Genetic Advance as percent of the Mean (GAM) were estimated according to the formula described by Singh and Choudhury (1985).

H2 (%) = σ2G x 100  σ2P

GA = kσPH2

Where k is the selection differential in standard units in the present study and it was 2.06 at 5% level of selection, σP is standard deviation of the phenotypic variance and H2 is Broad sense heritability. Genetic advance expressed as percentage of mean (GAM) was measured by the following formula:

GAM (%) = GA x 100 x

**RESULTS**

The result for the synergistic effects of different combinations of gamma rays and colchicines on individual accessions of fonio in the M4 generation is presented in Table 1. The result showed highly significant differences (P≤0.01) in the effects of the synergistic hormesis in all the accessions for all the traits (except in plant height). It was shown that, the synergistic combinations of low gamma rays doses and colchicines concentrations produced mutants with higher germination rates of 57.66% in Jiw 1 to as high as 66.66% in Jakah. The synergistic hormesis developed mutants with high number of leaves (5-6 leaves) that were larger in size (11.70-12.80 cm2). The mutants developed by the synergistic hormesis produced high number of tillers (7-12 tillers) with higher number of spikes (4-5 spikes) that were longer in size (9.46-10.00 cm) and which produced high number of seeds

(107-112 seeds/spikelets). The mutants’ seeds were larger in diameter (1.07-1.16 mm) and weighed However, the result for the synergistic effects of different combinations of gamma rays and colchicine on M4 generation of fonio is presented in Table 2. The result showed that a combination of lower dose of gamma rays with lower colchicine concentration (100 Gy+0.1 mM) produced mutants with highest mean values in almost all the selected traits except plant height at maturity. The mutants showed 63.86% germination after two weeks of sowing. The mutants attained height of 70.66 cm at maturity. The mutants also produced 5 leaves that were 12.32 cm2 in size, produced 10 tillers that possess 5 spikes that were 9.74 cm long and which bear 116seeds/spikelet. The 1000 seeds of the mutants weighed 0.62 g with diameter of 1.12 mm and attained maturity 97 days after sowing. More so, the result for the lethal dose and concentration of the mutagens is presented in Table 3. The result showed that, the lethal dose and concentration of gamma rays and colchicine were fixed between the ranges of 137 Gy+mM in accession Jiw 2 to 182 Gy+mM in accession Jakah.

Result for the genetic parameters estimates induced by a combination of different gamma rays doses with various colchicine concentrations is presented in Table 4. The result showed that the GCV values are slightly lower than the PCV values for all the traits studied. Moderate to high GCV and PCV values were found in terms of germination percents, leaf number and size, number of tillers and spikes, spikes length and number of seeds/spikelet. The highest GCV and PCV values were found among 500 Gy+2.0 mM treated mutants. However, the heritability values were found to be higher (>60%) among the mutants in all the traits studied. More so, the highest heritability values (>60%) were found among 100Gy+0.1mM treated mutants in terms of number of leaves (94.01%), number of tillers (79.04%), spikes length (78.75%) and number of seeds/spikelet (78.42%). The genetic advance and Genetic Advance as percent of the Means values were found to be higher (>20) among the mutants in all the traits studied.

**DISCUSSION**

Artificial induction of mutation through the synergistic hormesis in fonio using physical and chemical mutagens had proved vital in the cultivars improvement. The high rate of germination induced by synergy of low doses of gamma rays and colchicine in fonio revealed the significance of the two mutagens in stimulating germination process at low doses. This is in line with the findings of Hemavathy (2015) who reported decreased germination rate of mung bean (*Vigna radiata*).

Synergistic hormesis of combined gamma rays doses and colchicine concentrations in designing highyielding genotypes of fonio

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1:** M4 Generation effect of combined gamma rays and colchicine concentrations on agronomic traits of fonio accessions | | | | | | | | | | | | |
| Accession | Dose+  Concentration (Gy+mM) | %  Germination (2WAS) | Height at Maturity  (cm) | Number of Leaves | Leaf Area  (cm2) | Number of Tillers | Number of Spikes | Spikes Length  (cm) | Number of Seeds/Spikelets | 1000  Seeds Weight (g) | Seeds Diameter (mm) | Days to Maturity |
|  | 0 | 61.00c\*1 | 73.65a | 3.66d | 4.63d | 5.67c | 3.00d | 7.90d | 71.67d | 0.58c | 0.90d | 125.66a |
|  | 100+0.1 | 65.00b | 69.33b | 5.67a | 12.07a | 7.33a | 4.33a | 9.46a | 109.00a | 0.62a | 1.14a | 97.00e |
|  | 200+0.5 | 66.67a | 67.00c | 4.67b | 10.80b | 6.33b | 3.67b | 9.07b | 105.67b | 0.60a | 1.03c | 98.67d |
| Dinat | 400+1.0 | 55.00d | 67.33c | 4.00c | 9.63c | 6.00b | 3.33c | 8.27c | 86.33c | 0.60a | 1.05b | 99.33c |
|  | 500+2.0 | 51.00e | 58.67d | 3.00e | 9.10c | 4.33d | 3.33c | 6.63e | 52.33e | 0.59b | 0.91d | 100.67b |
|  | Means | 59.73 | 67.20 | 4.20 | 9.25 | 5.93 | 3.33 | 8.27 | 85.00 | 0.60 | 1.01 | 104.27 |
|  | 0 | 53.54d | 73.67a | 3.66d | 7.36d | 4.67d | 2.66c | 7.23d | 70.66d | 0.58d | 0.90e | 122.00a |
|  | 100+0.1 | 66.66a | 72.66b | 5.00a | 12.33a | 9.40a | 4.67a | 10.00a | 112.33b | 0.62a | 1.14a | 96.33e |
|  | 200+0.5 | 63.00b | 70.33c | 4.33b | 11.16b | 7.33b | 4.33b | 9.36b | 118.00a | 0.61b | 1.09b | 98.67d |
| Jakah | 400+1.0 | 57.00c | 64.67d | 4.00c | 8.33c | 5.00c | 2.67c | 7.80c | 87.66c | 0.59c | 1.05c | 105.00c |
|  | 500+2.0 | 46.33e | 65.66d | 3.00e | 6.60e | 4.00e | 2.33d | 6.30e | 41.33e | 0.57e | 1.01d | 108.67b |
|  | Means | 57.31 | 69.40 | 3.99 | 9.16 | 6.08 | 3.33 | 8.14 | 86.00 | 0.59 | 1.04 | 106.13 |
|  | 0 | 57.00b | 75.00a | 3.33d | 8.66e | 8.00c | 2.66d | 7.73c | 88.00d | 0.59c | 0.89e | 121.00a |
|  | 100+0.1 | 57.66b | 70.00b | 4.67a | 11.70a | 12.33a | 4.67a | 9.93a | 112.00a | 0.62a | 1.12a | 97.67e |
|  | 200+0.5 | 58.00a | 67.00c | 4.33b | 10.67b | 9.33b | 3.67b | 9.16b | 103.33b | 0.61b | 1.09b | 101.00d |
| Jiw1 | 400+1.0 | 53.66c | 63.00d | 3.67c | 9.03c | 7.33d | 3.33c | 7.56c | 89.00c | 0.59c | 1.00c | 103.66c |
|  | 500+2.0 | 48.33d | 61.33e | 2.67e | 7.07e | 5.33e | 2.33d | 5.97d | 63.66e | 0.57d | 0.98d | 108.33b |
|  | Means | 54.93 | 67.27 | 3.73 | 9.43 | 8.46 | 3.31 | 8.07 | 91.20 | 0.60 | 1.02 | 106.33 |
|  | 0 | 60.33c | 65.33c | 3.67c | 8.76d | 5.67d | 2.66d | 7.47d | 74.33d | 0.58d | 0.87e | 122.00a |
|  | 100+0.1 | 66.00a | 70.33a | 5.33a | 12.80a | 9.33a | 4.67a | 9.80a | 109.66a | 0.62a | 1.07b | 100.67e |
|  | 200+0.5 | 63.33b | 69.33b | 4.33b | 11.87b | 8.66b | 3.67b | 8.93b | 103.00b | 0.61b | 1.11a | 103.00d |
| Jiw 2 | 400+1.0 | 55.00d | 61.33d | 3.67c | 8.83c | 6.00c | 3.33c | 8.73c | 82.33c | 0.59c | 1.02c | 107.00c |
|  | 500+2.0 | 48.00e | 57.00e | 2.67d | 7.47e | 4.33e | 2.67d | 6.27e | 43.00e | 0.58d | 0.99d | 108.67b |
|  | Means | 59.40 | 64.66 | 3.93 | 9.95 | 6.80 | 3.40 | 8.24 | 82.46 | 0.60 | 1.01 | 108.27 |
|  | 0 | 58.33b | 64.67c | 3.00d | 9.43d | 6.00d | 2.67d | 7.36d | 78.33d | 0.58d | 0.97d | 120.66a |
|  | 100+0.1 | 64.00a | 71.00a | 5.33a | 12.70a | 10.66a | 4.67a | 9.50a | 107.33a | 0.62a | 1.16a | 94.33e |
|  | 200+0.5 | 58.66b | 66.67b | 4.33b | 10.33b | 8.00b | 3.33b | 8.63b | 103.66b | 0.61b | 1.09b | 98.67d |
| Nkpowas | 400+1.0 | 54.33c | 63.00d | 3.33c | 9.80c | 7.00c | 3.00c | 7.80c | 93.67c | 0.59c | 1.04c | 100.00c |
|  | 500+2.0 | 43.66d | 50.00e | 3.00d | 8.93e | 4.67e | 2.33d | 6.16e | 44.00e | 0.58d | 0.97d | 105.33b |
|  | Means | 55.80 | 63.07 | 3.80 | 10.24 | 7.27 | 3.20 | 7.89 | 85.40 | 0.60 | 1.05 | 103.80 |
| N.B: \*1 Means within the column with the same superscript(s) for each accession are not significantly different (P≤0.05) | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2:** M4 Generation combined effect of doses of gamma rays and colchicine on agronomic traits of fonio | | | | | | | | | | | |
| Dose + Concentration (Gy+mM)/ | %  Germination (2WAS) | Height at Maturity  (cm) | No. of Leaves | Leaf Area  (cm2) | No. of Tillers | No. of Spikes | Spikes Length  (cm) | No. of Seeds  Spikelets | 1000  Seeds Weight (g) | Seeds Diameter (mm) | Days to Maturity |
| 0 | 59.80b\*1 | 71.67a | 3.53c | 7.96d | 6.06c | 2.8c | 7.54d | 76.80d | 0.59c | 0.91e | 122.27a |
| 100+0.1 | 63.86a | 70.66a | 5.20a | 12.32a | 9.80a | 4.60a | 9.74a | 115.66a | 0.62a | 1.12a | 97.20e |
| 200+0.5 | 62.33ba | 66.86ba | 4.40b | 10.96b | 7.93b | 3.73b | 9.03b | 106.73b | 0.61b | 1.08b | 100.00d |
| 400+1.0 | 54.40c | 63.87b | 3.66c | 8.93c | 6.20c | 3.00c | 8.02c | 87.60c | 0.59c | 1.03c | 103.00c |
| 500+2.0 | 47.46d | 58.53c | 2.87d | 7.83d | 4.53d | 2.40d | 6.27e | 48.86e | 0.58d | 0.97d | 106.33b |
| Mean | 57.57 | 66.32 | 3.93 | 9.60 | 6.91 | 3.32 | 8.12 | 87.13 | 0.59 | 1.02 | 105.76 |
| S.E (±) | 4.92 | 8.83 | 0.87 | 0.69 | 1.29 | 0.62 | 0.62 | 7.45 | 0.02 | 0.04 | 1.64 |
| N.B: \*1 Means within the columns with the same superscript letter(s) are not significantly different (P≤0.05) | | | | | | | | | | | |

The observed synergistic hormesis agrees with the findings of Yadav *et al*. (2016) who reported significant improvements in growth and yield attributes among low doses induced-mutants of maize (*Zea mays*). High doses of gamma rays reduced the germination percent of fonio probably by inducing damage to the germinating seeds. Similar finding is reported by Rajapandian and Dhanam (2017) among mutants of maize. The increased in plant height at maturity and foliar attributing traits under low doses synergistic effects of the mutagens is due to the effect of low doses of gamma radiations and colchicine concentrations on plant growth and development probably by stimulating cell division and/or cell elongation at meristems. .

The significant improvement in fonio seed yield and quality due to synergistic hormesis of low gamma rays dose and colchicine concentration reported by the present study is in conformity with the previously reported work of Deshmukh *et al*. (2018) in sorghum, Kate *et al*. (2018) in proso millet (*Panicum miliaceum* L.) and Bhave *et al*. (2016) in proso millet. Similar findings were reported in other crops by Suresh *et al*. (2017) in lima bean (*Phaseolus lunatus* L.) and Kara *et al*. (2016) in soy bean (*Glycine max*). It therefore implies that it is possible to improve yield components of economic plants using a synergy of gamma dose of 100 Gy and 0.1 mM colchicines concentration. However, these findings were contrary to the work of Zeerak (1990) who observed reduced yield in combined treatments of gamma rays and EMS in eggplant (*Solanum melongena* L.).

The genetic parameters estimates revealed that PCV values were slightly greater than GCV values for all the traits studied which indicates the presence of high contribution of genotypic effect for phenotypic expression of the selected traits and that there is high genetic variability for the traits which may facilitate selection based on phenotypic performance as reported by Islam *et al*. (2009). This finding is in conformity with that of Yohannes *et al*. (2015) who reported similar finding in sorghum. Moderate to high heritability, G.A and GCV estimates coupled with high genetic advance as percent of the mean explained the influence of additive gene effect as reported by Ibrahim and Hussein (2006) in roselle (*Hibiscus sabdariffa*) and that heritability is a property of a character in the population, environment and the conditions of the genotypes as stressed by Yadav *et al*. (2011). The moderate to high heritability, GA and GAM estimates reported by this research on the number of tillers, number of spikes, spikes length, number of seeds/spikelet and 1000 seeds weight conforms to the earlier reports by Wolie *et al*. (2013) in finger millet, Ogunbayo *et al*. (2014) in rice and Shrimali *et al*. (2017) in barley that these yield parameters were important for selection.

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Thus, mutants with such characters need to be selected for improvement. Broad sense heritability (H2) therefore represents the relative strength of the traits and indicates the efficiency of selection systems as reported by Hugar and Savithramma (2015). The LD50 and LC50 are very important parameters to understand the sensitivity of various genotypes to the critical dose of mutagens creating 50 per cent mortality as stressed by Usharani *et al*. (2017). One fundamental tenet in mutation breeding experiments is the evaluation of the effect of mutagens on the M1 generation. The variation in the LD50 and LC50 reported by the present study indicated the differences in the response of the accessions to various doses and concentrations. Similar finding was reported in chick pea by Umavathi and Mullainathan (2015) and in butter bean by Suresh *et al*. (2017). This result showed that the LD50 and LC50 values are genotype dependents and is in line with the findings of Ramachander *et al*. (2015) in rice varieties.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3:** LD50/LC50 of combined gamma rays and colchicine on agronomic traits of Fonio | | | | | | | | |
| Accession | Dose (Gy)  +  Concentration (mM) | Log10 of Dose  +  Concentration | %Germination (2 WAS) | % of Control | %  Reduction over  Control | Observed % Mortality | Empirical Probit Unit | LD50/LC50 Value |
| Dinat | 0 | - | 56.83a | 0 | - | - | - |  |
|  | 100+0.1 | 2.00 | 55.30b | 97.31 | 2.69 | 45 | 4.87 |  |
|  | 200+0.5 | 2.30 | 49.37c | 86.87 | 13.13 | 51 | 5.03 | 143 |
|  | 400+1.0 | 2.60 | 48.93c | 86.09 | 13.91 | 51 | 5.03 |  |
|  | 500+2.0 | 2.70 | 41.40d | 72.85 | 27.15 | 59 | 5.23 |  |
| Jakah | 0 | - | 60.30a | 0 | - | - | - |  |
|  | 100+0.1 | 2.00 | 58.66b | 97.28 | 2.72 | 41 | 4.77 |  |
|  | 200+0.5 | 2.30 | 51.63c | 85.62 | 14.38 | 48 | 4.95 | 182 |
|  | 400+1.0 | 2.60 | 44.97d | 74.58 | 25.42 | 55 | 5.13 |  |
|  | 500+2.0 | 2.70 | 37.20e | 61.69 | 38.31 | 63 | 5.33 |  |
| Jiw 1 | 0 | - | 58.57a | 0 | - | - | - |  |
|  | 100+0.1 | 2.00 | 56.17b | 95.90 | 4.09 | 44 | 4.85 |  |
|  | 200+0.5 | 2.30 | 54.26c | 92.64 | 7.36 | 46 | 4.90 | 155 |
|  | 400+1.0 | 2.60 | 50.30d | 85.88 | 14.12 | 50 | 5.00 |  |
|  | 500+2.0 | 2.70 | 41.56e | 70.96 | 29.04 | 58 | 5.20 |  |
| Jiw 2 | 0 | - | 62.00a | 0 | - | - | - |  |
|  | 100+0.1 | 2.00 | 60.20b | 97.09 | 2.90 | 40 | 4.75 |  |
|  | 200+0.5 | 2.30 | 55.96c | 90.26 | 9.74 | 44 | 4.85 | 137 |
|  | 400+1.0 | 2.60 | 50.03d | 80.69 | 19.31 | 50 | 5.00 |  |
|  | 500+2.0 | 2.70 | 47.73e | 76.98 | 23.02 | 52 | 5.05 |  |
| Nkpowas | 0 | - | 56.36a | 0 | - | - | - |  |
|  | 100+0.1 | 2.00 | 55.30a | 98.12 | 1.88 | 45 | 4.87 |  |
|  | 200+0.5 | 2.30 | 50.50b | 89.60 | 10.39 | 50 | 5.00 | 156 |
|  | 400+1.0 | 2.60 | 43.30c | 76.83 | 23.17 | 57 | 5.18 |  |
|  | 500+2.0 | 2.70 | 38.03d | 67.48 | 32.52 | 62 | 5.31 |  |

Synergistic hormesis of combined gamma rays doses and colchicine concentrations in designing highyielding genotypes of fonio

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4: Genetic parameters estimates induced by combination of gamma rays and colchicine on agronomic traits of Fonio** | | | | | | | | | | | | |
| Dose+ Concentration | Parameter | %Germination (2WAS) | Height at Maturity (cm) | Number of Leaves | Leaf Area  (cm2) | Number of Tillers | Number of Spikes | Spikes Length  (cm) | Number of Seeds/Spikelets | 1000  Seeds Weight  (g) | Seeds Diameter  (mm) | Days to Maturity |
| Control | GCV | 10.47 | 1.86 | 11.63 | 12.57 | 10.65 | 6.35 | 10.67 | 7.07 | 0.96 | 3.72 | 1.45 |
|  | PCV | 13.38 | 2.86 | 12.38 | 16.54 | 13.48 | 9.69 | 13.56 | 9.02 | 1.24 | 4.24 | 1.71 |
|  | H2 | 78.25 | 65.03 | 93.94 | 75.99 | 79.01 | 65.53 | 78.69 | 78.38 | 77.41 | 87.74 | 84.79 |
|  | GA | 589.63 | 226.55 | 680.89 | 636.64 | 597.58 | 420.21 | 596.92 | 484.93 | 177.57 | 372.18 | 228.40 |
|  | GAM | 1250.28 | 312.61 | 20447.15 | 9779.42 | 6270.51 | 15392.31 | 7452.18 | 642.04 | 31152.63 | 46522.50 | 184.39 |
| 100Gy+0.1mM | GCV | 9.03 | 2.05 | 8.95 | 10.76 | 8.56 | 4.99 | 8.97 | 5.67 | 0.89 | 3.26 | 1.73 |
|  | PCV | 11.54 | 3.16 | 9.52 | 14.15 | 10.83 | 7.62 | 11.39 | 7.23 | 1.16 | 3.72 | 2.04 |
|  | H2 | 78.25 | 64.87 | 94.01 | 76.04 | 79.04 | 65.49 | 78.75 | 78.42 | 76.72 | 87.63 | 84.80 |
|  | GA | 547.59 | 237.55 | 597.53 | 589.23 | 535.83 | 372.41 | 547.49 | 434.37 | 170.22 | 348.17 | 249.50 |
|  | GAM | 1001.08 | 362.12 | 13799.77 | 7742.83 | 4510.35 | 10732.28 | .5744.91 | 461.46 | 27904.92 | 35893.81 | 240.37 |
| 200Gy+0.5mM | GCV | 9.42 | 2.22 | 10.38 | 12.36 | 10.15 | 5.41 | 9.65 | 5.89 | 0.91 | 3.33 | 1.70 |
|  | PCV | 12.04 | 3.42 | 11.05 | 16.27 | 12.85 | 8.26 | 12.27 | 7.51 | 1.18 | 3.79 | 2.00 |
|  | H2 | 78.24 | 64.91 | 93.94 | 75.97 | 78.99 | 65.49 | 78.65 | 78.42 | 77.12 | 87.86 | 85.00 |
|  | GA | 559.25 | 247.28 | 643.28 | 631.25 | 583.29 | 387.73 | 567.53 | 442.70 | 172.57 | 352.35 | 247.63 |
|  | GAM | 1066.66 | 407.58 | 17246.11 | 9535.49 | 5832.90 | 12116.56 | 6412.77 | 488.25 | 28761.67 | 37089.47 | 233.90 |
| 400Gy+1.0mM | GCV | 12.29 | 2.56 | 11.84 | 14.29 | 11.89 | 6.35 | 10.98 | 7.07 | 0.93 | 3.68 | 1.67 |
|  | PCV | 15.71 | 3.95 | 12.61 | 18.79 | 15.06 | 9.69 | 13.96 | 9.02 | 1.19 | 4.19 | 1.97 |
|  | H2 | 78.23 | 64.81 | 93.89 | 76.05 | 78.95 | 65.53 | 78.65 | 78.38 | 78.15 | 87.83 | 84.77 |
|  | GA | 638.75 | 265.34 | 686.82 | 679.09 | 631.15 | 420.21 | 605.35 | 484.92 | 175.62 | 370.35 | 245.09 |
|  | GAM | 1590.12 | 505.12 | 21003.67 | 11851.48 | 7399.18 | 15392.31 | 7780.85 | 642.53 | 29766.10 | 43063.95 | 227.65 |
| 500Gy  +2.0mM | GCV | 16.49 | 3.18 | 14.89 | 16.81 | 13.97 | 7.22 | 13.89 | 8.77 | 0.98 | 4.00 | 1.66 |
|  | PCV | 21.07 | 4.91 | 15.86 | 22.12 | 17.69 | 11.02 | 17.66 | 11.19 | 1.26 | 4.56 | 1.95 |
|  | H2 | 78.26 | 64.77 | 93.88 | 75.99 | 78.97 | 65.52 | 78.65 | 78.37 | 77.78 | 87.72 | 85.13 |
|  | GA | 740.01 | 295.65 | 770.18 | 736.23 | 684.22 | 448.06 | 680.87 | 540.05 | 179.85 | 385.88 | 244.89 |
|  | GAM | 2470.82 | 699.43 | 29622.31 | 15117.66 | 9424.52 | 18669.17 | 11071.06 | 887.36 | 32116.07 | 48845.57 | 225.77 |
| N.B: PCV and GCV: 0 – 10 % = Low, 10 – 20 % = Moderate and >20 % = High H2: 0 – 30 % = Low, 30 – 60 % = Moderate and >60 % = High GA: 0 – 10 % = Low, 10 – 20 % = Moderate and >20 % = High | | | | | | | | | | | | |

**CONCLUSION**

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The synergistic effects of lower colchicine concentration (0.1 mM) and lower dose of gamma rays (100 Gy) improved the yield and seeds sizes in fonio. The LD50 and LC50 of the mutagens were fixed at 137 Gy+mM. Moderate to high heritability GA and GAM estimates were found in almost all the traits studied signifying the additive gene effects induced by the mutagens in controlling such traits indicating that selection for improvement might be effective.

