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GROWTH, YIELD AND YIELD COMPONENTS OF CARROT (*Daucus carota* L.) VARIETIES AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZER COMBINATIONS IN ULTISOLS OF SOUTH-EASTERN NIGERIA

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ABSTRACT
Carrot (Daucus carota L.) is grown and consumed globally. Fertilizer enhances the soil environment to increase crop production. A study to determine the influence of variety and fertilizer combination on growth, yield and components of yield was conducted at the research farm of Department of Crop Science, University of Nigeria, Nsukka. Three carrot varieties; Graffas, Carrot Touchon and Nantes were tested using the following fertilizer rates: 10 t/ha of poultry manure (PM) + 200 kg of NPK 15:15:15 [PM (10 t) + NPK (200 kg)], 20 t/ha of pig manure (PIG) + 200 kg of NPK 15:15:15 [PIG (20 t) + NPK (200 kg)], 350 kg of NPK 15:15:15 [NPK (350 kg)] and control (0 t/ha). Data were collected on seedling emergence dates, survival count, leaves weight, root weight, whole plant biomass yield, harvest index, root circumference, root length, yield/ha, marketable yield, root uniformity and number of sorting groups. Carrot Touchon and Graffas were similar in their response and performed significantly (p < 0.05) better than Nantes in all the growth and yield parameters measured. However, among the fertilizer treatments, PIG (20 t) + NPK (200 kg) had a better influence on seedling emergence rate and survival count. PM (10 t) + NPK (200 kg) had a better influence on all the yield parameters except on harvest index where PIG (20 t) + NPK (200 kg) had the highest percentage mean value (61 %). Plots grown without fertilizer had poor performance on all the parameters considered, although, they had similar effect with NPK (350 kg) on leave weight and harvest index. Carrot Touchon and Graffas with the inherent ability to yield optimally may be the ideal carrot varieties to consider in an ultisol of Southeastern Nigeria. The use of PM (10 t) + NPK (200 kg) and PIG (20 t) + NPK (200 kg) in carrot production however improved carrot yield.

Keywords: Carrot variety; Organic fertilizer; Inorganic fertilizer; Ultisols; Yield components.

INTRODUCTION

Carrot (*Daucus carota* L.) is a member of the *Apiaceae* family and closely related to parsley, parsnip, cumin, and hemlock (Green, 2018). It is an important root vegetable crop grown and consumed all over the world. The root is eaten fresh or cooked. The nutritional and health role of carrot cannot be overemphasized. The healing properties of carrots from ages include prevention of vitamin A deficiency, relieving diarrhea, promoting urine and improving premenstrual symptoms (Fiorella *et al*., 2020). The high composition of carotene (alpha and beta) traits in the carrot roots is also implicated in its health benefits (Okoye, 2019). Nutritionally, carrot helps in the supply and maintenance of our daily body needs through the provision of beta carotene, vitamin K1, and fibre, including antioxidants (Sharma *et al*., 2012).

The world's leading producer of carrots is China, and 60% of the world's production share belongs to Asia (Fiorella *et al*., 2020). In Sub Sahara Africa, Nigeria took the lead position in the list of producing countries, also the 32nd principal producer in the world. In Nigeria, carrot production is mostly concentrated around the region of the north having Plateau as the lead producer among the producing states (Brand, 2019). In the past, efforts have been on extending carrot production to other parts of the country. Recently, carrots and other vegetable crops (*Cucumis sativus*, *Solanum melongena* etc.) are commercially grown in some states (Ebonyi and Enugu) of the southeastern region of the country (Okoye, 2019).

However, carrot production in the country will continue to be in short supply and its demand on the rise, if the production system is not streamlined to address agronomic challenges such as choice of farm inputs (improve variety, balanced nutrient etc.) and unimproved cultural practices.

Crop yield enhancement is normally attained by increase in fertilizer application. Nutrient needs of carrot are often supplied through fertilization to augment the inherent soil fertility. Carrot, although, a medium feeder requires fertilization for normal growth and optimum yield (Mbatha, *et al*., 2014). Organic manure chiefly supplies carbon-based