**REFERENCES**

Adoukonou-Sagbadja H., Dansi A., Vodouhè R. and Akpagana K. (2006). Indigenous knowledge and traditional conservation of Fonio millet (*Digitaria exilis, D. iburua*) in Togo. *Biodiversity Conservation,* **15,** 2379-2395.

Aliero A.A. (2000). Genetic variability, correlation and pollen studies in Acha- *Digitaria exilis* (Kipp) Stapf. *Nigerian Journal of Basic and Applied Science*, **9,** 29-39.

Aliero A.A. and Morakinyo J.A. (2001). Characterization of *Digitaria exilis* (Kipp) Stapf and *D*. *iburua* Stapf. accessions. *Nigeria Journal of Genetics*, 1**6,** 10-21.

Aliero A.A. and Morakinyo J.A. (2005). Photoperiodism in *Digitaria exilis* (Kipp) Stapf accessions. *African Journal of Biotechnology*, **4 (3)** 241-243.

Balde N.M., Besancon S. and Sidibe T.A. (2008). P191 glycemic index Fonio (*Digitaria exilis*) interest in feeding in diabetic subjects in West Africa. *Diabetes Metabolism.* **34 (3)**, H93.

Barikmo I. and Ouattara F. (2004). *Food Composition Table for Mali*. Oslo. Norway: Institut National de Recherche en Sante´ Publique, Akershus University College.

Bhave K.G., Dalvi V.V., Thaware B.L., Mahadik S.G., Kasture M.C. and Desai S.S. (2016). Mutagenesis in Proso millet (*Panicum miliaceum* L.). *Int. J. of Sci. and Res*., **5 (3),** 1635-1638.

Chahal G.S. and Gosal S.S. (2014). *Principles and Procedures of Plant Breeding*. Oxford: Alpha Science International Ltd., 399-412 pp.

Chukwu O. and Abdul-kadir A.J. (2008). Proximate Chemical Composition of Acha (*Digitaria exilis* and *Digitaria iburua*) Grains. *J. Food Tech.*, **6 (5),** 214-216.

CIRAD/Centre for International Development. (2004). Fonio: An African cereal crop. *http//:www.cirad.fr/en*. Accessed 14th July, 2015.

Dachi S.N. and Barko S.N. (2003). Nigerian Cereal Research Institute Acha Programme. NCRI Annual Report. Badeggi: 85-90.

Deshmukh S.B., Bagade, A.B. and Choudhari A.K. (2018). Induced mutagenesis in rabi sorghum. *Int. J. Curr. Microbiol. App. Sci.,* Special Issue **6,** 766-771.

Finney D.J. (1978). Statistical Method in Biological Assay. Charles Griffin and Co. Gyang, J.D. and Wuyep, E.O. (2005). Acha: The grain of life. Raw Materials Update. *A Bi -annual publication of the Raw Materials Research and Development Council,* **6 (1),** 39-41.

Hemavathy A.T. (2015). Effect of gamma irradiation on seed germination and seedling growth of *Vigna radiata* (L. Hepper). *International Journal of Advanced Scientific and Technical Research*, **2 (5)** 155-158.

Hugar A. and Savithramma D.L. (2015). Genetic variability studies for yield and surrogate traits related to water use efﬁciency in the recombinant inbred line (RIL) population derived from NRCG 12568 x NRCG 12326 of groundnut (*Arachis hypogaea* L.). *Intl J. Agric Sci. Res.,* 5:321–328.

Ibrahim A. (2001). Hungry Rice (Fonio): A neglected cereal crop. *NAQAS Newsletter* **1 (4),** 4-5.

Ibrahim M.M. and Hussein R.M. (2006). Variability, heritability and genetic advance in some genotypes of Roselle (*Hibiscus sabdariffa* L.). *World J. Agric. Sci.*, **2(3),** 340-345.

Iglesias-Andreu, L.G., Octavio-Aguilar P. and Bello-Bello J. (2015). *Current Importance and Potential Use of Low Doses of Gamma Radiation in Forest Species*. http://[*www.intechopen.com*](http://www.intechopen.com). 263-280 pp. Retried July 7 th, 2016.

Islam M.R., Amin M.R., Kabir A.K.M.A. and Ahmed M.U. (2009). Comparative study between semi-intensive and scavenging production system on the performances of Black Bengal goat. *J. Bangle Agric Univ.,* **7 (1),** 79–86.

Jideani I.A. (1999). Traditional and possible technological uses of *Digitaria exilis* (Fonio)and *Digitaria iburua* (iburu): A review. *Plant Foods Human Nutri.*, **54,**  363-374.

Jideani I.A. and Jideani V.A. (2011). Developments on the cereal grains *Digitaria exilis*

(acha) and *Digitaria iburua* (iburu). *J. Food Sci. Tech.*, **48 (3),**  251-259.

Kara Y., Vaizoğullar H. and Kuru A. (2016). Gamma radiation effects on crude oil yield of some soybean seeds: Functional properties and chemical composition of *Glycine max*-ataem-7 seeds. *Trop. J. Pharm. Res.,* **15 (12),**  2579-2585.

Kate S.M., Desai S.S., Bhave S.G., Thorat B.S. and Bal, C.P. (2018). Mutagene induced variability in Proso millet (*Panicum miliaceum* L.). *Intl J. Chem. Studies*, **6 (5),** 13-16

Kim J., Chung B., Kim, J. and Wi S. (2005). Effects of in-planta gamma-irradiation on growth, photosynthesis and antioxidative capacity of red pepper (*Capsicum annuum* L.) plants. *J. Plant Biol.*, **48 (1),**  47-56.

Kuta D.D., Kwon-Ndung E., Dachi S., Bakare O. and Ogunkanmi L.A. (2005). Optimization of protocols for DNA extraction and RAPD analysis in West-African Fonio (*Digitaria exilis* and *Digitaria iburua*) germplasm characterization. *Afr. J. Biotech,* **4,** 1368-1371

Luckey, T. (1980). *Hormesis with ionizing radiations*. CRC press. Boca Raton, FLO, USA.

Luckey, T. (2003). Radiation for health. *Radio Protec. Mgt.*, **20**, 13-21.

Maji A.T., Dachi S.N. and Yisa J. (2003). Evaluation of Morphological variations within and between 10 Acha collection in NCRI accessions. NCRI Annual Report, 90-94.

Maji A.T., Dachi S.N. and Yisa J. (2005). Improvement of Acha accession at NCRI, Badeggi, NCRI Annual Report. 83-93.

Maluszynski M. (1990). Gene manipulation in plant improvement. Vol. 2. Mullainathan, L. and Ambli, K. (2015). Induced chlorophyll mutation in pearl millet (*Pennisetum typhoides* (burn) Stapf. Var. Co (cu)-9). *J. Chem. Biol. Phy. Sci.,* **5 (1),** 340-348.

Synergistic hormesis of combined gamma rays doses and colchicine concentrations in designing highyielding genotypes of fonio

National Agricultural Extension, Research and Liason Services/NAERLS. (2012). Crop Production Training Manual for Agriculture Extension Workers. The U.S. Agency for International Development (USAID). 1-37 pp.

Ogunbayo, S.A., Sie, M., Ojo, D.K., Sanni, K.A., Akinwale, M.G., Toulou, B., Shittu, A., Idehen, E.O., Papoola, A.R., Daniel, I.O. and Gregorio, G.B. (2014). Genetic variation and heritability of yield and related traits in promising rice genotypes (*Oryza sativa* L.). *J. Plant Breed. Crop Sci.*, **6 (11),** 153-159.

Olorunmaiye, K.S. and Aliero, A.A. (2000). Responses of some varieties of *Digitaria exili* (Kipp) Stapf to Imidazolinone herbicides. *Nig. J. Pure Appl. Sci.*, **15,** 1051-1054.

Philip, T.K. and Isaac, N.I. (2012). Demographic characteristics, agricultural and technological profile of acha Farmers in Nigeria. *Agric Engn. Intl. CIGR J.*, **14 (1),** 1-7.

Rajapandian, P. and Dhanam, S. (2017). Utilization of Physical and Chemical Mutagenesis on germination studies of sweet corn *Zea mays* (L.). *Intl. J. Res. Bot.*, **7 (1),**  1-5.

Ramchander, S., Ushakumari, R. and Arumugam, P. (2015). Lethal dose fixation and sensitivity of rice varieties to gamma radiation. *Indian J. Agric Res.*, **49 (1),**  24-31.

Ramesh, B., Prasad, B.K. and Singh, V.P. (2001). Semi dwarf, high yielding and high protein mutants in barley. *Mut. Breed. Newsl.*, **45,**  26-27.

SAS/Statistical Analysis Software (2008). SAS/STAT 9.1 User’s guide. SAS Institute Inc., NC.

Shrimali, J., Shekhawat, A.S. and Kumari, S. (2017). Genetic variation and heritability studies for yield and yield components in barley genotypes under normal and limited moisture conditions. *J. Pharmacognosy and Phytochem.*, **6 (4),**  233-235

Singh, R.K. and Chaudhary, B.D. (1985). *Biometrical methods in quantitative genetic*

*analysis*. Kalyani Publishers, New Delhi, Ludhiana, India. **1985,** 39-78.

Singh, B.D. (2011). *A text book of plant breeding*. Kalyani Publishers, New Delhi, 175-212.

Sulaiman A., Murtala N., Gital, I.A., Muhammad J.R. and Muhammmad B. (2015).

Economics of Acha production in Bauchi State, Nigeria. *Res J. Agric*, **2(12),**  1-10.

Suresh D., Poonguzhali S., Sridharan S. and Rajangam J. (2017). Determination of Lethal Dose for Gamma Rays Induced Mutagenesis in Butter Bean (*Phaseolus lunatus L*) Variety KKL-1. *Intl. J. Curr Microb. Appl. Sci.,* **6 (3),** 712-717.

Syukur M., Sujiprihati S. and Yunianti R. (2012). Teknik Pemuliaan Tanaman. Penebar Swadaya. Jakarta.

Ukwunguwu M.N., Bakare S.O., Kuta D.D. and Dachi, S.N. (2003). Evaluation of accessions of Acha in Badaggi. NCRI Annual Report: 148-157.

Umavathi S. and Mullainathan L. (2015). Physical and chemical induced mutagenesis study for identifying lethality dose in chick pea (*Cicerarietinum* L.) Var. Co–4. *Intl Lett.Nat. Sci.*, **35,** 1-5.

Usharani K.S., Ananda Kumar CR. and Vanniarajan C. (2017). Fixation of Lethal Dose 50 and effect of Mutagens in M1 Generation under Laboratory Condition. *Intl J. Curr. Microb. Appl Sci.,* **6 (7),**  1356-1365.

Vaiserman A. (2010). Hormesis, adaptive epigenetic reorganization, and implications for human health and longevity. *Dose Response*, **8 (1)**, 16–21.

Vietmeyer N.D., Borlaugh N.E., Axtell J., Burton G.W., Harlan J.R. and Rachie K.O.

(1996). Fonio (Acha). *In*: *Vietmeyer ND, editor. Lost Crops of Africa*. BOSTID, National Academic Press, Washington, DC, USA.

Vodouhe S.R., Zannou A. and Achigan Dako E. (2003). Actes du Premier Atelier sur la Diversité Génétique du Fonio (*Digitaria exilis*) en Afrique de l’Ouest. Conakry, Guinée, du 04 au 06 Août 1998. Institut International des Ressources Phytogénétiques (IPGRI), Rome, Italie.

Wani M.R., Kozgar M.I., Khan S. and Dar N.A. (2013). Induction of genetic variability Through artificial mutagenesis in Chickpea (*Cicer arietinum* L.). *Thai J. Agric. Sci.*, **46 (3),** 141-147.

Wolie A., Dessalegn T. and Belete K. (2013). Heritability, variance components and genetic advance of some yield and yield related traits in Ethiopian collections of finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes. *Afr. J. Biotech*, **12 (36),**  5529-5534.

Yadav A.K., Maan R.K., Kumar S. and Kumar P. (2011). Variability, heritability and genetic advance for quantitative characters in hexaploid wheat (*Triticum aestivum* L.). *E J. Plant Breed*, **2 (3),**  405-408.

Yadav A, Singh B. and Singh R. (2016). Response of gamma irradiation on plant growth and yield of maize. *Intl. J. Adv. Tech. in Eng. Sci.,* **4 (3),** 300.

Yohannes, T., Weldetsion, M., Abraha, N., Manyasa, E. and Abraha, T. (2015). Combine selection for earliness and yield in pedigree developed sorghum (*Sorghum bicolor* L. Moench) progenies in Eritrea. *J. Plant Breed. Genet.,* **3 (01),** 1-8.

Zaka R.; Chenal C. and Misset M. (2004). Effects of low doses of short-term gamma irradiation on growth and development through two generations of *Pisum sativum*. *Sci. Total Environ.*, **320,** 121-129.

Zeerak N.A. (1990). Induced morphological variants in Brinjal (*Solanum melongena* L.). *Phytomorphology*, **40 (3 and 4),** 251-256.

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**GENETICS OF WITCHWEED (*STRIGA HERMONTHICA* (DEL.) BENTH) RESISTANCE IN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH)**

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**ABSTRACT**

***Study on the genetics of witchweed (Strigahermonthica (Del.) Benth) resistance in sorghum (Sorghum bicolor (L) Moench) was conducted in a randomised complete block design experiment at the Institute for Agricultural Research Samaru, (Northern Guinea Savanna 110 11' N: 70 38' E, 686m) Zaria, Kaduna state, Nigeria. Five sorghum varieties: two Strigaresistant varieties (ICSR94405 and ICSR94407) and three susceptible varieties, (SAMSORG40, SAMSORG14 and SAMSORG17) were used for the study. The study was undertaken to determine the variability for resistance to Strigaand other agronomic traits in sorghum and to determine inheritance of resistance to Strigain sorghum. The resistant varieties used as male parents were crossed to the susceptible parents which were the females and F1, F2 and backcross populations were generated. The six populations: P1, P2, F1. F2, BCP1, and BCP2 were evaluated at IAR SamaruStrigasick plot in 2012. The result revealed highly significant difference among the genotypes for the traits studied. The result showed that additive gene action is more important for the inheritance of Strigaresistance in sorghum. Inheritance of resistance to Strigain the F2 populations involving the male parent: ICSR94407 is controlled by two dominant genes which are complementary, while in F2 populations involving*** *ICSR94405; it is* ***controlled in part by genes at two or more loci.***

**Keyword:** Witchweed, sorghum, hybrid, genetics, backcross, coefficient of variation, inheritance, resistance.

**INTRODUCTION**

Sorghum (*Sorghum bicolor* (L.) Moench) is a major cereal in the semi-arid tropics of sub-Saharan Africa. It belongs to the family Poaceae, and probably originated from south of the Sahara in Africa. It is an important world crop, used for food, fodder, production of alcoholic and non-alcoholic beverages, as well as biofuels. Some varieties are drought and heat tolerant, and are especially important in arid regions, where the grain is staple or one of the staples for the poor and rural people. It is the "fifth most important cereal crop grown in the world after rice, maize, wheat and barley" (Kuhlman *et al*., 2010). Nigeria’s annual production of sorghum was 6.8 million metric tons in 2011 (FAO, 2012) and 6.9 million metric tons in 2012 (FAO, 2013).

However, sorghum production is affected by both biotic and abiotic constraints. One of the major biotic constraints to sorghum production in sub-Sahara Africa is the parasitic flowering weeds of the genus *Striga*. This seriously limits cereal production in sub-Saharan Africa. Two out of three fields cropped with cereals are estimated to be infested by *Strigaspp* (Lagoke*et al*., 1991). Beside withdrawal of water, nutrient and assimilates, *S. hermonthica*damages its host by inducing enzyme and plant hormone changes, disrupting host-water relationships and carbon fixation (Press *et al*. 1996).

Heavy infestations by these notorious hemi parasites have caused farms to be abandoned and at times, migrations of farming communities (Lagoke*et al*., 1991). *Striga*has infested over 40% of arable land in sub-Saharan Africa (SSA) (Lagoke*et al.* 1991) and caused yield losses of up to 100% (Hassan *et al.* 1994). In Nigeria, *Striga*is infesting about 6.5 million hectares (out of 9.32million ha under sorghum), causing an estimated 35% yield loss (amounting to about 3.3million MT of sorghum yield loss annually (Obilana, 2011a). It is imperative that *Striga*populations be controlled so that they remain below the economic threshold.

The recommended control methods of *Striga*infestation include heavy application of nitrogen fertilizer, the use of trap crops and chemical stimulants to abort seed germination, hoeing and hand pulling, herbicide application and the use of resistant or tolerant crop varieties. None of these methods is effective on its own and most farmers have not accepted the methods to a great extent due to technological and socio-economic reasons. Chemical control of *Striga*is expensive and cannot be afforded by resource-poor farmers (Lagoke*et al.,* 1991).

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However, Mabasa (1996) indicated that resistant cultivars offer an economically feasible and culturally sustainable technology for smallholder farmers since they can be grown under conditions of erratic rainfall and low soil fertility and do not require additional cost and inputs. *Striga*-resistant cultivars should be a major component of integrated *Striga*control packages, since they effectively reduce *Striga*emergence, and enhance the efficiency of other control measures. Inadequate information on the genetics of *Striga*resistance and the difficulty of evaluating the trait in segregating progenies has limited the transfer of resistance into varieties better adapted to target areas (Vasudeva, 1985: Ejeta*et al*., 1992).

The knowledge of inheritance of resistance to *Striga,* variance components and genotypic performance will therefore be useful in developing *Striga*resistant cultivars or genotypes.

There is therefore a need for solutions to the menace that would ensure satisfactory increase in grain yield without requiring additional investment (Gbehounou and Adengo 2003; Rodenburg*et al*., 2005). Thus, this study was undertaken with the following objectives:

To study the genetics of *Striga*resistance in some sorghum varieties,determine variability for resistance to *Striga*and other agronomic traits in sorghum and determine the mode of inheritance of *Striga*resistance in sorghum

**MATERIALS AND METHODS**

**Description of the study site**

The research was conducted at Institute for Agricultural Research (IAR) Farm, Samaru (110 11' N: 70 38' E, 686m) in Northern Guinea Savanna of Nigeria in 2011/2012.

**Description of the plant materials**

The materials that were used in this study comprised three IAR sorghum varieties: SAMSORG14, SAMSORG17 and SAMSORG40; and two *Striga*resistant varieties from ICRISAT India: ICSR94405 and ICSR94407. The IAR sorghum varieties were obtained from the Institute for Agricultural Research (IAR) Cereal Research Program. These varieties were chosen because they are most commonly grown cultivars by the farmers within the sorghum production zone.

**The F1 hybrids**

In 2011 growing season, the parent seeds were sown in order to make crosses between *Striga*resistant varieties (males) and the IAR varieties (females) using factorial mating design. The IAR varieties that were used flowered at variable periods: SAMSORG14, 100 days, SAMSORG17, 110 to 120 days, and SAMSORG40, 80 days; while the *Striga*resistant varieties: ICSR94405 flowers at 70 days and ICSR94407, at 75 days. Staggered sowing of the genotypes was adopted in order to synchronize the flowering and subsequent pollination. There were four plots, designated June plot, and July plots. June plot consist of two plots; SAMSOG17 was sown first on one plot, while SAMSORG14 was sown ten days later on the second plot. The July plots were also two; ICR94405, ICR94407 and SMSORG 40 were sown on the same day on one plot; and five days later ICSR94405 and ICSR94407 were sown again on the second plot. All genotypes were sown in plots consisting of 10 rows of 5meters long, with spacing of 75cm between rows and 30cm between plants. All the agronomic practices which include thinning, weeding, fertilizer application and earthen up were observed. In the June plot, SAMSORG14 and SAMSORG17 used as female were hand pollinated with ICSR94405 and ICSR94407 as male. In the July plots SMSORG40 used as female was hand pollinated with ICSR94405 and ICSR94407 as male and all the genotypes were also selfed. Hand emasculation was also done to remove the anthers in order to prevent self-fertilization. The seeds were hand harvested and seeds from each cross and the selfed parents were threshed separately and kept in clearly labelled bags.

**The F2 populations**

In 2012 dry season (January to June), the F1 hybrids developed from crosses in 2011, together with their parental lines were sown in the IAR Samaru irrigation field. All the recommended agronomic practices were observed. At heading, the F1 panicles in every cross were covered with paper bag to ensure complete selfing. Seeds from the selfed plants in each cross were harvested threshed and kept in clearly labelled bags as F2 s.

**The Backcross**

From the same plots that were used to produce F2s seeds, before anthesis, the F1 plant’s heads were covered with paper bags to collect pollen. However, the parental lines were emasculated at anthesis. Then the F1 of each cross was backcrossed to their respective parents to generate BCP1and BCP2, (given twelve backcross populations); and this was done by hand pollination. At maturity, seeds developed from the plants were harvested and kept in labelled bags as backcross seeds.

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**Evaluation of Genetic populations**

The parentals, F1s, F2s and backcross populations (twenty nine genotypes) were sown in 2012 planting season at the IAR Samaru*Striga*sick plot.

The experiment was carried out using Randomized Complete Block Design (RCBD), with three replications. There were six treatments representing plant populations by a given cross: P1, P2, F1, F2, BCP1 and BCP2. Plot size for non-segregating populations (P1, P2, and F1) was 2 rows of 4m length and 75cm apart. And that of the segregating populations (F2, BCP1 and BCP2) was 5 rows of 4m length and 75cm apart. The intra-row spacing was 30cm in every plot. The plots were inoculated with *Striga*during sowing by putting 10ml of *Striga*mixed with fine sand in the hole where the sorghum seeds were sown. Recommended agronomic practices were observed.

**Data collection*.***

Data were collected on the following;

* Germination percentage: percentage of sorghum plants that germinated after two weeks of sowing.
* Days to 50% heading – days taken from sowing to when 50% of the plants in a plot had completed heading.
* Plant height – distance in centimeter from soil surface to tip of panicle at maturity.
* Panicle length – the distance in centimeter between inflorescence base to its tip at maturity.
* Panicle weight – the weight in grams of un-threshed single panicle after harvesting.
* Grain yield per plant – Grains separated from the panicle of each plant were weighed and the weight of the grains recorded and expressed in grams.
* 1000 grain weight – the weight in grams of 1000 randomly selected grains from individual plant.
* *Striga*count per plant at 12 weeks after sowing - the number of *Striga*that emerged on each plant at 12 weeks after sowing was recorded.
* *Striga*damage score – crop syndrome rating which reflect the damage caused to the host plant in reaction to *Striga*infestation was recorded. This was done using a scale of 0 to 9 rating (Sinebo and Drennan 2001).

**Statistical analysis**

The data was subjected to analysis of variance using generalized linear model procedure of SAS package (SAS, 2009). Analysis of variance (ANOVA) model for RCBD is

yij = µ + αi + βj + eij and i = 1…..a, j = 1…..b

Where:  
yij= An observation in treatment i and block jµ = The overall mean αi =The effect of treatment βj = The effect of block j eij = Random error with mean 0 and variance σ2 ɑ = The number of treatments; b = The number of blocks

**Coefficient of variation**

The coefficient of variation was calculated to measure the relative variability of given populations. Variance estimates have units attached to them. A common application of variance is the test to find out if one biological sample is more variable for one trait than for another. The coefficient of variation facilitates the comparison because it is unit free. The coefficient of variation (CV) is calculated as:

CV = x 100

where: S = Standard deviation, and = mean.

**Chi-square test**

A chi-square test was conducted to test the goodness of fit of the F2 population of the six crosses involving the resistant and susceptible parents, into the following segregation ratios: 3:1, 9:7, and 13:3 using the formula by (Little and Hill, 1978).

At (n - 1) df.

Where:

= chi-square value, O = Observed value, E = Expected value, n = Number of classes, df = Degrees of freedom and ∑ = summation.

Deviations were taken as non-significant wherever the calculated value is less than the table value at 5% level of significance and the ratio presumed was taken as showing good fit.

**RESULTS**

**Analysis of variance**

The analysis of variance showed significant differences among the genotypes (P < 0.01) for all the traits measured. However, Mean squares for replication were not significant for all the traits measured (Table 1).

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1:** Mean square for eight agronomic traits of sorghum grown in Samaru in 2012 | | | | | | | | | |
| Source of variation | Df | GP | HD | PH | GY/Plt | 1000GW | PaL | SDS | SC |
| Rep | 2 | 15.53 | 0.84 | 0.56 | 0.42 | 1.42 | 0.54 | 0.92 | 0.05 |
| Genotype | 28 | 233.78\*\* | 113.03\*\* | 1813.86\*\* | 331.73\*\* | 55.51\*\* | 40.35\*\* | 27.26\*\* | 3.69\*\* |
| Error | 56 | 14.03 | 0.63 | 0.59 | 0.18 | 4.92 | 0.63 | 0.41 | 0.05 |
| \*\* Highly significant at 1 percent level of significant, GP: Germination percentage, HD: Days to 50% heading, PH: Plant height, GY/Plt: Grain yield per plant, 1000GW: 1000 grain weight, PaL: Panicle length, SDS: *Striga*damage score, SC: *Striga*count per plant. | | | | | | | | | |

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**Means, ranges and coefficient of variation**

The performances of various generations of the six crosses involving two *Striga*resistant parents and three IAR released varieties are presented in Table 2 below.

**Plant height.**

For the cross between SAMSORG14 and ICSR94405(SAMSORG14 x ICSR94405), the resistant parent, ICSR94405 had a mean height of 170.20cm and a range between 145cm and 200cm. SAMSORG14 had a mean of 200.70cm with a range between 157cm and 260cm. The F1 hybrid had a mean of 188.47cm with a range between 180 and 263cm. The F1 mean was a bit higher than the mid-parent (185.45). There was high level of segregation among the F2 population with the range of the F2 being outside the parental range (139 – 304) couple with the CV of 28.36% and mean height of 210.11cm. Mean Plant height for the backcrosses, BCP1 and BCP2 were 173.94 and 207.29, respectively.

In the second cross: SAMSORG17 x ICSR94405, SAMSORG17 had a mean plant height of 180.00cm. The F1 generation from this cross had a mean plant height of 179.87cm, higher than the mid-parental value (175.10cm). F2 population had a range from 136cm to 231cm with mean of 184.81cm and CV of 15.95%. The BCP1and BCP2 had mean values of 170.50cm and 184.56cm, respectively.

In the cross between SAMSORG40 x ICSR94405, SAMSORG40 had a mean plant height of 156.33cm, with the range of 137cm -167cm. The F1 mean was 167.00cm higher than the mid-parental mean (163.26cm), and the F2 ranges from 130cm - 210cm with mean plant height of 170.67cm and CV of 12.93%. The BCP1 and BCP2 had mean values of 160.50cm and 161.56cm, respectively.

In crosses involving ICSR94407 as the resistant parent, ICSR94407 had a mean plant height of 155.73cm.The F1 hybrid of SAMSORG14 x ICSR94407 had a mean height of 180.5cm. The F2 population had a mean height of 204.64cm with a range of (135-281cm) and CV of 23.42%. Mean Plant height for the backcrosses BCP1 and BCP2 were 160.31cm and 217.82cm, respectively.

In the second cross: SAMSORG17 x ICSR94407, the F1 hybrids had a mean plant height of 170.13cm, the F2 population had a range from 127cm to 225cm with mean of 166.68cm and CV of 12.67%. The BCP1and BCP2 had mean values of 157.08cm and 176.59cm, respectively.

In SAMSORG40 x ICSR94407, the mean height of the F1s was 157.57cm, similar to the mid parent mean (156.03cm). The F2 had a mean height of 170.67cm with a range of 130cm to 210cm and CV of 14.82%. The BCP1and BCP2 had mean height of 157.08cm and 176.59cm, respectively.

**Panicle length.**

In all the crosses, the mean panicle lengths of the susceptible parents are higher than that of the resistant parent. The mean panicle length for the susceptible parents varied from 27.77cm for SAMSORG40 to 30.35cm for SAMSORG14. Those of the resistant parents were 20.96 and 22.82 for ICSR94405 and ICSR94407, respectively. Mean Panicle length of the F1 hybrids in the first cross (SAMSORG14 x ICSR94405) was 34.25cm, higher than the mid parent mean (25.66cm). The F2 population had mean panicle length of 33.76cm, range from 24cm to 40cm and CV of 13.01%. The backcrosses, BCP1 and BCP2 had mean panicle length of 25.98cm and 29.04cm, respectively.

In SAMSORG17 x ICSR94405, the F1 had mean panicle length of 27.02cm; the F2 had mean panicle length of 24.15cm, range from 19cm to 39cm and CV of 15.84%. BCP1 and BCP2 had mean panicle length of 23.09cm and 31.32cm, respectively. F1 (SAMSORG40 x ICSR94405) recorded mean panicle length of 25.59cm; the F2 had mean panicle length of 26.12cm, range of 19cm-31cm and CV of 10.98%. The BCP1 and BCP2 population recorded mean panicle length of 22.69cm and 27.98cm, respectively. For the crosses involving ICSR94407, the resistant parent ICSR94407 had mean panicle length of 22.82cm. The F1 (SAMSORG14 x ICSR94407) recorded mean panicle length of 34.19cm a bit higher than the mid parent mean (26.59cm). The F2 had mean panicle length of 31.10cm, range of 25cm-44cm and CV of 14.68%. BCP1 and BCP2 had mean panicle length of 23.99cm and 31.34cm, respectively.

In the cross between SAMSORG17 and ICSR94407, the F1 had mean panicle length of 28.42. The F2 had mean of 27.28cm, range of 22cm-38cm and CV of 18.35%. BCP1 and BCP2 had mean value of 23.23cm and 29.75cm, respectively.

In SAMSORG40 x ICSR94407, the F1 had mean panicle length value of 26.43cm. F2 population had mean panicle length of 23.92cm, range of 19cm-36cm and CV of 14.48%. The BCP1 and BCP2 recorded mean panicle length of 24.63cm and 27.21cm, respectively.

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**Panicle weight.**

Mean values for panicle weight varied from 82.62g (SAMSORG40) to 118.09g (SAMSORG17), then 76.43g and 81.90g for ICSR94405 and ICSR94407 respectively. In the six crosses, the mean values for the F1 hybrids varied from 80.77g (SAMSORG40 x ICSR94405) to 107.23g (SAMSORG17 x ICSR94407). The F2 population had a wide range of segregation. The mean panicle weight for the F2 population in the six crosses varied from 83.35g (SAMSORG40 x ICSR94405) to 121.31g (SAMSORG17 x ICSR94407), the CV range from 18.67% (SAMSORG17 x ICSR94407) to 40.74% (SAMSORG14 x ICSR94405). Mean panicle weight for BCP1varied from 78.32g [ICSR94407 x (SAMSORG40 x ICSR94407)] to 85.92g [ICSR94407 x (SAMSORG17 x ICSR94407)] and that of BCP2 varies from 80.19g [SAMSORG40 x (SAMSORG40 x ICSR94407)] to 120.26g [SAMSORG17 x (SAMSORG17 x ICSR94407)].

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| **Table 2:** Range, mean and CV of plant height, panicle length and panicle weight of the parents, F1, F2 and backcross populations of six sorghum crosses evaluated under Strigainfestation at IAR SamaruStrigasick plot in 2012. | | | | | | | | | | | | |
| Generation/Cross | Plant height (cm) | | | Panicle length (cm) | | | | Panicle weight/plant (g) | | | | |
| |  | | --- | | Range | | Mean | CV | |  | | --- | | Range | | | |  | | --- | | Mean | | CV | |  | | --- | | Range | | | |  | | --- | | Mean | | | CV |
| SAMSORG14 x ICSR94405 | | | | | | | | | | | | |
| ICSR94405 | 145-200 | 170.20 | 10.89 | 19-27 | | 20.96 | 8.69 | 50-108 | | 76.43 | | 10.25 |
| SAMSORG14 | 157-260 | 200.70 | 10.98 | 25-36 | | 30.35 | 9.22 | 60-120 | | 113.03 | | 12.96 |
| F1 | 180 – 263 | 188.47 | 11.29 | 28-44 | | 34.25 | 11.48 | 88-112 | | 100.52 | | 16.44 |
| F2 | 139 -304 | 210.11 | 28.36 | 24-40 | | 33.76 | 13.01 | 78-126 | | 103.19 | | 40.74 |
| BCP1 | 130 -220 | 173.94 | 28.32 | 20-34 | | 25.98 | 10.30 | 45-111 | | 87.40 | | 40.87 |
| BCP2 | 143 – 242 | 207.29 | 16.47 | 25-37 | | 29.04 | 11.63 | 48-124 | | 118.64 | | 28.52 |
| Table 2 Continued. | | | | | | | | | | | | |
| Generation/Cross | Plant height (cm) | | | Panicle length (cm) | | | | Panicle weight/plant (g) | | | | |
| |  | | --- | | Range | | Mean | CV | |  | | --- | | Range | | | |  | | --- | | Mean | | CV | |  | | --- | | Range | | | |  | | --- | | Mean | | | CV |
| SAMSORG 17XICSR94405 | | | | | | | | | | | | |
| ICSR94405 | 145 – 200 | 170.20 | 10.89 | 19-27 | | 20.96 | 8.69 | 50-108 | | 76.43 | | 10.25 |
| SAMSORG17 | 140 – 190 | 180.00 | 8.26 | 22-36 | | 29.07 | 8.04 | 79-129 | | 118.09 | | 10.91 |
| F1 | 150 – 246 | 179.87 | 10.60 | 25-31 | | 27.02 | 6.21 | 71-125 | | 100.75 | | 15.28 |
| F2 | 136 – 231 | 184.81 | 15.95 | 19-39 | | 24.15 | 15.84 | 42-131 | | 105.21 | | 25.48 |
| BCP1 | 120 – 221 | 170.50 | 13.89 | 18-31 | | 23.09 | 11.99 | 44-108 | | 79.56 | | 22.66 |
| BCP2 | 130 – 218 | 184.56 | 13.73 | 21-38 | | 31.32 | 12.97 | 63-112 | | 110.45 | | 23.72 |
| SAMSORG40 x ICSR94405 | | | | | | | | | | | | |
| ICSR94405 | 145 – 200 | 170.20 | 10.89 | 19-27 | | 20.96 | 8.69 | 50-108 | | 76.43 | | 10.25 |
| SAMSORG40 | 137 – 167 | 156.33 | 6.62 | 24-32 | | 27.77 | 7.14 | 57-111 | | 82.62 | | 12.26 |
| F1 | 155 – 180 | 167.00 | 4.20 | 21-29 | | 25.59 | 8.82 | 61-117 | | 80.77 | | 15.51 |
| F2 | 130 – 210 | 170.67 | 12.93 | 19-31 | | 26.12 | 10.98 | 36-123 | | 83.35 | | 23.89 |
| BCP1 | 121 -231 | 160.50 | 14.11 | 19-29 | | 22.69 | 9.82 | 35-117 | | 79.31 | | 20.33 |
| BCP2 | 127 – 208 | 161.56 | 12.63 | 21-32 | | 27.98 | 10.10 | 33-102 | | 80.19 | | 21.92 |
| SAMSORG14 x ICSR94407 | | | | | | | | | | | | |
| ICSR94407 | 140 – 170 | 155.73 | 6.11 | | 20-27 | 22.82 | 8.97 | 60-95 | | 81.90 | | 10.25 |
| SAMSORG14 | 157 – 260 | 200.70 | 10.98 | | 25-36 | 30.35 | 9.22 | 60-120 | | 113.03 | | 12.96 |
| F1 | 167 – 221 | 180.50 | 13.58 | | 25-40 | 34.19 | 11.65 | 84-130 | | 102.30 | | 13.74 |
| F2 | 135 – 281 | 204.64 | 23.42 | | 25-44 | 31.10 | 14.68 | 53-134 | | 119.95 | | 35.66 |
| BCP1 | 120 – 231 | 160.31 | 22.91 | | 19-30 | 23.99 | 11.82 | 30-115 | | 82.85 | | 33.41 |
| BCP2 | 155 – 271 | 217.82 | 11.75 | | 22-39 | 31.34 | 11.42 | 87-124 | | 112.26 | | 16.68 |
| SAMSORG17 x ICSR94407 | | | | | | | | | | | | |
| ICSR94407 | 140 -170 | 155.73 | 6.11 | | 20-27 | 22.82 | 8.97 | | 60-95 | | |  |  | | --- | --- | | 81.90 |  | | 10.25 |
| SAMSORG17 | 140 -190 | 180.00 | 8.26 | | 22-36 | 29.07 | 8.04 | | 79-129 | | 118.09 | 10.91 |
| F1 | 150 - 180 | 170.13 | 8.48 | | 22-34 | 28.42 | 10.82 | | 86-133 | | 107.23 | 11.94 |
| F2 | 127 - 215 | 166.68 | 12.67 | | 22-38 | 27.28 | 18.35 | | 57-135 | | 121.31 | 18.67 |
| BCP1 | 136 - 190 | 157.08 | 6.48 | | 19-29 | 23.23 | 14.14 | | 58-109 | | 85.92 | 15.46 |
| BCP2 | 147 - 209 | 176 59 | 8.52 | | 26-34 | 29.75 | 16.29 | | 61-115 | | 120.15 | 14.42 |
| SAMSORG40 x ICSR94407 | | | | | | | | | | | | |
| ICSR94407 | 140 - 170 | 155.73 | 6.11 | | 20-27 | 22.82 | 8.97 | | 60-95 | | 81.90 | 10.25 |
| SAMSORG40 | 137 - 167 | 156.33 | 6.62 | | 24-32 | 27.77 | 7.14 | | 57-111 | | 82.62 | 12.26 |
| F1 | 140 - 167 | 157.57 | 5.19 | | 20-30 | 26.43 | 10.32 | | 60-104 | | 84.84 | 11.64 |
| F2 | 130 - 210 | 170.67 | 14.82 | | 19-36 | 23.92 | 14.48 | | 42-114 | | 88.80 | 20.71 |
| BCP1 | 122 - 195 | 160.21 | 10.98 | | 21-32 | 24.63 | 12.11 | | 46-103 | | 78.32 | 18.74 |
| BCP2 | 125 - 185 | 161.94 | 10.67 | | 24-34 | 27.21 | 11.90 | | 49-96 | | 80.10 | 18.57 |

**Grain yield**

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As shown in table 3, mean values for grain yield per plant, ranges from 75.73g (SAMSORG40) to 110.93g (SAMSORG17) and 67.97g (ICSR94405) to 78.33cm (ICSR94407). The F1 means ranges from 73.40g (SAMSORG40 x ICSR94405) to 96.10g (SAMSORG17 x ICSR94407) in all the crosses. F2 means for grain yield per plant ranges from 77.84g (SAMSORG40 x ICSR94407) to 117.29g (SAMSORG17 x ICSR94407). The CV varied from 12.74% (SAMSORG40 x ICSR94407) to 28.55% (SAMSORG14 x ICSR94405). There were high ranges of segregation among the F2 populations as shown in the CV. Mean grain yield per plant for BCP1 in all the crosses varied from 73.65g [ICSR94405 x (SAMSORG17 x ICSR94407)] to 84.73g [ICSR94407 x (SAMSORG14 x ICSR94407)], while that of BCP2 varied from 76.44g [SAMSORG40 x (SAMSORG40 x ICSR94407)] to 110.33g [SAMSORG17 x (SAMSORG17 x ICSR94407)].

**Grain weight (1000)**

SAMSORG14, SMSORG17 and SAMSORG40 had mean values of 34.04g, 39.35g and 27.71g with range of 30g - 36g, 38g – 42g and 27g -30g and CV of 6.64%, 3.29% and 6.12%, respectively, while the resistant parents had mean values of 22.48g and 21.83g with range of 20 – 27g and 20g - 24g and CV of 7.62% and 5.54% for ICSR94405 and ICSR94407 respectively. In the cross between SAMSORG14 and ICSR94405 the F1 means was 30.62g, with the range of 30g -34g and CV of 4.28%. The F2 had a mean of 28.14g, with range of 20g – 30g and CV of 13.47. Mean, range and CV for BCP1 in the same cross were: 25.71g, 23g-29g and 9.77%, respectively and BCP2 had mean, range and CV of 38.01g, 35g – 41g and 11.41%, respectively.

For the second cross; SAMSORG17 x ICSR94405, the F1 had the mean 1000 grain weight of 32.03g, with range of 29g – 36g and CV of 8.06%. The F2 recorded mean 1000 grain weight of 30.31g, range of 21g – 37g and CV of 13.74%. BC1P1 mean was 22.67g with CV of 12.67% and range of 21g- 26g, while BC1P2 of the same cross had mean of 34.45g, CV of 10.10% and range of 20g – 38g. Cross between SAMSORG40 and ICSR94405 had F1 mean, range, and CV values for the trait to be 27.68g, 26g – 32g and 8.85%, respectively and the F2 mean was 25.67g, with the range of 25g-37g and CV of 15.96%. Also the BCP1 mean, range and CV of the trait were 24.99g, 22g-29g and 10.74%, respectively. BCP2 of the same cross had mean, range and CV of 26.35g, 24g – 32g and 12.61%, respectively.

Cross of SAMSORG14 and ICSR94407 had F1 mean, range and CV values for 1000 grain weight to be 29.01g, 32g – 35g and 9.62%. The F2 mean was 29.34g, with range of 27g – 38g and CV of 16.45%. BCP1 had mean, range and CV of 25.66g, 26g-31g and 11.17%, respectively and BCP2 of the same cross had mean, range and CV of 30.69g, 29g – 34g and 13.16%, respectively.

For SAMSORG17 X ICSR94407 cross, the F1 mean was 31.28g with the range of 31g – 34g and CV of 2.24%. The F2 had mean, range and CV of 26.35g, 23g – 29g and 10.02%, respectively. BCP1 mean for the trait was 22.70g with CV of 9.37% and range of 21g - 27g and BCP2 of the same cross had mean of 35.35g, CV of 6.54% and range of 28g – 39g.

SAMSORG40 x ICSR94407 had F1 mean, ranges and CV values for the same trait to be 26.96g, 26g – 30g and 5.83%. The F2 mean was 24.67g, with range of 22g – 29g and CV of 10.18%. BCP1 mean was 25.97g with CV of 8.53% and range of 23g-30g and BCP2 of the same cross had mean of 30.02g, CV of 9.54 and range of 26g – 33g.

**Striga count.**

In the six crosses, ICSR94405 and ICSR94407 were resistant, with mean *Striga*count value: 0.03 for ICSR94405 (only one *Striga*emerged) and 0 for ICSR94407 (no *Striga*emergence). Meanwhile SAMSORG14 and SAMSORG40 were susceptible to *Striga,* with mean *Sriga*count value of 3.13 and 4.53 and the range of 2-6 and 2-7 respectively. SAMSORG17 was tolerant with mean *Striga*count of 1.13, range of 0 – 4 and CV of 6.51%. The F1 of the cross between SAMSORG14 and ICSR94405 had a mean *Striga*count value of 0.97, range of 0-3 and CV of 9.12%. The F2 had a mean of 1.18, range of 0-5 and CV of 24.20%. BCP1 of the same cross had mean value of 0.39, range of 0-4 and CV of 16.34%, while the BCP2 had mean of 2.05, range of 0-5 and CV of 13.40%.

In the cross between SAMSORG17 x ICSR94405, the F1 had mean *Striga*count value of 0.70, range of 0-3 and CV of 11.34%. The F2 had a mean of 1.03 and range of 0-5 and CV of 24.10%. BCP1 of the same cross had mean value of 0.62, range of 0-3 and CV of 16.23%., while the BC1P2 had mean *Striga*count of 1.13, range of 0-4 and CV of 12.56%.

The cross of SAMSORG40 x ICSR94405 had F1 mean *Striga*count value of 1.06, with the range of 0-3 and CV of 9.42%. The F2 had a mean of 1.17 with the range of 0-5 and CV of 18.73%. BCP1 of the same cross had mean value of 0.30, with range of 0-4 and CV of 12.33%, while the BCP2 had mean of 3.75, range of 0-5 and CV of 10.62%.

In the cross between SAMSORG14 x ICSR94407, the F1 had mean *Striga*count value of 0.90 with range of 0-3 and CV of 10.44%. The F2 had a mean of 1.25, with range of 0-4 and CV of 25.11%. BCP1 of the same cross had mean value of 0.36, with range of 0-3 and CV of 15.30%, while the BCP2 had mean of 1.92, range of 0-5 and CV of 16.18%.

The cross of SAMSORG17 x ICSR94407 had F1 mean *Striga*count value of 0.63, with the range of 0-3 and CV of 11.71%. The F2 had a mean of 0.99, range of 0-5 and CV of 21.33%. BCP1 of the same cross had mean value of 0.60, with range of 0-3 and CV of 16.61% while the BCP2 had mean of 1.12, with range of 0-4 and CV of 14.21%.

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Finally, in the cross between SAMSORG40 x ICSR94407, the F1 had mean *Striga*count value of 1.00, with range of 0-3 and CV of 9.50%. The F2 had a mean of 1.16 with range of 0-5 and CV of 19.43%. BCP1 of the same cross had mean value of 0.29, range of 0-4 and CV of 13.94%, while the BCP2 had mean of 3.01, range of 0-5 and CV of 11.41%.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3**.Range, mean and CV of grain yield/ plant, 1000 grain weight and Striga count of the parents, F1, F2 and backcross populations of six sorghum crosses evaluated under Striga infestation at IAR SamaruStriga sick plot in 2012. | | | | | | | | | | | | | |
| Generation/Crosses | Grain yield/plant (g) | | | 1000 Grain weight (g) | | | | | *Striga*count/plt | | | | |
| |  | | --- | | Range | | |  | | --- | | Mean | | CV | |  | | --- | | Range | | |  | | --- | | Mean | | CV | | |  | | --- | | Range | | | |  | | --- | | Mean | | | **CV** | |
| SAMSORG14 x ICSR94405 | | | | | | | | | | | | | |
| ICSR94405 | 45 – 100 | 70.97 | 11.85 | 20-27 | 22.48 | 7.62 | | 0-1 | | 0.03 | | - | |
| SAMSORG14 | 54 – 111 | 102.1 | 9.34 | 30-36 | 34.04 | 6.64 | | 2-6 | | 3.13 | | 6.51 | |
| F1 | 78 – 101 | 91.47 | 10.39 | 30-34 | 30.62 | 4.28 | | 0-3 | | 0.97 | | 9.12 | |
| F2 | 65 – 113 | 94.77 | 28.55 | 20-30 | 28.14 | 13.47 | | 0-5 | | 1.18 | | 24.20 | |
| BCP1 | 40 – 107 | 78.75 | 27.55 | 23-29 | 25.71 | 9.77 | | 0-4 | | 0.39 | | 16.34 | |
| BCP2 | 42 – 118 | 108.78 | 17.90 | 35-41 | 38.01 | 11.41 | | 0-5 | | 2.05 | | 13.40 | |
| SAMSORG17 x ICSR94405 | | | | | | | | | | | | | |
| ICSR94405 | 45 – 100 | 70.97 | 11.85 | 20-27 | 22.48 | 7.62 | | 0-1 | | 0.03 | | - | |
| SAMSORG17 | 68 – 120 | 110.93 | 8.94 | 38-42 | 39.35 | 3.29 | | 0-4 | | 1.13 | | 6.56 | |
| F1 | 62 – 114 | 93.80 | 11.04 | 29-36 | 32.03 | 8.06 | | 0-3 | | 0.70 | | 11.34 | |
| F2 | 37 – 120 | 97.36 | 14.96 | 21-37 | 30.31 | 13.74 | | 0-5 | | 1.03 | | 24.10 | |
| BCP1 | 36 – 94 | 73.65 | 12.07 | 21-26 | 22.67 | 12.67 | | 0-3 | | 0.62 | | 16.23 | |
| BCP2 | 43 – 122 | 112.13 | 13.97 | 20-38 | 34.45 | 10.10 | | 0-4 | | 1.13 | | 12.56 | |
| SAMSORG40 x ICSR94405 | | | | | | | | | | | | | |
| ICSR94405 | 45 – 100 | 70.97 | 8.85 | 20-27 | 22.48 | | 7.62 | | 0-1 | | 0.03 | | - |
| SAMSORG40 | 50 – 105 | 75.73 | 6.67 | 27-30 | 27.71 | | 6.12 | | 2-7 | | 4.53 | | 7.30 |
| F1 | 55 – 107 | 73.40 | 4.31 | 26-32 | 27.68 | | 8.85 | | 0-3 | | 1.06 | | 9.42 |
| F2 | 31 – 117 | 78.59 | 14.83 | 25-37 | 25.67 | | 15.96 | | 0-5 | | 1.17 | | 18.73 |
| BCP1 | 37 – 92 | 69.49 | 12.47 | 22-29 | 24.99 | | 10.74 | | 0-4 | | 0.30 | | 12.33 |
| BCP2 | 43-107 | 75.85 | 13.11 | 24-32 | 26.35 | | 12.61 | | 0-5 | | 3.75 | | 10.62 |

***Table 3 continued***

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Generation/Crosses** | **Grain yield/plant (g)** | | | **1000 Grain weight (g)** | | | ***Striga*count/plt** | | |
| |  | | --- | | **Range** | | |  | | --- | | **Mean** | | **CV** | |  | | --- | | **Range** | | |  | | --- | | **Mean** | | **CV** | |  | | --- | | **Range** | | |  | | --- | | **Mean** | | **CV** |
| SAMSORG14 x ICSR94407 | | | | | | | | | |
| ICSR94407 | 53 – 82 | 78.33 | 5.55 | 20-24 | 23.83 | 5.54 | 0 | 0.00 | - |
| SAMSORG14 | 54 – 111 | 102.10 | 9.34 | 30-36 | 34.04 | 6.64 | 2-6 | 3.13 | 6.51 |
| F1 | 80 – 124 | 91.40 | 4.23 | 32-35 | 29.01 | 9.62 | 0-3 | 0.90 | 10.44 |
| F2 | 49 -128 | 108.93 | 23.24 | 27-38 | 29.34 | 16.45 | 0-4 | 1.25 | 25.11 |
| BCP1 | 27 – 110 | 84.73 | 22.89 | 26-31 | 25.66 | 11.17 | 0-3 | 0.36 | 15.30 |
| BCP2 | 80 – 118 | 99.82 | 11.67 | 29-34 | 30.69 | 13.16 | 0-5 | 2.92 | 16.18 |
| SAMSORG17 x ICSR94407 | | | | | | | | | |
| ICSR94407 | 53 – 82 | 78.33 | 5.55 | 20-24 | 23.83 | 5.54 | 0 | 0.00 | - |
| SAMSORG17 | 68 – 120 | 110.93 | 8.94 | 38-42 | 39.35 | 3.29 | 0-4 | 1.13 | 6.56 |
| F1 | 79 -126 | 96.10 | 6.23 | 31-34 | 31.28 | 2.24 | 0-3 | 0.63 | 11.71 |
| F2 | 53 – 129 | 117.29 | 18.91 | 23-29 | 26.35 | 10.02 | 0-4 | 0.99 | 21.33 |
| BCP1 | 53 – 98 | 80.63 | 16.67 | 21-27 | 22.70 | 9.37 | 0-3 | 0.60 | 16.61 |
| BCP2 | 55 – 106 | 110.33 | 10.05 | 28-39 | 35.35 | 6.54 | 0-4 | 1.22 | 14.21 |
| SAMSORG40 x ICSR94407 | | | | | | | | | |
| ICSR94407 | 53 – 82 | 78.33 | 5.55 | 20-24 | 23.83 | 5.54 | 0 | 0.00 | - |
| ICSR94407 | 50 – 105 | 75.73 | 6.67 | 27-30 | 27.71 | 2.14 | 2-7 | 4.53 | 7.30 |
| F1 | 54 – 98 | 79.87 | 5.51 | 26-30 | 26.96 | 5.83 | 0-3 | 1.00 | 9.50 |
| F2 | 34 – 105 | 77.84 | 12.74 | 22-29 | 24.67 | 10.18 | 0-5 | 1.16 | 19.43 |
| BCP1 | 36 – 99 | 78.71 | 11.23 | 23-30 | 25.97 | 8.53 | 0-4 | 0.29 | 13.94 |
| BCP2 | 32 – 85 | 76.44 | 10.56 | 26-33 | 30.02 | 9.54 | 0-6 | 3.01 | 11.41 |
| CV = Coefficient of Variation | | | | | | | | | |

**Segregation Ratios and Chi-square for Striga Damage Score.**

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Table 5 shows mean *Striga* damage score, range and segregation in F2 and backcross populations. Plants with scores of 0 to 4 were considered resistant, while plants with score 5 to 9 were considered susceptible (Sinebo and Drennan, 2001). The female parents had mean damage score of 6.6, 5.3, and 6.4, and range of 5-9, 5-6, and 5-8 for SAMSORG14, SAMSORG17 and SAMSORG40, respectively, while the mean damage score for the male parents were 1.2 and 0.9 with range of 0-3, and 0-2 for ICSR94405 and ICSR94407, respectively. The F1 populations had the following means: 1.4, 1.1, 1.3, 1.3, 0.8, and 1.0 for SAMSORG14 x ICSR94405, SAMSORG17 x ICSR94405, SAMSORG40 x ICSR94405, SAMSORG14 x ICSR94407, SAMSORG17 x ICSR94407 and SAMSORG40 x ICSR94407, respectively. In the F2 population the chi-square values at expected segregation ratio 3:1 (resistant: susceptible) are significant in all the crosses. The expected ratio 9:7 is significant in F2 of three crosses involving the resistant parent: ICSR94405 but not significant in the three crosses involving the resistant parent: ICSR94407. Similarly significant chi-square values were obtained in three crosses involving ICSR94407 at the expected segregation ratio 13:3, while the F2 of three crosses involving ICSR94405 were not significant.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4** continued. | | | | | | | | |
| Cross | Parent and  Progeny | Mean SDS and Range | Observed | Total | Expected Ratio |  | df | P(0.05) |
|  |  |  | **R S** |  |  |  |  |  |
| ICSR94407X SAMSORG14 | P1(ICSR94407) | 0.9 (0-2) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG14) | 6.6 (5-9) | 30 0 | 30 | 0:1 |  |  |  |
|  | F1 | 1.3 (0-3) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 2.5 (0-9) | 93 57 | 150 | 9:7 | 2.19 | 1 | 0.14NS |
|  | BCP1 | 1.4 (0-4) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 2.4 (0-9) | 77 73 | 150 | 1:1 | 0.11 | 1 | 0.74NS |
| ICSR94407 X SAMSORG17 | P1 (ICSR94407) | 0.9 (0-2) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG17) | 5.3 (5-6) | 30 0 | 30 | 0:1 |  |  |  |
|  | F1 | 0.8 (0-2) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 2.3 (0-6) | 94 56 | 150 | 9:7 | 2.71 | 1 | 0.10NS |
|  | BCP1 | 1.0 (0-4) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 2.5 (0-9) | 75 75 | 150 | 1:1 | 0.00 | 1 | 1.00NS |
| ICSR94407 X SAMSORG40 | P1 (ICSR94407) | 0.9 (0-2) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG40) | 6.4 (5-8) | 30 0 | 30 | 0:1 |  |  |  |
|  | F1 | 1.0 (0-4) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 2.4 (0-8) | 95 55 | 150 | 9:7 | 3.27 | 1 | 3.27NS |
|  | BCP1 | 1.2 (0-4) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 2.2 (0-8) | 79 71 | 150 | 1:1 | 0.43 | 1 | 0.51NS |
| -\* Highly significant at 1% level of significant, \* Significant at 5% level of significant, R = resistant  S = susceptible | | | | | | | | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4:** mean *Striga* damage score, range and segregation ratio for*Striga*resistance among parents and their F1, F2 and backcrosses | | | | | | | | |
|  | Parent and Progeny | Mean SDS and Range | Observed R S | Total | Expected Ratio |  | Df | P(0.05) |
| ICSR94405 X SAMSORG14 | P1 (ICSR94405) | 1.2 (0-3) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG14) | 6.6 (5-9) | 0 30 | 30 | 0:1 |  |  |  |
|  | F1 | 1.4 (0-4) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 2.1 (0-9) | 126 24 | 150 | 13:3 | 0.88 | 1 | 0.35NS |
|  | BCP1 | 1.5 (0-4) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 2.0 (0-9) | 112 38 | 150 | 3:1 | 0.01 | 1 | 0.92NS |
| ICSR94405 X SAMSORG17 | P1(ICSR94405) | 1.2 (0-3) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG17) | 5.3 (5-6) | 0 30 | 30 | 0:1 |  |  |  |
|  | F1 | 1.1 (0-3) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 1.6 (0-7) | 130 20 | 150 | 13:3 | 3.13 | 1 | 0.08NS |
|  | BCP1 | 1.3 (0-4) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 1.6 (0-9) | 115 35 | 150 | 3:1 | 0.22 | 1 | 0.64NS |
| ICSR94405 X  SAMSORG40 | P1 (ICSR94405) | 1.2 (0-3) | 30 0 | 30 | 1:0 |  |  |  |
|  | P2(SAMSORG40) | 6.4 (5-8) | 0 30 | 30 | 0:1 |  |  |  |
|  | F1 | 1.3 (0-4) | 30 0 | 30 | 1:0 |  |  |  |
|  | F2 | 1.5 (0-4) | 115 35 | 150 | 13:3 | 1.83 | 1 | 0.18NS |
|  | BCP1 | 2.9 (0-8) | 150 0 | 150 | 16:0 |  |  |  |
|  | BCP2 | 2.7 (0-9) | 109 41 | 150 | 3:1 | 0.44 | 1 | 0.51NS |

**DISCUSSION**

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**Analysis of Variance**

In the present study, the mean square values of all the characters studied were highly significant among the genotypes, indicating that there are variations among the genotypes for all the characters.

**Mean, Range and Coefficient of Variation**

The susceptible parent (SAMSORG14) had the highest mean plant height value of 200.70cm while resistant parent (ICSR94407) had the lowest mean plant height value of 155.73cm. The mean plant heights for the F1 hybrid in the entire cross were similar to the mid parental value. This indicated the preponderance of additive gene action for plant height. The height of F2 plants were distributed over the range of both parents with continuous distribution, suggesting the involvement of more than one gene controlling the inheritance of the trait and it also suggests that gene controlling the trait, are dispersed among the parents. Also from the result, the mean plant heights for the backcrosses (BCP1 and BCP2) skewed towards their respective recurrent parents. Mean values of the F1 hybrids in the six crosses, for panicle lengths were similar to their respective susceptible parents. The distributions of the segregating F2 populations in the crosses imply that the trait is governed by more than one gene. The frequency distribution of the backcrosses skewed towards their respective recurrent parents.

SAMSORG17 had the highest panicle weight, with mean value of 118.09g, while ICSR94405 had the lowest with mean value of 76.43g. Mean value of F1 hybrids in almost all the crosses were similar to the mid parental value, indicating preponderance of additive gene for this trait. The F2 populations segregated outside their parental range, suggesting that the panicle weight genes are dispersed among the parents. BCP1 and BCP2 mean distribution skewed towards their respective recurrent parents.

The low mean grain yield values of the resistant varieties were not due to *Striga*effect, rather it was due to the poor agronomic qualities of the varieties. Most of the F1 means were similar to their mid parental value, indicating preponderance of additive gene effect. The distributions of the segregating F2 populations in all the crosses imply that grain yield is governed by more than one gene. Quantitative inheritance of grain yield has been reported by Showemimo*et al.,* (2005) in the study of genetics of sorghum cultivars under *Striga*infestation. BCP1 and BCP2 frequency distribution skewed towards their respective recurrent parents.

SAMSORG17 had the highest 1000 grain weight while ICSR94405 had the lowest. Most of the F1 means were similar to the mid parental value, indicating predominance of additive gene effect. The distributions of the segregating F2 populations in the crosses imply that the trait is governed by more than one gene. The backcrosses mean distribution skewed towards their respective recurrent parents.

The donor parents; ICSR94405 and ICSR94407 were truly *Striga*resistance with mean *Striga*count value of 0.03 and 0.00, respectively. Only one *Striga*emerged on ICSR94405, while on ICSR94407 there was no *Striga*emergence. Also the other three parents (SAMSORG14, SAMSORG17 and SAMSORG40) were susceptible with SAMSORG40 having the highest *Striga*emergence with mean *Striga*count value of 4.53, followed by SAMSORG14 with mean value of 3.13 while SAMSORG17 had fewer *Striga*emergence with mean value of 1.13. The fewer *Striga*emergences observed in SAMSORG17 conforms to result of Showemimo (2005) that SAMSORG17 is a promising genotype with some level of *Striga*resistance*.* There were few *Striga*emergences on the F1 plants from the six crosses. This was in agreement with result from similar investigations with other sorghum genotypes (Vogler*et al.,* 1996; Haussmann *et al.,* 2000a).

For the F2 and backcrosses, *Striga*emerged on some plants while some plants had no *Striga.*

**Chi-square Values at Expected Segregation Ratios.**

In the present study, plants with score of 0 to 4 were considered resistant, while plants with scores of 5 to 9 were considered susceptible (Sinebo and Drennan 2001). From the result, resistant parents common in different crosses showed consistency in reaction to *Striga*resistance in their F1. The hybrids for all combinations were resistant with the mean damage score near that of the resistant parent, thus indicating that one or more dominant gene(s) which are complimentary controlled the resistance. In the F2 population the chi-square values at expected segregation ratio 3:1 (resistant: susceptible) are significant in all the crosses, indicating poor fit of the observed segregation ratios. The expected ratio 9:7 is significant in the F2 of three crosses, indicating poor fit of the observed segregating ratio, while it is non-significant in SAMSORG14 x ICSR94407, SAMSORG17 x ICSR94407 and SAMSORG40 x ICSR94407, indicating good fit of the observed segregating ratio. The 9:7 indicate complementary gene action or duplicate recessive epistasis where recessive alleles at either of two loci mask the expression of dominant alleles at both loci. This is in agreement with the result of (Ejeta et al., 2001). Similarly, significant chi-square values were obtained in three crosses at the expected segregation ratio 13:3, indicating poor fit of the observed segregation ratio. While three crosses where not significant, therefore indicating good fit of the observed segregation ratio. Three F2 populations gave the best fit of 9:7 and the other three populations gave the best fit of 13:3 ratios. While those F2 populations that fit into13:3 revealed that resistance is controlled by inhibitory gene interaction where a dominant article at one locus mask the expression of both dominant and recessive alleles at the second locus.Similar to result of Obilana, A.T. (1984). The BCP1 populations gave the best fit of 3:1 backcross ratio, while BCP2 fitted into 1:1 ratio.

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**CONCLUSION**

From the study, Analysis of variance revealed highly significant difference among the genotypes for all the traits studied. It was confirmed that the two male parents (ICSR94405 and ICSR94407) were truly resistant, though their mean grain yield, plant height, panicle weight, panicle length and 1000 grain weight values were not the highest, due to their poor agronomic qualities when compared to the female parents, but the *Striga* damage score and *Striga* count which are the major resistance criteria, prove them to be resistant to *Strigahermonthica*. From the experiment, SAMSORG17 showed some level of tolerance because it recorded the lowest mean value for *Striga* count and *Striga* damage score among the IAR varieties.

Chi-square test revealed that none of the F2 populations fitted into 3:1 (resistance: susceptible) segregation ratio, suggesting that resistance is not controlled by one dominant gene, three crosses fit into 9:7 ratio, suggesting that two dominant genes which are complimentary are in control and three crosses fit into 13:3 segregation ratio, revealing that resistance is controlled in part by gene at two or more loci.

In conclution,the study revealed that *Striga*resistance in sorghum is controlled by a few genes (oligogenic). Thus oligogenic inheritance of pest resistance genes is generally assumed to be more stable than monogenic resistance. All the traits are quantitatively heritable, thus repeatability of result and traits can be easily improved on.

**REFERENCE**

Ejeta G., Babiker A. G., Belete K., Bramel P., Ellicott A., Grenier C., Housley T., Kapran I., Mohamed A., Rich P., Shaner C. and Toure A. (2001). Breeding for durable resistance to *Striga* in sorghum. Page 166-169. In Fer,A., Thalouarn, P., Joel, D. M., Musselman, L. J., Prker, C. and Verkleij J. A. C. (eds). *Proceeding of the 7th International Parasitic Weed Symposium held at Nantes, France, 5-8 June 2001.* Organised by Le Groupe de PhysilogieetPathologieVegetales.

Ejeta G., Butler L.G. and Babiker A.G. (1992).New approaches to the control of *Striga*.*Striga* Research at Purdue University.*Research Bulletin RB-991*.Agricultureal Experiment Stations Purdue University.West Lafayetter IN.

Food and Agriculture Organization of the United Nation (FAO), Rome (2012). Year Book Statistics.Pp 224.

Food and Agriculture Organization of the United Nation (FAO), Rome (2013). Year Book Statistics. Pp 203

Gbehounou G., Adengo E. (2003). Trap crops of *Strigahermonthica*: *In vitro* identification and effectiveness in situ. *Crop protection* **22,** 395-404.

Hassan R., Ransom J., Ojiem, J. (1994) The spatial distribution and farmers strategies to control *Striga*in maize: survey results from Kenya. Fourth Eastern and Southern Africa Regional Maize Conference; P.250-254.Mar 28-Apr 1.

Haussmann B.I.G., Hess D.E., Koyama M.L., Grivet L., Rattude H.F. W. and Geiger H.H. (2000a). Breeding for *Striga*resistance in cereals. MargrafVerlag, Weikersheim, Germany.

Kuhlman L.C. (2010). Early-generation germplasm introgression from *Sorghum macropermum* into*Sorghum bicolor Plant Breed* **53** 419-421.

Lagoke S.T.O, Parkinson V, Agunbiade R.M, (1991). Parasitic weeds and control method in Africa. *In* Kim S,K, (editor*). Combating Striga in Africa*. Proceedings of an inter-national Workshop organized by IITA, ICRISAT and IDRC; August 22-24;IITA, Ibadan, Nigeria. P.3-14.

Little T.M. and Hills F.J. (1978). Agricultural Experimentation. John Wiley and sons, inc. Canada. PP.38.

Mabasa, S. (1996). Screening sorghum cultivars for resistance to witchweed (*Striga asiatica)* I Zimbabwe; In; MutengwaTongoona P. Mabasa S. and Chivinge O. A. (1999) *Resistance to Strigaasiatica (L) Kuntze in sorghum*; Parent characterization and combining ability analysis, *African Crop Science Journal.,* **36,** 321-326.

Obilana A.B. (2011a). Implementing sorghum transformation value chain in Nigeria pp 1.

Obilana A.T., (1984). Inheritance of resistance to *Striga (Strigahermonthica*Benth.) in sorghum.*Prot. Ecol*. 7,305—311.

Press M. C, Gurney, A. L, Frost, D. L, Scholer J. D. (1996). “How does the parasitic angiosperm

*Strigahermonthica*influence host growth and carbon relations?”*In*: Moreno, M.T, Cubero J. I, Berner D, Joel D, Musselman L. J, Parker C, editors. Proceedings of the Sixth International Parasitic weed symposium on Advances in parasite Research, Cordoba, Spain. Pp 303-310.

Rodenburg, J., Bastiaans L., Weltzien E., Hess D. E. (2005). How can selections for *Striga*resistance and tolerance in sorghum be improved? *Field Crop Research* 93:34-50.

SAS Institute. (2009). SAS user’s guide.Statistics, version 9.0 ed. SAS Institute. Inc., Cary, NC, USA.

Showemimo, F. A., Kimbeng, C. A. (2005). Genetic studies of sorghum cultivars under *Striga*

Infestation in Northern Guinea Savannah of Nigeria.*AgriculturaTropicaetSubtropicaVol* **38(2),** 91-95.

Sinebo, W. and Drennan, D. S. H. (2001). Vegetative growth of sorghum and *Strigahermonthica* in response to nitrogen and the degree of host root infection*. European Journal of Plant Pathology*, 107 **(9) -**860.Doi: 10.1023/A:1013150108056.

Vasudeva, R. (1985). Techniques for screening sorghums for resistance to *Striga*. ICRISAT *Information Bulletin* No 20 pp 18.

Chukwu C, Yeye M.Y., ,Onyia V.N. Atugwu, A.I.

Vogler, R. K., Ejeta, G. and Butler, L. G. (1996). Inheritance of low Production of *Striga* germination stimulant in sorghum. *Crop Sci*., **36,**  1185-1191.

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**ASSESSMENT OF PROXIMATE AND CURCUMIN CHEMICAL COMPOSITION OF NIGERIAN TURMERIC (*CURCUMA LONGA* L.*)* GERMPLASM**

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**ABSTRACT**

***The present research work assessed the proximate and curcumin chemical composition of 47 Turmeric accessions in the laboratory, using standard methods. Finger rhizomes samples were collected dried and grind into powder from the three replicates at harvest. This was laid out in a randomized complete block design (RCBD) on the field experiment at Nsukka, Nigeria. The results showed that Turmeric powder contains high content of total carbohydrate (68.16%), low contents of ash (2.65%), fat (5.48%), fibre (3.63%) and moisture (10.72%). Turmeric accessions NCL 58, 52, 50 and 41, differed in protein content, which ranged from 11.12 – 13.57%. Accessions NCL 32, 48, 59, 43, 46 and IBF 222, recorded the highest curcumin content, which ranged from 6.67 – 6.90% with water as solvent. Likewise, with ethanol as solvent, Turmeric accessions NCL 49, 18, 50 and 46, had high curcumin content, ranging from 6.43 – 6.67% when assayed. Fibre (-0.181\*) and moisture content, had significant and negative correlation with ash and carbohydrate (-0.953\*\*). Conclusively, Turmeric is highly nutritious and serves as a good source of value addition to food products. And, curcumin are natural phenolic compounds with potent antioxidant properties.***

**Key words:** Turmeric, curcumin, proximate, ethanol, water, germplasm and NCL with IBF.

**INTRODUCTION**

Turmeric (*Curcuma longa* Linn.) is a tropical perennial monocotyledonous herb, belonging to the family Zingiberaceae (Ravindran *et al.* 2007). It’s importance lie in its underground rhizome, which contains yellow coloured phenolic pigment known as Curcuminoids. This active ingredient includes curcumin – diferulylmethane, demethoxycurcumin and bismethoxycurcumin (Chaini – Wu, 2003). Curcumin is an important compound, which is responsible for the biological activities of Turmeric. And posses medicinal properties such as chemo preventive activity, cholesterol lowering and as antioxidant, anti-inflammatory, anti fungal and anti bacterial effects (Peter, 2000; Olojede *et al.,* 2009). The melting point of curcumin (C2H52OO6) is 184.2 0c. It dissolves in ethanol but insoluble in water (Joe, *et al.,* 2004). Turmeric nutrients boost the body immune system against diseases, and has high nutritional potential that has not been fully exploited (Ikpeama *et al., 2014*). Turmeric is being consumed in Africa and sub – Saharan countries, as a good source of spice and natural colouring agent for food, cosmetics and dye. Yet, the curcuma species are neglected, underutilized and termed minor root crop, grown mostly at the homestead gardens in Nigeria and wild in the Asian forests, for myriad of uses. The leaves are rich in vitamin and minerals (Chattopadhyan *et al.,* 2004). Turmeric is been use traditionally as household remedy in curing various ailments, such as anorexia, cough, rheumatism and intestinal disorder (Ikpeama *et al., 2014*). There is need to characterized the biochemical properties of Nigerian Turmeric germplasm scientifically, for industrial food and drug production. Since there is a general shift of consumer and patience preference away from synthetic / orthodox medicine to natural herbal plant, for the treatment of human ailments (Adeniji, 2004).

This study will reveal the nutritional values and curcumin content of Turmeric plant, which would be of immense benefits for captain of industries and medical practitioner to explore.

The specific objectives of this work are to:

Assessment of proximate and curcumin chemical composition of Nigerian turmeric

1. Evaluate the proximate composition of 47 Nigerian Turmeric germplasm, and
2. Determine the curcumin content of the 47 Nigerian Turmeric accessions.

**MATERIALS AND METHODS**

A Field to Laboratory trial was established and the biochemical properties of Turmeric rhizomes were analyzed at harvest in 2013, after evaluating the yield parameters. Samples were collected at harvest from the 47 Turmeric accessions, which was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. Each block contained 47 plots with 47 Turmeric accessions which gave 188 experimental plots. Proximate properties and Curcumin content were characterized in the Laboratory, according to the methods of (Pearson, 1976, A.O.A.C. 2000).

**Ash content**

Ash is the inorganic residue obtained by burning off the organic matter of sample at 400 - 600 0C in muffle furnace for 4 hrs. Two grammes (2 g) of the sample were weighed into a platinum crucible. The crucible was placed into muffle furnace at 400 - 600 0C for 4 h, until whitish - grey ash were obtained. The crucible was then placed in the desiccator and weighed.

% Ash = wt of the ash x 100

wt of the sample

**Moisture content**

Principle

This is based on an indirect distillation method (evaporation of moisture). The amount of moisture in the sample is the loss in weight after drying in the oven at 1050C until a constant weight is recorded.

Procedure

Sample (2 g) was weighed and dried in the oven at 105 0C to a constant weight. The dishes and sample were cooled and weighed. The moisture content was then calculated from the equation below.

%Moisture=wt of sample +dish before drying – wt of sample + dish after drying x 100 wt of sample taken

**Fat determination**

Principle

The sample was continuously extracted with petroleum ether, using an extraction apparatus. After extraction, the petroleum ether was evaporated to dryness and the residue designated the petroleum ether extract. This was referred to as the fat portion of the sample. Procedure An anhydrous diethyl ether (petroleum ether) (150 ml) of boiling point of 40 - 60 0C was placed in the flask. Sample (2 g) was weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the 2 flasks was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and drop back into the sample in the thimble, the ether soluble substances were dissolved and were carried into solution through the siphon tube back into the flask. The extraction continued for 4 h. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65 0C for 4 h, cooled in a desiccator and weighed.

%Fat=wt of flask + extract – tare wt of flask x100 Wt of sample

**Crude fibre**

Principle

This is insoluble and combustible organic residue which remains after the sample has been treated under prescribed condition. The most common conditions are consecutive treatments with light petroleum ether boiling dilute sulphuric acid, boiling dilute sodium hydroxide, dilute hydrochloric acid, alcohol and ether. This treatment provides a crude fibre consisting largely of the cellulose content together with a proportion of the lignin and hemicelluloses content of the sample.

Procedure

The defatted sample (2 g) was transferred into 500 ml flask / beaker and 200 ml of pre - heated 1.25 % H2SO4 was added and the solution was gently boiled for 30 mins, maintaining constant volume of acid by the addition of hot water. Residue was washed three times with hot water and returned to the beaker. Then 200 ml of pre - heated 1.25 % Na2OH was added and boiled for another 30 min. This was filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65 0C for about 24 h and weighed. The residue was transferred into a crucible and placed in muffle furnace (400 - 600 0C) and ashed for 4 h. It was then cooled in a desiccator and weighed.

%Crude fibre=Dry wt of residue before ashing -wt

of residue after ashing x100

wt of sample

**Protein determination**

Principle

The crude protein content was determined using the micro - Kjeldhal method. The method is based on the wet combustion of the sample by heating with concentrated sulphuric acid in the presence of metallic and other catalysts to effect the reduction of organic nitrogen in the sample to ammonia, which is retained in solution as ammonium sulphate. The digest having been made alkaline, is distilled to remove ammonia which is trapped and titrated.

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Procedure:This involves three major steps.

Digestion: sample (2 g) was weighed inside Kjeldhal digestion flask and 25 ml of concentrated sulphuric acid, 0.5 g of copper sulphate, 5 g of sodium sulphate and a speck of selenium tablet was added. Heat was applied in a fume cupboard slowly at first to prevent undue frothing. Digestion continued for 45 min until the digest became clear pale green. This was left until completely cool. Distilled water (100 ml) was added.

Distillation: Markham distillation apparatus was used for distillation. The distillation apparatus was heated and 10 ml of the digest was added into the apparatus via a funnel and allowed to boil. Sodium hydroxide (10 ml) of 50 % was added from the measuring cylinder so that ammonia was not lost. This was distilled into 50 ml of 2 % boric acid containing screened methyl red indicator.

Titration: The alkaline ammonium borate formed was then titrated directly with 0. 01N HCl. The titre value which is the volume of acid used was recorded.

% protein = Titrex 0.01N HCl x 14.01(At.utN)

x100 x 50 x 100

1000 x 0.5 g x 10

**Carbohydrate determination**

Carbohydrate was determined by mathematical calculation. It was obtained by subtracting the sum of percentages of all the nutrients already determined from 100.

% Carbohydrate = 100 - (% Ash + % Moisture + % Fat + % Protein + % Fibre)

Carbohydrate is an easily utilizable non-nitrogenous substance in sample.

**Determination of curcumin (%) using visible spectroscopic method -** by Soni, *et al.,* (2011).

0.1 gm of dried extract was dissolved in 25 ml of ethanol. This solution was filtered and volume made upto 100 ml. Then 10 ml of above solution was taken in volumetric flask and again volume made upto 100 ml with ethanol. The absorbance was measured at 425 nm and curcumin was determined.

A standard curcumin 0.25 g litre-1 give absorbance at 425 nm = 0.42.

Absorptivity of curcumin (A) = 0.42 / 1 x 0.025 = 16.8

% Curcumin = a x 100 / L x A x W

Where, a = absorbance of sample at 425 nm

L = path length (1cm)

A = Absorptivity

**Statistical Analysis**

Micro-soft Excel window software 2003 was used to determine the Means and Percentages. Also, analysis of variance (ANOVA), is done to identify differences between means, according to the procedure outlined for RCBD experiment, using GenStat Release 7.22 Discovery Edition 3(2008). The treatment Means was compared using Fisher’s protected Least Significant Difference (F-LSD) test at the 5% level of probability as outlined by Obi (2002).

**RESULTS**

**Proximate composition (%) of 47 Turmeric accessions in Nigeria**

The characteristics of 47 Turmeric characters evaluated based on chemical composition is shown in Table 1. Characters such as ash, with the highest mean value of 3.15%, carbohydrate (71.44%), and fat (6.03%), differed non significantly (p > 0.05) among the accessions. Fibre differed significantly (p < 0.01) among the accessions. With accession NCL 26 recording the highest mean value of 3.64%, this is similar statistically with NCL 63 and 30 (3.39% and 3.35%). But, NCL 27 recorded the least mean value of 2.63%. Also, protein differed significantly (p < 0.01) among the accessions. Accessions NCL 44, 30 and 50, which ranged from 13.28 – 13.58% had the highest mean values, while accessions NCL 21 and 22 recorded the lowest mean value of 10.95%. Coefficient of variationwas 10.10%.

**Characterization of 47 Turmeric accessions for Curcumin content at Nsukka**

The evaluation for curcumin content of 47 Turmeric rhizome accessions in Table 1, revealed that Curcumin in ethanol differed non significantly (p > 0.05) among the accessions. However, accessions NCL 49, 18, 50 and 46 recorded the highest curcumin values range of 6.43 – 6.67%. But, NCL 61 and 37 had lower curcumin content of 5.12 – 5.20. Also, curcumin in water did not differ significantly (p > 0.05) among the accessions. However, accessions NCL 32, 48, 59, 43, 46 and 1BF 222, recorded the highest curcumin values. This range from 6.67 – 6.90%, while NCL 12, 25, 14, 20 and 28, which ranged from 5.00 – 5.25% had lower curcumin content values.

**Linear correlation matrix for proximate qualities of 47 Turmeric accessions at Nsukka**

Correlation studies on six biochemical properties in Table 2 revealed that ash had a significant and negative relationship with fibre (-0.181\*), but non significant with fat (-0.040), moisture (-0.116) and protein (-0.156), while positively correlated with carbohydrate (0.102).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1:** Proximate and Curcumin chemical composition (%) of 47 Turmeric accessions in Nigeria  Assessment of proximate and curcumin chemical composition of Nigerian turmeric | | | | | | | | |
| Accession | Ash | Carbohydrate | Fat | Fibre | Moisture | Protein | Curcumin | |
| **Water** | **Ethanol** |
| NCL30 | 2.71 | 72.93 | 5.97 | 4.03 | 9.57 | 9.59 | 6.31 | 5.42 |
| IBF222 | 2.79 | 68.08 | 5.65 | 3.03 | 10.58 | 9.86 | 6.79 | 5.87 |
| NCL37 | 2.74 | 68.75 | 5.43 | 3.74 | 10.25 | 9.09 | 5.95 | 5.20 |
| NCL60 | 2.43 | 68.57 | 5.49 | 3.61 | 10.24 | 9.65 | 6.67 | 5.60 |
| NCL4 | 2.50 | 67.82 | 5.60 | 3.33 | 0.42 | 10.32 | 5.95 | 5.95 |
| NCL41 | 2.60 | 67.42 | 5.49 | 3.54 | 9.84 | 11.12 | 5.95 | 6.28 |
| NCL23 | 2.56 | 67.63 | 5.42 | 3.83 | 10.86 | 9.70 | 5.95 | 5.78 |
| NCL48 | 2.63 | 68.70 | 5.52 | 3.66 | 9.67 | 9.82 | 6.43 | 5.60 |
| NCL17 | 2.66 | 70.55 | 5.55 | 3.74 | 10.74 | 10.15 | 6.55 | 5.72 |
| NCL14 | 2.59 | 71.08 | 5.54 | 4.02 | 9.77 | 10.50 | 5.24 | 5.79 |
| NCL38 | 2.47 | 67.40 | 5.27 | 3.40 | 10.29 | 10.17 | 6.55 | 6.15 |
| NCL50 | 2.73 | 67.05 | 5.50 | 3.75 | 9.50 | 11.47 | 6.19 | 6.35 |
| NCL63 | 2.58 | 68.22 | 5.38 | 4.70 | 9.54 | 10.17 | 5.95 | 5.66 |
| NCL35 | 2.58 | 69.17 | 5.27 | 3.14 | 10.43 | 9.41 | 6.19 | 5.55 |
| NCL20 | 2.42 | 68.07 | 5.20 | 3.61 | 10.83 | 9.88 | 5.24 | 5.59 |
| NCL6 | 2.80 | 68.50 | 5.47 | 3.54 | 8.96 | 10.71 | 6.55 | 5.44 |
| IBF111 | 2.62 | 68.73 | 5.66 | 3.36 | 3.36 | 9.84 | 6.55 | 6.19 |
| NCL27 | 2.71 | 70.01 | 5.39 | 2.94 | 9.17 | 9.19 | 5.71 | 5.83 |
| NCL19 | 2.68 | 66.96 | 5.89 | 3.92 | 10.44 | 10.10 | 5.36 | 5.54 |
| NCL34 | 2.79 | 67.93 | 5.62 | 3.49 | 10.86 | 9.31 | 6.43 | 6.23 |
| NCL49 | 2.59 | 67.17 | 5.57 | 4.06 | 10.61 | 10.00 | 6.19 | 6.35 |
| NCL55 | 2.71 | 71.88 | 4.77 | 3.78 | 10.37 | 9.74 | 5.95 | 5.91 |
| NCL39 | 2.69 | 66.83 | 6.03 | 3.70 | 10.66 | 10.09 | 5.71 | 5.40 |
| NCL13 | 2.65 | 67.66 | 5.83 | 3.52 | 10.57 | 9.77 | 5.48 | 6.27 |
| NCL43 | 2.62 | 71.76 | 5.48 | 4.11 | 9.45 | 9.86 | 6.79 | 5.60 |
| NCL61 | 2.31 | 68.53 | 5.33 | 3.72 | 10.31 | 9.80 | 6.07 | 5.12 |
| NCL46 | 2.80 | 69.35 | 5.42 | 3.43 | 9.36 | 9.65 | 6.90 | 6.67 |
| NCL16 | 2.76 | 67.68 | 5.40 | 3.95 | 10.67 | 9.54 | 5.95 | 5.79 |
| NCL28 | 2.59 | 67.88 | 5.93 | 3.70 | 10.38 | 9.52 | 5.24 | 5.99 |
| NCL32 | 2.57 | 68.04 | 5.43 | 3.33 | 10.89 | 9.74 | 6.67 | 5.95 |
| NCL12 | 2.76 | 69.78 | 5.38 | 3.54 | 8.88 | 9.67 | 5.00 | 6.07 |
| NCL44 | 2.56 | 78.21 | 5.06 | 3.79 | 10.39 | 9.58 | 5.95 | 5.79 |
| NCL26 | 2.33 | 67.40 | 5.39 | 4.45 | 10.98 | 10.20 | 6.31 | 5.91 |
| NCL5 | 2.63 | 67.16 | 5.80 | 3.88 | 10.57 | 9.96 | 5.95 | 5.71 |
| NCL59 | 3.10 | 68.97 | 5.70 | 3.19 | 9.42 | 9.62 | 6.67 | 5.60 |
| NCL47 | 2.86 | 69.19 | 5.37 | 3.81 | 9.35 | 9.41 | 6.43 | 5.60 |
| NCL24 | 2.62 | 67.20 | 5.74 | 3.76 | 11.38 | 9.31 | 5.60 | 5.42 |
| NCL25 | 2.55 | 72.18 | 5.08 | 2.98 | 10.46 | 10.13 | 5.00 | 5.60 |
| NCL42 | 2.55 | 68.07 | 5.53 | 3.90 | 10.15 | 9.81 | 5.60 | 6.07 |
| NCL29 | 2.54 | 68.13 | 5.37 | 4.00 | 9.84 | 10.35 | 5.48 | 6.19 |
| NCL45 | 2.61 | 68.50 | 5.44 | 3.63 | 10.00 | 9.82 | 6.19 | 5.56 |
| NCL18 | 3.19 | 66.70 | 5.58 | 3.17 | 11.24 | 10.12 | 5.95 | 6.43 |
| NCL36 | 2.66 | 67.77 | 5.92 | 3.61 | 10.55 | 9.49 | 6.19 | 5.64 |
| NCL52 | 2.50 | 70.00 | 4.00 | 2.95 | 7.40 | 12.00 | 6.19 | 5.84 |
| NCL22 | 2.63 | 68.01 | 5.26 | 3.94 | 11.09 | 9.07 | 5.60 | 5.95 |
| NCL58 | 2.76 | 63.40 | 5.53 | 3.63 | 11.12 | 13.57 | 5.89 | 5.52 |
| NCL21 | 2.70 | 67.24 | 5.92 | 3.35 | 10.88 | 9.51 | 6.55 | 5.96 |
| Mean | 2.65 | 68.16 | 5.48 | 3.63 | 10.72 | 9.99 | 6.01 | 5.84 |
| F-LSD (p<0.05) | ns | ns | ns | \*\*\*  0.68 | ns | \*\*  1.71 | ns | ns |
| C V (%) | 10.50 | 13.50 | 9.10 | 11.60 | 81.60 | 10.50 | - | 12.97 |
| Note: \*\*\*, \*\* Significant at 1% and 5% level of probabilities,ns = not significant at (P > 0.05). NCL = Nigerian Curcuma longa accession number, was named by the National Root Crop Research Institute (NRCRI), Umudike. IBF = Ibadan Finger. | | | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 2:** Linear correlation matrix among proximate composition of 47 Turmeric accessions | | | | | | |
| **Traits** | **Ash** | **Carbohy drate** | **Fat** | **Fibre** | **Moisture** | **Protein** |
| sh | 1 | .102 | -.040 | -.181\* | -.116 | -.156 |
| Carbohydrate |  | 1 | -.038 | .077 | -.953\*\* | -.155 |
| Fat |  |  | 1 | .011 | -.042 | .091 |
| Fibre |  |  |  | 1 | .005 | .055 |
| Moisture |  |  |  |  | 1 | .046 |
| Protein |  |  |  |  |  | 1 |
| Note: \*, \*\* = Significant @ p< 0.05 and 0.01 levels (2 - tailed) respectively. n = 47. | | | | | | |

Moisture content had a highly significant and negative relationship with carbohydrate (-0.953\*\*), but insignificant with ash (-0.116) and fat (-0.042). But, it had a positive correlation with fibre (0.156). Protein had an insignificant and negative correlation with ash (-0.156) and carbohydrate (-0.155). While positive correlation existed with fat (0.091), fibre (0.055) and moisture content (0.046).

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**DISCUSSION**

**Proximate properties (%)**

Turmeric contains good nutritional and chemical composition, which will be of immense benefit for value addition in food products needed for body

growth, and boost the immune systems against various ailments. The results of the proximate analysis, implies that Turmeric is a rich source of protein (13.58%), carbohydrate (71.44%), ash (3.15%), fat (6.03%), fibre (3.64%) and moisture content of 9.72%. This work is in line with that of Ikpeama, *et al.* (2014), who reported 9.42% crude protein, carbohydrate (67.38%), ash (2.85), fat (6.85%), crude fibre (4.60%) and 8.92% moisture content. While, Mane, *et al.* (2018) in his studies, reported lower values of protein (1.20%), carbohydrate (9.10%), ash (0.66%), fat (1.08%), fibre (0.72%), but higher moisture content of 84.24%, with acidity (0.70%), pH (5.7) and high curcumin content of 5.1%, respectively. The carbohydrate content of 71.44% in this study corroborate with that of Ikpeama (67.38%), and is higher than that of *Acalypha racemosa* (45.26 %) and *Acalypha marginata* (38.24 %), which are known medicinal plants. However, the crude fibre, crude protein and ash (3.64%, 13.58% and 3.15%) of Turmeric, are lower than that of *Acalypha racemosa* (7.20 %, 16.19 % and 13.14 %) and *Acalypha marginata* (10.25 %, 18.15% and 10.32 %) respectively (Iniaghe *et al.,* 2009, Ikpeama, *et al.,* 2014). The ash content of 3.15% in Turmeric shows that it will contain reasonable amount of mineral. The 3.64% fibre presents in turmeric, will help the body to absorb excess cholesterol and cleanse the digestive tract of its consumer by removing potential carcinogens. Fibre also, adds bulk to the food and prevents the intake of excess starchy food. This could guard against metabolic conditions such as diabeties mellitus and hypercholesterdemic (Bamishaiye *et. al*., 2011, Ikpeama, *et al.,* 2014).

**Curcumin content**

The curcumin content in Turmeric leave and rhizome, are used widely for imparting aroma and yellow colourations in variety of food products. In this study, accessions NCL 49, 18, 50 and 46 recorded the highest curcumin values range from 6.43 – 6.67%, using ethanol as solvent. Work on curcumin content had been reported by several authors. Manjunathgoud, (2002) found that spacing of 30 x 45 cm enhanced maximum curcumin content. Chiu, *et al.* (1993) reported that curcumin content differed significantly in mother rhizomes (5.5%) as compared to 4.9% from finger rhizome. Madhusankha, *et al.* (2018) reported lower range of curcumin content of 3.76 – 5.05%. Higher curcumin content of 7.73% was extracted and reported by Vikramsinh, *et al.*(2013), while 9.3% came from two clones PTS - 10 and PTS - 24 released from India (FAO, 2014). And, Edapalayan cultivar recorded 10.9% (Zachariah, *et al.,* 1999). The relative reduction in curcumin content in some genotypes can be attributed to accumulation of starch and fibre (Zachariah, *et al.,* 1999). The linear correlation matrixes showed significant and negative correlation between the proximate parameters. The improvement of the biochemical characters, results in simultaneous high value of all the related characters.

**CONCLUSION**

The data recorded that Turmeric rhizomes had high amount of Protein (13.58%) and Curcumin content (6.67%). Turmeric contains good nutritional and chemical composition, which will be of immense benefit for value addition in food products needed for body growth. Curcumin, a potent antioxidant of the herb can be use in the development of pharmaceutical industries as a therapy against various diseases. The results of the study support the development of new drugs from the plant.

**Recommendation**

For Curcumin, Turmeric accessions NCL 49, 18, 50 and 46, which recorded the highest Curcumin contents of 6.43 – 6.67%. And, Protein with accessions NCL 44, 30 and 50, which had the highest mean values of 13.28 – 13.58%, are selected for commercial cultivation. The identified Turmeric accessions will be of immense benefits to medical health practitioners, nutritionists, researchers and captains of industries in drug production.

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**REFERENCES**

A.O.A.C. (2000). Official Methods of Analysis. Association of Official Analytical Chemists, Washington D.C. Adeniji M.O. (2004) Herbal Treatment of Human diseases. pp 82.

Bamishaiye E.I; Olayemi F.F, Awagu E.F. and Bamshaiye O.M. (2011). Proximate and phytochemical composition of moringa oleifera leaves at three stages of maturation. Advance Journal of Food Science and Technology **3(4),**  233 – 237.

Chainani-Wu, N. (2003). Safety and anti-inflammatory activity of curcumin : a component of turmeric (*Curcuma longa*). Journal of Alternative and Complement medicine **9,** 161-168.

Chattopadhyan L., Biswas K., Bandyo-Padhyay U. and Banerjee R.L. (2004). Turmeric and Curcumin: Biological Action and Medicinal Applications. Current Science **87,**  44 - 53.

Assessment of proximate and curcumin chemical composition of Nigerian turmeric

Genstat (2005) Genstat 3.0 Release 4.23 DE. Discovery Edition, Iawes Agricultural Trust, Rothmanisted Experimental station, Nk.

Ikpeama *et al.* (2014). Nutritional composition of Turmeric (*Curcuma longa*) and its Antimicrobial properties. International Journal of Scientific and Engineering Research, **Vol. 5,** Issue 10.

Iniaghe O.M., Malomo S.O. and Adebayo J.O. (2009). Proximate composition and phytochemical constituents of leaves of some acalypha species. Pakistan Journal of Nutrition **8,** 256 - 258.

Joe B.M., Vijaykumar, M and Lokesh, B.R. (2004). Biological properties of curcumin- cellular and molecular mechanisms of action. Critical Reviews in Food Science and Nutrition **44,**  97:111

Pearson D. (1976). Roots and Rhizomes. The Chemical Analysis of Foods 7th Edition. Edinburgh Churchil living stone. p. 319-323.

Peter K.V. (2000). Informatics on Turmeric and Ginger. India Spices **36 (2 and 3),** 12 - 14.

Ravindran P.N, Nirmal, B.K, Sivaraman, K (2007). The golden spice of life. In: Turmeric. The Genus Curcuma. Boca Raton, FL, USA: CRC Press; p. 1- 14.

Soni H, Patel Sita Shara (2011). Quantitative and Qualitative Profile of curcumin from ethanolic extract of *Curcuma longa*. International Research Journal of Pharmacy. **2 (4),**  p. 180-184.

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**CHARACTERIZATION OF SOME MAIZE VARIETIES IN A GUINEA SAVANNAH AGRO-ECOLOGY**

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**ABSTRACT**

*Crop varieties differ in performances and it is on this basis that varieties with economically important agronomic traits should undergo extensive evaluation in order to recommend them for commercial production. Twenty six maize (Zea mays L.) varieties obtained from National Seed Council of Nigeria were evaluated for cob and seed yields at the Teaching and Research Farm of Plateau State College of Agriculture, Garkawa, Nigeria in 2018 and 2019 cropping seasons. The maize varieties were laid out in a randomized complete block design (RCBD) with three replications. The result showed that the maize varieties differed significantly (p<0.05) in mean husk weight plant-1, cob weight plant-1, seed weight plant-1, number of seeds plant-1 and grain yield ha-1. Frequency of better performance than grand mean for traits quantified identified eight varieties having high frequencies (3-5; 5=100%) for traits with significant treatment means. The varieties within this category included: SAMAZ 15, SC651, OBA98, SDM-2, SAMAZ 45, SAMAZ 48, DUPONT P4226 and OBA SUPER 3. These varieties also had high rank scores (90 - 130) and were within the 1st and 8th positions of ranking among the 26 maize varieties. On the bases of the superior cob and grain yield ranking, these varieties were recommended for commercial maize production in the study area.*

**Keywords**: Characterization, grand mean, maize, rank scores, varieties

**INTRODUCTION**

Maize (Zea mays L.) is a major staple food crop in sub-Saharan Africa. Its high energy content has made it very important in human and animal diets (Akinwale *et al*., 2013). The crop is considered a model system for the study of genetics, evolution, and domestication (Lu *et al*., 2009). In the global context, the genetic improvements in maize, combined with suitable agronomic practices, have allowed increase in grain yield (USDA, 2015).

Maize provides a major source of calories in Nigeria as well as other parts of the world (Ado *et al.*, 2013). It is an excellent source of carbohydrate and good quality oil and it is more complete in nutrients when compare with other cereals such as sorghum. The protein content of maize is higher than that of paddy and polish rice. Maize is also a good source of minerals (Ado *et al*., 2013). According to West Africa Agricultural Productivity

Programme (WAAPP, 2014) maize is one of the most important staple food crops in Nigeria.

Crop varieties with outstanding performance should undergo extensive multi-location testing and promotion for adoption for commercial production. Consequently, much work has been done in the characterization of maize germplasm and this has led to continued improvement of the adaptive characteristics in relation to yield (Olaiya *et al*., 2019; Asare-Bediako, 2019), pest and disease resistance (Buso *et al*., 2019; Asare-Bediako, 2019; Craven and Fourie, 2011), striga resistance (Akinwale *et al*., 2013) and other adaptive features. Improved varieties have been developed which are suitable for cultivation in specific ecological zones. Field trials of these varieties have been conducted across several locations. For instance, two test locations, Mokwa and Abuja, both in the southern guinea savannah zones of Nigeria, have been routinely used for the evaluation of maize

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genotypes in the IITA Maize programmes (Akinwale *et al*., 2013).

The emergence of several seed companies in the West Africa sub-region have necessitated intensified efforts towards hybrid development and extensive testing. This is because the improved varieties vary in performances across locations. Consequently, the evaluation of the performances of cultivars in different ecological zones for adaptability is imperative and should be carried out on a continuous basis (Manggoel and Panwal, 2009). Akinwale *et al.* (2013) also posits that hybrids with outstanding performance should undergo extensive multi-location testing and promotion for adoption for commercial production. This study was aimed at the characterization of 26 maize varieties at Garkawa in the southern guinea savannah agro-ecology and to recommend outstanding varieties for commercial production of the crop in the study area.

**MATERIAL AND METHODS**

**Experimental site and materials**

The field experiments were carried out at the Teaching and Research Farm of Plateau State College of Agriculture, Garkawa, in 2018 and 2019 cropping seasons. The area lies on Latitude 10.11'N and Longitude 8.21'E and an altitude of 1,195m above sea level in the Guinea savanna ecological zone of Nigeria. The experimental site was a sandy loam soil and the climate is characterized by two distinct seasons; wet and dry. The wet season starts by late April and ends in October while the dry season starts in November and ends mid-April. The mean annual rainfall is about 1,450mm and a mean annual relative humidity of 60%. The mean monthly maximum and minimum temperature are 220C and 150C, respectively; (Da’ar *et al*, 2014).

The experimental materials (treatments) were made up of 26 maize varieties; namely: SDM 2, DUPONT P4226, OBA SUPER 3, SAMAZ 14, OBA SUPER 6, SAMAZ 48, SAMAZ 19, SDM 1, SAMAZ 37, SAMAZ 24, DUPONT P4063W, SC651, DUPONT 30Y87, SAMAZ 40, DUPONTP3 966W, SC719, SC649, SAMAZ 17, OBA SUPER 11, SAMAZ 39, OBA 98, SAMAZ 33, SAMAZ 18, SAMAZ 15, SDM 6 and SAMAZ 45 obtained from the National Seed Council (NSC) of Nigeria.

**Land preparation and field layout**

The land was ploughed using a disc plough, harrowed and ridged to give a fine tilth. A total of 78 plots were marked out and each plot was made up of a 3m length ridges. Each plot had 4 rows, spaced 75cm apart giving a net plot area of 3m x 3m (9m2). The space between blocks and between plots (discard) was 1m. The total land area used for the research work was 0.125ha (104m x 12m = 1248 m2).

**Experimental design and agronomic practices**

The experimental design used was randomized complete block design (RCBD) with three replications. The treatments were randomly allocated in the 26 plots within each replicate. The intra and inter row spacing was 25cm x 75cm. Weeding was done manually at 3 and 6 weeks after sowing (WAS). Fertilizer application was done in two split doses at the rate of 150 kg ha−1 NPK (15:15:15) and 100kg ha-1 NPK (20:10:10). Harvesting was carried out when the crops reached physiological maturity. This was when the cobs and shoots were dried.

**Data Ccollection and analysis**

The number of cobs produced on five sampled plants were counted and recorded to obtain the mean number of cobs/plant. The cob weight of the sampled plants was obtained using an electronic weighing scale. The husk of each cob was weighed and seed rows per cob counted. The numbers of seeds on each cob of the sampled plants were counted. The shelled seeds on each cob were weighed and recorded as mean number of seeds plant-1 and extrapolated to hectare equivalent. Data were analyzed using Genstat 10.3 DE statistical package and significant treatment means were separated using the least significant difference (LSD) at 5% level of probability (Obi, 2002).

The frequencies of better performance than grand variety means were recorded for significantly different treatment means. This was done by comparing each variety mean with the grand mean. Varietal performances were ranked and scored: 1st = 26 points, 2nd = 25 points…26th = 1 point. The total rank score was plotted by variety (Manggoel and Panwal, 2009).

**RESULTS AND DISCUSSION**

The mean, range, mean squares and coefficient of variations for the traits assessed averaged over two cropping seasons (2018 and 2019) for the 26 maize varieties are presented in Table 1. The analysis of variance showed that the means for the varieties differed significantly (p<0.05) for husk weight plant-1 (HW/P), cob weight plant-1(CW/P), seed weight plant-1(SW/P), number of seed plant-1 (NS/P), and grain yield (GY)**.** The significant differences in the mean and wide range for the traits considered implied there were discernable evidences of inherent genetic variability among the varieties, hence a wider scope for improvement of the crop (Manggoel *et al.,* 2012).

Results obtained for the two cropping seasons (2018 and 2019) were statistically similar and variety x year interaction were not significant (p<0.05); hence the data were averaged over the two cropping seasons (Table 2). The variety SAMAZ 15 recorded the highest mean value for HW/P (112.3g) which was above the grand variety mean (62.3g); and was statistically similar to the mean husk weight of SDM-2 (106.8g), SC651 (98.3g), OBA98 (91.1g), SAMAZ 48 (86.1g), OBA SUPER3 (83.2g), DUPONT P4226 (79.8g) and SAMAZ 45 (75.8g). The least mean husk weight was recorded for the variety DUPONT P3966W (32.9g), which was below the grand mean. Mean cob weight plant-1 (CW/P) followed the same trend (Table 2), with the variety SAMAZ 15 being distinct for mean value of CW/P (669.0g) which was above the grand mean (322.0g). The mean value for CW/P was still low for the variety DUPONT P3966W (185.0g), implying that maize varieties with higher husk weight plant-1 had corresponding higher cob weight plant-1. The significant statistical differences in mean husk weight and cob weight obtained in this study are evidence of variations in the yield potentials of the maize genotypes. Damiyal *et al.* (2017) reported significant treatment effect (*p≤0.05*) for husk weight plant-1 in an earlier report when the authors evaluated some hybrid maize varieties.

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| --- | --- | --- | --- | --- | --- |
| **Table 1:** Mean, range, mean squares, Fisher’s probability and coefficient of variations for 7 reproductive traits in maize averaged over two cropping seasons | | | | | |
| **Characters** | **Mean** | **Range** | **MS** | **Fpr** | **CV (%)** |
| Husk weight/plant(g) | 62.3 | 32.9 - 122.3 | 41.34\*\* | 0.044 | 18.3 |
| Cob weight/plant(g) | 322.0 | 185.0 - 669.0 | 123.67\*\* | 0.002 | 10.0 |
| Number of cobs/plant | 1.23 | 1.0 – 1.6 | 0.89ns | 0.825 | 4.4 |
| Seed row/cob | 13.04 | 12.0 -15.4 | 1.27ns | 0.674 | 1.8 |
| Seed weight/plant (g) | 263.91 | 157.5 - 479.5 | 167.40\*\* | <.001 | 18.4 |
| Number of seed/plant | 462.8 | 341.7 – 744.0 | 89.35\*\* | <.001 | 15.4 |
| Grain yield t/ha | 2.65 | 1.58 – 4.29 | 236.49\*\* | 0.029 | 4.9 |
| Fpr = Fisher’s probability; MS = Mean square (Genotype); CV = Coefficient of variation (%), \*\* = Significant at 1% probability; ns = not significant | | | | | |

Fig. 1: Rank score summed over cob and seed yields for 26 maize varieties

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2:** Mean values for husk weight, cob weight and number of cobs/plant for 26 maize varieties averaged over two growing seasons (2018 and 2019) | | | | | | | | | | |
| Varieties |  | HW/P(g) | | | CW/P (g) | | | NC/P | | |
|  |  | 2018 | 2019 | **Mean** | 2018 | 2019 | **Mean** | 2018 | 2019 | **Mean** |
| SDM 2 | 1 | 107.0 | 106.5 | 106.8 | 428.3 | 430.4 | 429.4 | 1.2 | 1.0 | 1.1 |
| DUPONT P4226 | 2 | 79.3 | 80.2 | 79.8 | 417.0 | 416.3 | 416.7 | 1.4 | 1.2 | 1.3 |
| OBA SUPER 3 | 3 | 83.3 | 83.0 | 83.2 | 364.6 | 361.3 | 363.0 | 1.0 | 1.2 | 1.1 |
| SAMAZ 14 | 4 | 59.0 | 59.2 | 59.1 | 295.7 | 294.1 | 294.9 | 1.4 | 1.4 | 1.4 |
| OBA SUPER 6 | 5 | 57.3 | 57.5 | 57.4 | 245.2 | 244.5 | 244.9 | 1.0 | 1.4 | 1.2 |
| SAMAZ 48 | 6 | 86.3 | 85.9 | 86.1 | 389.0 | 388.6 | 388.8 | 1.2 | 1.0 | 1.1 |
| SAMAZ 19 | 7 | 42.3 | 45.0 | 43.7 | 272.3 | 270.7 | 271.5 | 1.2 | 1.4 | 1.3 |
| SDM 1 | 8 | 60.0 | 61.2 | 60.6 | 273.3 | 275.0 | 274.2 | 1.4 | 1.2 | 1.3 |
| SAMAZ 37 | 9 | 45.7 | 45.5 | 45.6 | 299.0 | 300.3 | 299.7 | 1.4 | 1.4 | 1.4 |
| SAMAZ 24 | 10 | 45.7 | 45.4 | 45.6 | 282.6 | 281.7 | 282.7 | 1.0 | 1.0 | 1.0 |
| DUPONT P4063W | 11 | 51.3 | 50.9 | 51.1 | 306.6 | 305.4 | 306.0 | 1.4 | 1.0 | 1.2 |
| SC651 | 12 | 98.7 | 97.9 | 98.3 | 489.3 | 487.3 | 488.3 | 1.2 | 1.4 | 1.3 |
| DUPONT 30Y87 | 13 | 37.7 | 39.3 | 38.5 | 261.0 | 260.5 | 260.8 | 1.6 | 1.2 | 1.4 |
| SAMAZ 40 | 14 | 59.7 | 60.1 | 59.9 | 279.6 | 278.3 | 279.0 | 1.0 | 1.4 | 1.2 |
| DUPONTP3 966W | 15 | 32.7 | 33.1 | 32.9 | 185.3 | 184.6 | 185.0 | 1.0 | 1.0 | 1.0 |
| SC719 | 16 | 45.0 | 46.0 | 45.5 | 254.0 | 254.2 | 254.1 | 1.2 | 1.0 | 1.1 |
| SC649 | 17 | 62.0 | 62.3 | 62.2 | 269.6 | 268.6 | 269.1 | 1.4 | 1.4 | 1.4 |
| SAMAZ 17 | 18 | 57.3 | 58.4 | 57.9 | 225.3 | 224.9 | 225.1 | 1.6 | 1.4 | 1.5 |
| OBA SUPER 11 | 19 | 39.7 | 39.9 | 39.8 | 256.0 | 257.0 | 256.5 | 1.0 | 1.0 | 1.0 |
| SAMAZ 39 | 20 | 39.3 | 40.5 | 39.9 | 212.0 | 213.5 | 212.8 | 1.2 | 1.2 | 1.2 |
| OBA 98 | 21 | 91.7 | 90.5 | 91.1 | 417.3 | 418.9 | 418.1 | 1.2 | 1.0 | 1.1 |
| SAMAZ 33 | 22 | 59.7 | 60.6 | 60.2 | 381.5 | 380.5 | 381.0 | 1.4 | 1.4 | 1.4 |
| SAMAZ 18 | 23 | 50.3 | 51.3 | 50.8 | 273.9 | 272.1 | 273.0 | 1.0 | 1.2 | 1.1 |
| SAMAZ 15 | 24 | 113.7 | 110.9 | 112.3 | 669.6 | 668.4 | 669.0 | 1.6 | 1.6 | 1.6 |
| SDM 6 | 25 | 34.7 | 36.3 | 35.5 | 215.3 | 217.0 | 216.2 | 1.4 | 1.0 | 1.2 |
| SAMAZ 45 | 26 | 77.3 | 74.3 | 75.8 | 413.3 | 412.5 | 412.9 | 1.2 | 1.0 | 1.1 |
| GRAND MEAN |  |  |  | **62.3** |  |  | **322.0** |  |  | **1.23** |
| F-LSD (p<0.05) |  |  |  |  |  |  |  |  |  |  |
| Varieties (V) |  |  |  | **37.23** |  |  | **107.6** |  |  | **NS** |
| Year (Y) |  |  |  | **NS** |  |  | **NS** |  |  | **NS** |
| V x Y |  |  |  | **NS** |  |  | **NS** |  |  | **NS** |
| HW/P (g) = Hush weight/plant, CW/P (g) = Cob weight/plant, NC/P = Number of cobs/plant, NS = Not significant (p<0.05) | | | | | | | | | | |

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Seed parameters assessed in this study averaged over the two cropping seasons (2018 and 2019) are presented in Table 3. Though differences were recorded among the maize varieties in number of seed rows cob-1 (SR/C), the differences were not significant (p<0.05). Mean values for seed weight plant-1 (SW/P), number of seed cob-1 (NS/C) and grain yield (GY) were however, statistically significant (p<0.05) and ranged from 157.5g-479.5g, 341.7-744.0 and 1.58 - 4.29t/ha, in that order. The maize variety SAMAZ 15 was outstanding for SW/P (479.5g), NS/C (744.0) and GY (4.29t/ha), and was above the grand variety mean (SW/P=263.91g; NS/C=462.77; SW/ha= .65t/ha) for the three traits. The mean values of these traits for this same variety (SAMAZ 15) were however statistically similar to that of SC651 SW/P=418.0g; NS/C=704.5; GY=4.16t). Other maize varieties with SW/P, NS/C and GY above the grand variety mean included SDM-2, DUPONT P4226, OBA SUPER3, SAMAZ48, OBA98, SAMAZ15, and SAMAZ 45. The number of seeds plant-1 obtained in this study (Grand mean= 462.8; ranged 341.7-744.0) falls within that obtained when improved varieties were grown under optimum organic manure (cattle) recommended application of 5t/ha, which gave the highest number of seeds plant-1 of 625 (Damiyal *et al*., 2017). The mean grain yield obtained in this study

(1.58-4.29t/ha) is similar to the grain yield (1.84-3.48t/ha) reported by Sorsa and Kassa (2015). A recent study (Goshime *et al*., 2020) however, reported higher values (8.10-10.10t/ha) for grain yield of maize for some new selected maize hybrids under sole and inter crop systems in Ethiopia. The differences in yield obtained in these studies are obviously due to variations in the environmental conditions and genetic potentials of the maize genotypes used for the studies.

Frequency of better performance than grand means for parameters quantified (Table 4) identified eight varieties having high frequencies (3-5) for the five traits considered. Varieties within this category included: SAMAZ 15, SC651, OBA98, SDM-2, SAMAZ 45, SAMAZ 48, DUPONT P4226 and OBA SUPER3. These varieties also had high rank scores of between 90 and 130 (Fig. 1) and were within the 1st and the 8th position of ranking (Table 5). These varieties were regarded to have performed better (adapted) at the Garkawa agro-ecology. Three other varieties (SAMAZ 33, SAMAZ 14 and DUPONT P4063W) had moderate frequencies (1-2) of better varietal performance than grand mean as well as moderate rank scores (77-87). Frequencies of better performance than grand mean was used by Manggoel and Panwal (2009) to recommend seven elite varieties of cowpea within the Makurdi agro-ecology.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3:** Mean seed yields of 26 Maize varieties averaged over two growing seasons (2018 and 2019) | | | | | | | | | | | | |
| **Varieties** | **SR/C** | | | **SW/P (g)** | | | **NS/P** | | | **GY/ha (t)** | | |
|  | 2018 | 2019 | **Mean** | 2018 | 2019 | **Mean** | 2018 | 2019 | **Mean** | 2018 | 2019 | **Mean** |
| SDM 2 | 13.0 | 12.3 | 12.7 | 343.5 | 341.6 | 342.6 | 523.3 | 530.2 | 526.8 | 3.43 | 3.42 | 3.43 |
| DUPONT P4226 | 12.0 | 12.3 | 12.2 | 341.2 | 344.0 | 342.6 | 498.4 | 499.1 | 498.8 | 3.41 | 3.40 | 3.41 |
| OBA SUPER 3 | 12.3 | 13.0 | 12.7 | 293.4 | 295.7 | 294.6 | 411.1 | 413.6 | 412.4 | 2.93 | 2.89 | 2.91 |
| SAMAZ 14 | 13.3 | 13.0 | 13.2 | 246.6 | 247.8 | 247.2 | 465.4 | 469.0 | 467.2 | 2.46 | 2.46 | 2.46 |
| OBA SUPER 6 | 13.3 | 13.0 | 13.2 | 193.1 | 195.8 | 194.5 | 400.9 | 403.8 | 402.4 | 1.93 | 1.94 | 1.94 |
| SAMAZ 48 | 13.3 | 12.3 | 12.8 | 344.2 | 347.1 | 345.7 | 599.4 | 601.3 | 600.4 | 3.44 | 3.45 | 3.45 |
| SAMAZ 19 | 13.3 | 12.3 | 12.8 | 219.7 | 220.2 | 220.0 | 375.8 | 377.2 | 376.5 | 2.19 | 2.20 | 2.20 |
| SDM 1 | 14.3 | 12.0 | 13.2 | 221.4 | 225.3 | 223.4 | 428.3 | 430.2 | 429.3 | 2.21 | 2.21 | 2.21 |
| SAMAZ 37 | 12.7 | 13.0 | 12.9 | 252.5 | 253.5 | 253.0 | 445.5 | 448.3 | 446.9 | 2.52 | 2.53 | 2.53 |
| SAMAZ 24 | 12.3 | 12.0 | 12.2 | 243.1 | 243.9 | 243.5 | 379.2 | 378.9 | 379.1 | 2.43 | 2.44 | 2.44 |
| DUPONT P4063W | 13.0 | 13.3 | 13.2 | 262.9 | 260.3 | 261.6 | 465.4 | 469.3 | 467.4 | 2.62 | 2.61 | 2.62 |
| SC651 | 16.0 | 14.7 | 15.4 | 416.5 | 419.5 | 418.0 | 708.4 | 700.5 | 704.5 | 4.16 | 4.15 | 4.16 |
| DUPONT 30Y87 | 15.3 | 15.0 | 15.2 | 226.6 | 229.0 | 227.8 | 437.3 | 440.4 | 438.9 | 2.26 | 2.27 | 2.27 |
| SAMAZ 40 | 12.3 | 12.0 | 12.2 | 225.0 | 227.6 | 226.3 | 411.3 | 412.9 | 412.1 | 2.25 | 2.27 | 2.26 |
| DUPONTP3 966W | 13.0 | 13.3 | 13.2 | 154.8 | 160.1 | 157.5 | 382.4 | 389.1 | 385.8 | 1.55 | 1.60 | 1.58 |
| SC719 | 14.7 | 13.7 | 14.2 | 213.3 | 218.4 | 215.9 | 404.5 | 401.6 | 403.1 | 2.13 | 2.14 | 2.14 |
| SC649 | 13.3 | 13.3 | 13.3 | 228.6 | 229.5 | 229.1 | 375.8 | 376.4 | 376.1 | 2.28 | 2.28 | 2.28 |
| SAMAZ 17 | 13.3 | 13.0 | 13.2 | 179.3 | 180.1 | 179.7 | 350.6 | 356.2 | 353.4 | 1.79 | 1.78 | 1.79 |
| OBA SUPER 11 | 12.5 | 12.3 | 12.4 | 214.6 | 216.4 | 215.5 | 441.5 | 443.0 | 442.3 | 2.14 | 2.15 | 2.15 |
| SAMAZ 39 | 12.0 | 12.0 | 12.0 | 170.8 | 185.4 | 178.1 | 341.1 | 342.2 | 341.7 | 1.70 | 1.72 | 1.71 |
| OBA 98 | 13.0 | 13.3 | 13.2 | 352.5 | 354.7 | 353.6 | 591.3 | 590.4 | 590.9 | 3.52 | 3.52 | 3.52 |
| SAMAZ 33 | 11.3 | 13.7 | 12.5 | 234.4 | 237.2 | 235.8 | 468.5 | 466.9 | 467.7 | 3.34 | 3.30 | 3.32 |
| SAMAZ 18 | 12.7 | 12.6 | 12.7 | 224.6 | 229.5 | 227.1 | 361.2 | 365.4 | 363.3 | 2.24 | 2.25 | 2.25 |
| SAMAZ 15 | 14.3 | 13.3 | 13.8 | 478.4 | 480.6 | 479.5 | 746.6 | 741.4 | 744.0 | 4.28 | 4.30 | 4.29 |
| SDM 6 | 12.3 | 12.0 | 12.2 | 184.7 | 185.5 | 185.1 | 410.3 | 409.3 | 409.8 | 1.84 | 1.79 | 1.82 |
| SAMAZ 45 | 12.7 | 13.7 | 13.2 | 363.7 | 365.4 | 364.6 | 592.3 | 591.5 | 591.9 | 3.63 | 3.64 | 3.64 |
| **GRAND MEAN** |  |  | **13.04** |  |  | **263.91** |  |  | **462.77** |  |  | **2.65** |
| **F-LSD (p<0.05)** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Variety (V)** |  |  | **NS** |  |  | **63.25** |  |  | **159.62** |  |  | **1.01** |
| Year (Y) |  |  | NS |  |  | NS |  |  | NS |  |  | NS |
| V x Y |  |  | NS |  |  | NS |  |  | NS |  |  | NS |
| SR/C = Seed row/cob, SW/P (g) = Seed weight/plant (g), SW t/ha = Seed weight/ha, NS/P = Numbers of seed/plant, NS = Not significant | | | | | | | | | | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 4:** Frequency of better performance than grand variety mean\*\* for parameters quantified\* | | | | | |
| 5 | 4 | 3 | 2 | 1 | 0 |
| SAMAZ 15 | - | OBA SUPER 3 | SAMAZ 33 | SAMAZ 14 | SAMAZ 37 |
| SC651 |  |  | DUPONT | P4063W | SAMAZ 40 |
| OBA 98 |  |  |  |  | SDM 1 |
| SDM 2 |  |  |  |  | SAMAZ 24 |
| SAMAZ 45 |  |  |  |  | SC649 |
| SAMAZ 48 |  |  |  |  | DUPONT 30Y87 |
| DUPONT P4226 |  |  |  |  | SAMAZ 18 |
|  |  |  |  |  | OBA SUPER 11 |
|  |  |  |  |  | SAMAZ 19 |
|  |  |  |  |  | SC719 |
|  |  |  |  |  | OBA SUPER 6 |
|  |  |  |  |  | SAMAZ 17 |
|  |  |  |  |  | SDM 6 |
|  |  |  |  |  | SAMAZ 39 |
|  |  |  |  |  | DUPONTP3 966W |

|  |  |
| --- | --- |
| \*Parameters quantified | \*\*Grand variety means |
| Hush weight/plant (g) | 62.30 |
| Cob weight/plant (g) | 322.00 |
| Seed weight/plant (g) | 263.91 |
| Seed weight (t/ha) | 2.65 |
| Numbers of seed/plant | 462.77 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 5:** Rank score and position for better performance than grand variety mean  Characterization of some maize varieties in a guinea savannah agro-ecology | | | |
| S/N | VARIETY | RANK SCORE | POSITION |
| 1 | SDM 2 | 112 | 4th |
| 2 | DUPONT P4226 | 103 | 7th |
| 3 | OBA SUPER 3 | 90 | 8th |
| 4 | SAMAZ 14 | 77 | 11th |
| 5 | OBA SUPER 6 | 35 | 22nd |
| 6 | SAMAZ 48 | 110 | 6th |
| 7 | SAMAZ 19 | 37 | 20th |
| 8 | SDM 1 | 60 | 14th |
| 9 | SAMAZ 37 | 74 | 12th |
| 10 | SAMAZ 24 | 59 | 15th |
| 11 | DUPONT P4063W | 81 | 9th |
| 12 | SC651 | 124 | 2nd |
| 13 | DUPONT 30Y87 | 50 | 17th |
| 14 | SAMAZ 40 | 61 | 13th |
| 15 | DUPONTP3 966W | 10 | 26th |
| 16 | SC719 | 36 | 21st |
| 17 | SC649 | 57 | 16th |
| 18 | SAMAZ 17 | 25 | 25th |
| 19 | OBA SUPER 11 | 39 | 19th |
| 20 | SAMAZ 39 | 12 | 25th |
| 21 | OBA 98 | 114 | 3rd |
| 22 | SAMAZ 33 | 87 | 10th |
| 23 | SAMAZ 18 | 47 | 18th |
| 24 | SAMAZ 15 | 130 | 1st |
| 25 | SDM 6 | 22 | 24th |
| 26 | SAMAZ 45 | 112 | 4th |

**CONCLUSION**

Eight (8) varieties had mean cob and grain yields above grand variety mean and these varieties included: SAMAZ 15, SC651, OBA98, SDM-2, SAMAZ 45, SAMAZ 48, DUPONT P4226 and OBA SUPER3. The varieties also had high rank scores (90 - 130) and were within the 1st and the 8th positions of ranking among the 26 maize varieties. On the bases of the superior cob and grain yields these varieties were recommended for commercial maize production in the study area.

**ACKNOWLEDGEMENT**

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**REFERENCE**

Ado S.G, Abubakar I.U. and Mami H. (2013). Prospect of extra-early maize varieties in the Nigeria Savanna Zones. First National Conference of the Crop Science Society of Nigeria. (CSSN). Nsukka, pp 50-51

Akinwale R.O., Badu-apraku B. and Fakorede M.A.B. (2013). Evaluation ofstriga-resistant early maize hybrids and test locations under striga-infested and striga-free environments. *African Crop Science Journal*, 21 (1): 1 – 19

Asare-Bediako E., Taah K.J., Puije G.V., Amenorpe G., Appiah-Kubi, A. and Akuamoa-Boateng, S. (2019) Evaluation of Maize (*Zea mays* L.) Genotypes for High Grain Yield and Resistance to Maize Streak Virus Infections under Diverse Agro-Ecological Zones. *Res J Plant Pathol*, **2 (2),**  1-9

Buso W.H.D.; Gomes L.L.; Ballesta P.; Mora F. (2019).A phenotypic comparison of yield and related traits in elite commercial corn hybrids resistant to pests. *Idesia,* **37 (2) ,** 45-50

Damiyal D.M., Manggoel W. Ali S., Dalokom D.Y. and Mashat I.M. (2017). Effect of Cattle Manure and inorganic fertilizer on the growth and yield of hybrid maize (Zea mays L.). *World Research Journal of Agricultural Sciences*, **4 (1),** 102-110.

Craven M. and Fourie A.P. (2011) Field evaluation of maize inbred lines for resistance to *Exserohilumturcicum*. *South African Journal of Plant and Soil*, **28 (1)**, 69-74,

Da’ar J.W., Manggoel W., Loks N.A. and Mamzing D. (2014). Evaluation of Some Soil Properties at Kuru-Jos in the Nigerian Northern Guinea Savanna Ecological Zone. *Nigerian Journal of Crop Science*, **2 (1),** 14-17.

Goshime M.M., Solomon-Admassu S. and Alemayehu Z.L. (2020). Performance evaluation and selection of new maize hybrids under sole and inter crop production systems. Journal of Plant Breeding and Crop Science, **12 (3),** 219-227

Lu Y.L.; Yan J., Guimarães C.T., Taba S., Hao Z., Gao S., Chen, S., Li, J., Zhang S., Vivek B.S., Magorokosho C., Mugo S., Makumbi D., Parentoni S.N., Shah, T., Rong T., Crouch J.H. and Xu Y. (2009). Molecular characterization of global maize breeding germplasm based on genome-wide single nucleotide polymorphisms. *Theoretical and Applied Genetics*, **120 (1),**  93-115.

Manggoel W. and Panwal E.F. (2009). Preliminary Evaluation of 20 Elite Varieties of Cowpea at Markudi, Nigeria. *Gindiri Educational Forum: Journal of COEASU,* 1, 105-116.

Manggoel W., Uguru M.I., Ndam O.N. and Dasbak M.A. (2012). Genetic variability, correlation and path coefficient analysis of some yield Components of ten Cowpea *(Vigna unguiculata* (L.)Walp*)* accessions*. Journal of Plant Breeding and Crop Science,***4 (5*),*** *80-86* <http://www.academicjournals.org/jpbcs>

Obi I.U. (2002). *Statistical Methods of Detecting Differences Between Treatment Means and Research Methodology Issues in Laboratory and Field Experiments.* AP Express Publishers Ltd., Nsukka.117pp.

Olaiya A.O., Oyafajo A.T., Atayese M.O., Bodunde J.G. (2019).Field evaluation of extra early maize varieties in two agro ecological zones of Nigeria.*Biodiversity International Journal,* **3 (4),** 156‒160

Manggoel W.; Dasbak M.A; Badi S.H.; Da’ar J.W. and Mashat I.M.

Sorsa Z. and Kassa M. (2015). Evaluation of Yield Performance and Variation on its Adaptation-Related Traits of Quality Protein Maize (QPM) (Zea mays L.) Varieties at Selected Woredas of Wolaita Zone, Ethiopia. *International Journal of Plant Breeding and Genetics* **9 (4),**  255-261

USDA (2015). Crop production historical track records. National Agriculture Statistics Service, Washington, DC.

WAAPP (2014). Extension Bulletin of Maize Production, Marketing, Processing and Utilization. Extension Bulletin No. 217. Published by National Agricultural Extension Research Liaison Services, pp.3.

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**EFFECTS OF FERTILIZERS ON THE GROWTH AND YIELD OF UPLAND RICE *(Oryza sativa*L*.*) VARIETY IN SOUTHERN NIGERIA.**

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**ABSTRACT**

***The experiment was conducted at the University of Port Harcourt Teaching and Research farm, Port Harcourt in 2019 on the effect of fertilizers on the growth and yield of upland rice (Oryza sativa) variety in Port Harcourt, Rivers State. There were 4 treatments which included control, NPK 15:15:15, spent mushroom substrate and poultry manure. The experiment was done in a Randomized Complete Block Design with 4 replications and 4 treatments. The growth and yield contributing characters that were measured include: plant height, leave number, tiller number, leaf area, leaf area index, panicle length, panicle weight, grain yield, 1000 grain weight, fresh and dry weight of straw. The result showed that the fertilizers applied (organic and inorganic fertilizers) positively affected the growth and yield of the rice variety when compared with the control. The highest growth and yield were recorded in the plot treated with poultry manure, followed by spent mushroom substrate and NPK while the lowest was obtained in control. The experiment indicates that organic manure (poultry manure and spent mushroom substrate) gave better and higher yield than the inorganic fertilizer (NPK 15:15:15). Thus, the use of organic manures especially poultry manure was recommended for the cultivation of rice in the study area.***

**Key words:** Fertilizers, growth, yield, upland rice.

**INTRODUCTION**

Rice (*Oryza sativa*) is a staple food in the country and the most widely consumed according to FAOSTAT data (2012). It is the second most cultivated cereal crop worldwide and is central to the lives of billions of people around the world (Nguyen and Ferrero, 2006). Rice provides 23% of calories out of the 49% calories consumed by human population where wheat and maize provide 17% and 9% respectively (Subudhi*et al.,* 2006), thus almost one-fourth of the calories consumed by the entire world population comes from rice. Rice is one of the main sources of carbohydrate and also contains considerable amount of protein, minerals and vitamins (Naorem, 2018). Eighty-five percent of rice that is produced in the world is used for direct consumption. Rice is the only cereal crop that grow for a long period of time in standing water. Furthermore, 57% of rice is grown on irrigated land, 25% on rain fed lowland, 10% on uplands, 6% in deep water and 2% in tidal wet lands (Chopra, 2002).

Today, global agriculture is at a crossroad as a consequence of increased population, climate change and detrimental environmental effect. The increasing population imposes the need for more food and more pressure on crop production from available cultivable land with limited available resources. Application of suitable fertilizers is one of the ways to attain maximum crop yield. Chemical fertilizer has been the major supplier of nutrients besides organic manure and its use has been the headpin of modern agriculture. This undoubtedly boosted the food production but at the same time showed detrimental effects on physiochemical properties of soil, nitrogen transformation, micro and macro nutrient uptake and nutritional composition (Mahesh and Hosmani, 2004). However, the simultaneous use of chemical fertilizer and organic manure has revealed diverse result relative to the plant types and soil characteristics. Chad *et al., (*2016), reported that mixed use of nitrogen, phosphorus and potassium (chemical fertilizer) and organic manure increases the mean growth of Mints.

Organic materials are the safer sources of plant nutrient without detrimental effect to crop and soil. Examples of organic materials include poultry droppings, cattle dung, farm yard manure, green manure are excellent sources of organic matter as well as major and secondary plant nutrients (Pieters, 2004). Organic manures leave behind sufficient residual effect for the sequence crops (Singh *et al.,*1996). The use of various sources of organic material has been promoted as one of the principal sustainable management options for improving soil quality and productivity (Wagner *et al.,* 2002). Energy crises, higher fertilization cost, sustainability in agricultural production system and ecological stability are the important issues which triggers the interest of researchers and farmers to the use of non-chemical fertilizers such as farm yard manure (FYM), compost, poultry manure, bio fertilizers, etc. and the balanced use of nutrients through organic materials are pre-requisite to sustain soil fertility, produce maximum crop yield with optimum input level (Dahiphale*et al.,* 2003).

Spent mushroom substrate (SMS) is the leftover of wastes after different flushes of mushroom have been harvested. This growing substrate may be composed of different waste materials such as sawdust, rice straw, bedded horse manure, paper waste, cocoa shells, cotton wastes, wheat straw, maize husk and other various waste (Jonathan *et al.,*2011). After the cultivated mushroom have exhausted the nutrients within the substrates and there are no more fruit bodies to harvest, the so called remains regarded as useless material is known as spent mushroom substrate (Fasidi*et al*., 2008). Spent mushroom substrate is believed to be a source of humus formation and humus is known to provide plants with micro nutrients which improve soil aeration, soil water holding capacity and also helps to maintain soil structure (Chang and Yau, 1981). It has been reported that spent mushroom substrate contains nutrients which could be used for the growth of plants and these materials are generally non-toxic to cultivated plants and spent mushroom have also been reported to contain cellulose and lignin which is important for soil improvement and safe for human consumption (Orluchukwu and Ugwu, 2018b).

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Poultry manure also known as chicken manure provides nutrient for cultivated plant and it is an excellent material for soil amendment that improves soil quality because of its high organic matter content and available nutrients for plant growth (Van Ryssen*et al*., 1993). Poultry manure has been reported to contain more plant nutrient than other organic materials or manure (Ali, 2005). Poultry manure is an excellent organic fertilizer as it contains high NPK and other essential plant nutrients (Boateng*et al*., 2006). Nitrogen-Phosphorus-Potassium (NPK) fertilizer is a complex fertilizer comprised primarily of three (3) primary nutrients required for plant growth. The agricultural industry relies heavily on the use of NPK fertilizer to meet global food supply and ensure healthy crops (Carrie and Shane, 2019). Rice production is facing serious constraints including declining rate in growth and yields, depletion of natural resources such as soil and the high cost of inorganic fertilizers are beyond the reach of local farmer in developing countries like Nigeria.The hazardous environmental effect makes inorganic fertilizer undesirable and also uneconomical. Hence, the alternative source of organic manures which would enhance the growth and production of rice by farmers and is environmentally friendly. This experiment is to determine the effect of organic manure (poultry dropping and spent mushroom substrate) and inorganic fertilizer (NPK) that would increase the yield and growth of upland rice variety.

**MATERIALS AND METHOD**

**Experimental site**

The experiment was carried out at the University of Port Harcourt, Faculty of Agriculture Teaching and Research Farm. University of Port Harcourt lies on latitude 40 54’N and longitude 60 55’E, with an average temperature of 270 C, relative humidity of 78% and average rainfall that ranges from 2500-4000mm (Nwankwo and Ehirim, 2010). The experimental land area of 10m x 17m (170m2) was marked out. The land was cleared using simple farm tools such as cutlass, shovels. The land was cleared to remove excess vegetation. The land was mapped using pegs and twine to avoid or reduce experimental error. Tillage and bed preparation of 2m x 3m was done using simple farm tools such as hoes and shovels.The area was marked into blocks and plots and each plot had a dimension of 2m x 3m (6m2) and 0.5m alleyway for easy movement. The statistical design was a simple Randomized Complete Block Design (RCBD) of four (4) treatments with four (4) replications. The treatments include spent mushroom substrate, poultry manure, and inorganic (NPK) fertilizer and control. The spent mushroom substrate and poultry manure was applied at the rate of 10,000kg per hectarerandomly and was incorporated into the soil before planting using shovel.Soil samples were collected before planting at the depth of 15cm which was analyzed for the presence and percentage of Nitrogen (N), Phosphorus (P) and Potassium (K), Calcium (Ca), Magnesium (Mg), organic matter in the soil and soil pH.The treatments, poultry manure and spent mushroom substrate were also analyzed for the afore mentioned parameters except for organic matter content.Spent mushroom substrate and poultry manure were added to the designated experimental unit randomly at the rate of 10,000kg per hectare before planting and the inorganic fertilizer (NPK) was added at the rate of 108kg per hectaretwo weeks after planting.

The seeds were sown directly by seed dibbling in holes less than 2cm depth with a planting space of 30cm within rows and 30cm between rows. Two seeds were planted per hole. Proper weeding was employed to control weed infestation and pest that uses weed as an alternative host

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**Data Collection**

The initial fertility status of the soil was collected and recorded. Data collection was done at an interval of two weeks. Data was collected on growth parameters such as plant height, number of leaves, number of tillers, leaf area, leaf area index, and the yield parameter collected were on grains and the 1000 grain weight (dry matter weight), weight of panicles, length of panicles, fresh and dry weight of straw which was obtained after harvesting manually, in which the tillers was weighed and recorded and the dry weight after sun drying. Data was obtained from 3 plants using random selection in each experimental unit and the mean was collected from the representative sample of the population. The parameters taken were analyzed statistically using analysis of variance (ANOVA)and the means were separated using least significance difference (LSD) at 5% level of probability using statistical GenStat release, version 12.1 package.

**RESULTS**

**Chemical analysis of soil and organic materials**

The result of the chemical analysis of the soil taken before planting and those of the organic materials which are poultry manure and spent mushroom are shown in Table 1. The result indicates that total nitrogen of the soil recorded 0.08%, available Phosphorus recorded 18.6mg/kg, potassium recorded 0.08 cmol/kg, Magnesium recorded 2.21 cmol/kg, Calcium 1.72 cmol/kg and Organic matter recorded 3.5% with pH of 5.2 which is acidic. For organic manure used, poultry manure and spent mushroom after analysis, the result indicates that poultry manure and spent mushroom substrate has a pH of 7.1 and 6.4 respectively and total nitrogen was 4.8% and 1.74% respectively, available Phosphorushad 9.7 mg/kg and 1.73 mg/kg respectively, Potassium was 1.8 Cmol/kg and 2.26

Cmol/kg respectively, Magnesium was 2.01 cmol/kgand 1.94 cmol/kg respectively while Calciumwas 2.31 cmol/kg and 1.95 cmol/kg respectively.

**GROWTH PARAMETERS**

The effects of poultry manure, spent mushroom substrate and NPK I5:15:15 on plant height, number of leaves and number of tillers, leaf area are represented in the Tables below.

**Effect of fertilizers on Plant height (cm) of rice**

The effects of fertilizers on plant height at 4 weeks and 14 weeks after planting, is statistically significant(P< 0.05)but at 6weeks to 12weeks after

planting, there were no Significant (P>0.05)difference between treatment means. However, from observations using the raw data collected from the plot, the highest plant height was obtained from the plot treated with poultry manure at 4-14weeks after planting with a mean range of 36.02 - 79.36cm, followed by spent mushroom substrate (31.19 - 75.89cm), and by NPK 15:15:15 (30.11-70.32cm) and then control which has the mean range (28.78 - 64.39cm).

**Effect of fertilizers on Number of leaves of rice**

The number of leaves from 4weeks to 14weeks after planting in Table 3 is not statistically affected for all treatment means at 0.05 probability level of significance. However, from observations using the raw data collected from the plot, the highest number of leaves was obtained from the plot treated with poultry manure at 4 -10weeks after planting with a mean range of 9.33 - 45.92, followed by spent mushroom substrate (8.58 - 44.42), and NPK 15:15:15 (8.25 - 41.4) while control had mean range value of 8.08 -32.92 but at 12 weeks and 14 weeks after planting, spent mushroom substrate increased with the highest mean number of leaves followed by poultry manure, NPK 15:15:15 and then control.

**Effect of fertilizers on Number of tillers of rice**

The number of tillers as shown in Table 4 shows that there is no statistically significant difference for all treatments means at 0.05 probability level of significance at 4weeks, 6 weeks, 8weeks and 10 weeks after planting, but at 12weeks and 14 weeks after planting, there were significant(P<0.05) difference among treatment means. Nevertheless, from observations using the raw data collected from the plot, the highest number of tillers was obtained from the plot treated with poultry manure at 4-10weeks after planting with a mean range of 2.33 - 11.75, followed by spent mushroom substrate (2.08-10.25), and NPK 15:15:15 (1.92-10.17) but the control had the mean range of 2.00 - 8.17at 12 weeks and 14 weeks afterplanting, but spent mushroom substrate had the highest mean number of tillers followed by NPK 15:15:15, poultry manure and then control.

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 1.** Chemical analysis of soil and organic materials | | | |
| **Chemical properties Materials** | | | |
| **Soil poultry manureSpent mushroom substrate** | | | |
| pH | 5.2 | 7.1 | 6.4 |
| N(%) | 0.08 | 4.8 | 1.74 |
| P(mg/kg) | 18.6 | 9.7 | 1.73 |
| K(cmol/kg) | 0.08 | 1.8 | 2.26 |
| Mg(mg/dl) | 2.21 | 2.01 | 1.94 |
| Ca(mmol/l) | 1.72 | 2.31 | 1.95 |
| Organic matter (%) | 3.5 |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 2:** Effect of fertilizers on plant height | | | | | |
| TREATMENTS | | | LEAF AREA (cm2) | | |
| 4WAP | 6WAP | 8WAP | 10WAP | 12WAP | 14WAP |
| CONTROL 28.78 | 40.55 | 46.20 | 51.12 | 53.79 | 64.39 |
| NPK15:15:15  30.11 | 42.54 | 47.67 | 57.39 | 60.82 | 70.32 |
| SMS31.19 | 45.53 | 52.01 | 57.39 | 67.01 | 75.89 |
| PM36.02 | 46.23 | 53.62 | 60.4 | 66.68 | 79.36 |
| LSD(0.05) 7.03 | 8.39 | 10.69 | 52 |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 3:** Effect of fertilizers on number of leaves | | | | | |
| TREATMENTS | | | NUMBER OF LEAVES | | |
| 4WAP | 6WA | 8WAP | 10WAP | 12WAP | 14WAP |
| CONTRO 8.08 | 14.17 | 22.42 | 32.92 | 45.00 | 54.58 |
| NPK15:15:15 8.25 | 17.25 | 26.42 | 41.4 | 55.75 | 65.33 |
| SMS 8.58 | 15.67 | 25.75 | 44.42 | 73.25 | 85.6 |
| PM 9.33 | 17.33 | 27.92 | 45.92 | 64.67 | 66.25 |
| LSD (0.05) 3.26 | 7.78 | 13.35 | 20.97 | 39.54 | 21.02 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 4:** Effect of fertilizers on number of tillers | | | | | |
| TREATMENTS | | | NUMBER OF TILLERS | | |
| 4WAP | 6WAP | 8WAP | 10WAP | 12WAP | 14WAP |
| CONTROL 2.00 | 3.50 | 5.17 | 8.17 | 9.33 | 10.92 |
| NPK15:15:15 1.92 | 4.50 | 5.92 | 10.17 | 11.67 | 13.25 |
| SMS2.08 | 4.17 | 5.75 | 10.25 | 12.25 | 14.08 |
| PM2.33 | 4.83 | 7.00 | 11.75 | 11.75 | 12.42 |
| LSD (0.05) | 1.04 | 2.61 |  |  |  |

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**Effect of fertilizers on Leaf Area (cm2)**

The effects of fertilizers on leaf area are in Table 5 and it showed that the leaf area at 4weeks, 8weeks, 12 weeks and 14weeks after planting, is statistically significant for all treatment means at 0.05 probability level of significancewhile at 6weeks and 10weeks there were no significant difference among treatments. However, from observations using the raw data collected from the plot, the highest leaf area was obtained from the plot treated with poultry manure at 4 - 14weeks after planting with a mean range of 12.74 - 49.65cm2, followed by spent mushroom substrate (9.73 - 49.08cm2), and NPK 15:15:15 (8.74 - 36.33cm2) while control had the mean range of 9.52 - 28.35cm2.

**Effect of fertilizers on Leaf area index (cm2)**

Table 6 showed that the leaf area index at 4weeks, 6 weeks, 8weeks and 10 weeks after planting is not statistically significant for all treatment means at 0.05 probability level of significance but was statistically different at 12weeks and 14 weeks after

planting. However, from observations using the raw data collected from the plot, the highest leaf area index was obtained from the plot treated with poultry manure at 4-8weeks after planting with a mean range (0.11-0.67cm2), followed by spent mushroom substrate (0.08-0.58cm2), followed by NPK 15:15:15 (0.07-0.56cm2) and then control which has the mean range (0.07-0.69cm2) and at 12 weeks and 14 weeks after planting, spent mushroom substrate increased with the highest   
mean in number of leaves followed by poultry manure, NPK 15:15:15 and then control.

**Yield Parameters**

The effect of NPK 15:15:15, spent mushroom and poultry manure on panicle weight, panicle yield, fresh and dry weight of tillers, weight of grains and 1000 grain weight is represented in Table 7. From the first week after planting till end of harvest, the P-value is greater than ᾱ (0.05) for panicle length, 1000 grain weight, fresh and dry weight of straw which implies that the test is not statistically significant for all treatment means at 0.05 probability level of significance. However, from observations using the raw data collected from the plot, the highest panicle length (cm), was obtained from the plot treated with poultry manure at 14 weeks after planting, followed by spent mushroom substrate, and NPK 15:15:15 before control. Also, there were significant difference in the treatments means for panicle weight (g), although the highest weight was obtained from the plot treated with poultry manure followed by spent mushroom substrate, and NPK 15:15:15 before control. The 1000 Grain weight from the same Table 7 showed that the P-value is greater than ᾱ (0.05) which implies that the test is not statistically significant for all treatment means at 0.05 probability level of significance. However, from observations using the raw data collected from the plot, the highest 1000 grain weight (cm) was obtained from the plot treated with poultry manure at 4-14 weeks after planting, followed by spent mushroom substrate, followed by NPK 15:15:15 and then control. Also, there was no significant difference in the treatments

means for panicle weight (g), although the highest weight was obtained from the plot treated with poultry manure followed by spent mushroom

substrate, followed by NPK 15:15:15 and then control.

Also, from the same Table 7, the fresh and dry weight of tillers after harvest showed that the P-value is greater than ᾱ (0.05) which implies that the test is not statistically significant for all treatment means at 0.05 probability level of significance. But the raw data collected from the plot, the highest fresh and dry weight of tillers (Kg) was obtained from the plot treated with poultry manure at 4-14 weeks after planting, followed by NPK 15:15:15, spent mushroom substrate and then control. Whereas the grain yield was statistically significant in the treatment means with poultry manure having the highest grain yield when compared to control.

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**DISCUSSION**

The result obtained from the soil analysis indicates that the soil had the pH of 5.2 implying that the soil is acidic and is below the pH range of 5.5-6.5 that is required for maximum availability of nutrient and support optimum plant growth (Stewart, 2006). The total nitrogen in the soil is low which is below the critical level of 0.15% (FDALR, 2004) and this could be attributed to mineralization and leaching effect caused by intensive rainfall in this part of the country. The soil had a high organic matter content of 3.5% as against the critical value of 2% as reported by (Loveland and Webb, 2003) which could be attributed to bush fallowing and crop residues. The available phosphorus was higher with the value of 18.6 compared with the critical value of 15mg/kg reported by Ibedu*et al.,* 1988, thus phosphorus was soluble and available for plant use. The soil had a high calcium content of 1.72cmol/kg when compared to the critical value of 0.5cmol/kg, potassium was low as against the critical value of 0.20cmol/kg and magnesium had a high content of 2.21 when compared to the critical value of 0.30cmol/kg according to Ibedu*et al.,*1988. The chemical properties of the organic material before planting shows that pH of poultry manure and spent mushroom substrate were close to neutral and poultry manure had higher content of nitrogen, phosphorus, magnesium, calcium than spent mushroom substrate while spent mushroom substrate was higher in potassium than poultry manure. Addition of different fertilizers (organic and inorganic) significantly increased plant height, number of leaves, number of tillers, leaf area when compared to control. The nutrients available in the various fertilizers used enhanced the plant height and leaf area which resulted in higher assimilates and dry matter accumulation as supported by the earlier findings of Swarup and Yaduvanshi (2000) and Yadana*et al., (*2009).

The application of organic fertilizers increases plant height, number of tillers, number of leaves, leaf area. As indicated, poultry manure increased plant height, number of tillers in comparison with other fertilizers which may be attributed to greater availability of nutrients as stated by Sivakumar*et al.,* (2007) and Nguyen *et al.,* (2004). Availability of nutrient from organic sources is due to microbial action and improves soil physical condition as stated by Sarkar *et al.,* (2004). The variation in number of leaves is attributed to the variation in the availability of major nutrients as Yadana*et al.,* (2009) reported similar results with the application of organic manure and compost in rice. Rice panicle weight and grain yield was also significantly different among the various treatments. These observations obviously are due to the availability of more nutrients following the application of soil amendment treatment relative to the control treatment.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 5:** Effect of fertilizers on leaf area | | | | | |
| TREATMENTS | | | LEAF AREA (cm2) | | |
| 4WAP | 6WAP | 8WAP | 10WAP | 12WAP | 14WAP |
| CONTROL9.52 | 14.09 | 18.92 | 22.90 | 22.29 | 28.35 |
| NPK15:15:158.74 | 17.10 | 21.32 | 26. 95 | 26.76 | 36.33 |
| SMS 9.73 | 17.85 | 24.76 | 33.91 | 33.63 | 49.08 |
| PM 12.74 | 19.30 | 26.26 | 32.21 | 33.80 | 49.65 |
| LSD (0.05)4.03 | 4.94 | 7.81 | 10.53 | 8.97 | 5.73 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 6:** Effect of fertilizers on leaf areaIndex | | | | | |
| TREATMENTS | | | LEAF AREA INDEX (cm2) | | |
| 4WAP | 6WAP | 8WAP | 10WAP | 12WAP | 14WAP |
| CONTROL0.07 | 0.19 | 0.39 | 0.69 | 1.40 | 1.39 |
| NPK15:15:150.07 | 0.28 | 0.56 | 1.09 | 1.40 | 2.21 |
| SMS 0.08 | 0.25 | 0.58 | 1.39 | 2.64 | 3.38 |
| PM 0.11 | 0.30 | 0.67 | 1.34 | 1.97 | 2.96 |
| LSD (0.05) 0.05 | 0.17 | 0.41 | 0.85 | 1.38 | 1.49 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 7:** Effect of fertilizers on Yield parameters | | | | | | |
| TREATMENTS Panicle | Panicle Grain | | | 1000 Grain Fresh weight Dry weight | | |
| length(cm) | weight(g) | weight(g) | weight(g) | | ofstraw(Kg) | ofstraw(kg) |
| CONTROL 21.73 | 25.52 | 33.38 | 6.75 | | 1.38 | 0.78 |
| NPK15:15:15 22.41 | 32.38 | 54.70 | 6.75 | | 1.63 | 1.05 |
| SMS 22.47 | 34.42 | 62.20 | 7.500 | | 1.38 | 1.00 |
| PM 23.72 | 50.02 | 90.90 | 8.500 | | 2.25 | 1.43 |
| LSD (0.05)2.82 | 23.13 | 40.52 | 2.33 | | 1.09 | 0.91 |

Dhanasekaran and Govindasamy (2002) reported that the availability of nutrients during reproductive stage resulted in better grain filling and as a result grain weight is increased hence the significant increase in 1000 grain weight by the addition of fertilizers compared to control, and with poultry manure as the highest in 1000 grain weight followed by spent mushroom substrate and NPK. The plot treated with poultry manure had a higher growth and yield when compared to spent mushroom substrate which is probably due to poultry manure which was richer in nutrient (Umanah*et al.,* 2009). The best growth and yield characteristics were obtained from the plots treated with poultry manure which is in accordance with similar result findings of Orluchukwu and Adedokun (2014) who reported higher growth and yield in pineapples treated with poultry manure over those treated with spent mushroom substrate. Also, Orluchukwu and Okosa (2018a) reported higher growth and yield in okra treated with poultry manure over those treated with spent mushroom substrate. In conclusion, the result of the study shows that the rice variety responded positively to the various treatment applications. The highest plant height, number of tillers, leaf area, grain and 100 grain yield, panicle length and weight and also the fresh and dry weight of straws were found in poultry manure, while the Spent mushroom had the highest number of leaves, and the lowest values were obtained from control treatment.

Effects of fertilizers on the growth and yield of upland rice *(oryza sativa*l*.*) Variety in southern Nigeria**.**

**REFERENCES**

Ali G.A., (2005). Uses of manure and fertilizer as soil management technique for suitable crop production, Paper presented at Workshop

Organized by Taraba State Local Government Service Commission.

Boateng S.A., Zickermann, J. and Kornahrens, M., (2006). Poultry manure effect on growth and yield of maize. West Africa Journal of Applied Ecology.Carrie, C. and Shane, L.C.(2019). Agricultural revolution demands specialty fertilizers and soil amendments. Retrieved from feeco.com.

Chad S., Anwar M., Palra DD. (2016). Influence of long-term application of organic and inorganic fertilizer to build up soil fertility and nutrient uptake in mint mustard cropping sequence. Commun Soil Sci. Plant Anal **37(1-2),** 63-76.

Chang S.T. and Yau P. (1981). *Production of mushroom, food and crop fertilizer from organic wastes*. In Global Impact of Applied Microbiology. Academic Press, New York, pp. 647-652.

Chopra V.L and Prakash S. (2002). Evolution and adaptation of cereal crops (Ed). Science Publishers Inc, NH, USA. (Gramene Reference ID 8381).

Dahiphale A.V.; Giri, D.G. Thakre, G.V. and Gin, M.D. (2003). Effect of integrated nutrient

management on yield contributing parameters of the scented rice. Annal. Plant physiol., **17 (1),**  24-26.

Dhanasekaran K. and Govindasamy R., (2002). Effect of Urea coated with lignite derived humic substances on the performance of rice in a typicChromustert soil. Adv. Plant Sci.:**15 (2)** 505-509.

Fasidi I.O., Kadiri M., Jonathan S.G., Adenipekin O.O., Kuforiji (2008). Cultivation of tropical mushrooms. Ibadan University Press.

FAOSTAT (Food and Agricultural Organization Statistics (2012).[www.faostatfao.org/.[Accessed](http://www.faostatfao.org/.%5bAccessed) 17 September 2019].

FDALR (Federal Department of Agric Land Resources) (2004). Handbook on soil test- Based fertilizer Recommendation for Extension Workers. National special programme for food security. pp:39.

Ibedu M.A., Unammra RPA. and Udealor, A. (1988). Soil management

strategies in relation to farming system development in southwestern agricultural zone of Nigeria. Paper presented

at the national farming system research workshop, Jos, Plateau State Nigeria.

Jonathan S.G., Lawal, M.M and Oyetunji, O. J. (2011). Effect of spent mushroom compost of Pleurotuspulmonanuson growth performance of four Nigerian leafy vegetables. mycology.**39,** 164-169.

Loveland, P. and Webb, J. (2003). Is there a critical level of organic matter in the agricultural soils of temperate regions: a review. Soil and Tillage Research **70 ,**1-8

Mahesh, M.K. &Hosmani, S.P., (2004). Effects of pesticides and herbicides, fumigants and

synthetic fertilizers on the nutrient’s uptake of rice. *Journal of current science*., **5,**  433-438.

Naorem, L.C. (2018). Effect of organic manures and chemical fertilizers on the yield of rice seed “lalat”. International Journal of current Microbiology and Applied Science. ISSN:2319.7706 Vol 7, No 10.

Nguyen, B.V., Olk, D.C. and Cassman, K.G., (2004). Nitrogen Minerilization from Humic Acid Fractions in Rice Soils- Depends on degree of humification. Faculty Publication-Agronomy and Horticulture

Nguyen, N.V. and Ferroro, A. (2006). Meeting the challenges of global rice production. Paddy water Environ., **4**, 1-9

Nwankwo, C.A. and Ehirim, C.A., (2010). Evaluation of aquifer characteristics and ground water characteristics using geo-electric method in Choba, Port Harcourt. *Journal of Scholars Research library* **(2),** .396-403.

Orluchukwu, J. A. and Okasa, E.U., (2018a). Effects of spent mushroom substrate and poultry manure on growth and yield of okra (*Abelmoschusesculentus*L. Moench) in Port Harcourt, Rivers State. *International Journal of Agriculture and Earth Science, Vol.4*, No.2 ISSN 2489-0081.

Orluchukwu, J.A., and Ugwu, C., (2018b). Response of upland rice (*Oryza sativa*) varieties to poultry manure and spent mushroom substrate in humid agro ecology of South-South, Nigeria. *International Journal of Agronomy and Agricultural Research(IJAAR), Vol. 12*, No.5, pp. 9-8. ISSN: 2223-7045

Orluchukwu, J.A. and Adedokun, O.M., (2014). Comparable effect of poultry manure and spent mushroom substrate on the growth ad yield of pineapple (*Ananascosmosus*) in Nigeria. *African Journal of Agricultural Research.Vol.* **9(26),** .pp. 2041-2044.

Orluchukwu J.A. and Kari L.B.

Pieters, A.J., (2004).Green manuring: Principles and practices. Agrobios, Jodhpur. pp.356.

Sarkar, MAR, Pramanik MYA, Faruk GM. and Ali MY., (2004). Effect of green manures and levels of nitrogen on some growth attributes of transplanted rice. *Parkistan J. Bio.Sci.*7, *739-742.*

Singh, A. Singh, R.D., Awasthi, R. (1996). Organic and inorganic sources of fertilizers for sustained productivity in rice- wheat sequence on humid hilly soils of Sikkim.

SivaKumar, K., Devarajan, L., Dhanasekaran, K., Venkatakrishnan, D.andSurendran, U., (2007). Effect of humic acid on the yield and nutrient uptake of rice.ORYZA-*An International Journal on Rice;***44(3),** 277-279.

Subudhi, PK., Sasaki, T., Khush, GS. (2006). Rice. In C.Kole (Ed). Genome mapping and molecular breeding in plants (1). Cereals and millets, Springer-Verlag Berlin Heidelberg.

Swarup, A., Yaduvanshi, NPS. (2000). Effect of integrated nutrient management on soil

properties and yield of rice in Akali soils*. J. Indian Soc. Soil Sci.*; **48,**  279-282.

Stewart, D.P. (2006). The effect of spent mushroom compost on soil conditions and plant growth[dissertation].

Umanah, EE., Ekpe EO., Ndon, Ba., Etim, ME and Agbogu, MS. (2009). Effects of poultry manure on growth characteristics, yield and yield components of upland rice in south Eastern Nigeria. J. Sustainable Agric and Environment **5(1),**

Van- Ryssen, J.B.J., van Malsen, S. and Verbeeek, A.A. (1993). Mineral composition of poultr manure in south Afica with reference to the farm feed Act. *South African Journal of Animal Science, vol.* **23, no.2**, pp 54-57.

Wagner, W. Gawel, J., Furami, H., Pereira de souza, M.; Texeira, D., Rios, L., Ohgaki, S.,

Zehnder, A. and Hemond, H.F (2002). Sustainable watershed management: a

international multi watershed case study. Ambio **31**, 2-13

Yadana K.L., Aung, K.M., Takeo, Y.a. and Kazuo, O., (2009). The Effects of Green Manure

(Sesbania and rostrata) on the Growth and Yield of Rice. *J. of Faculty of Agric. Kyushu University.* **54(2),** *313-319.*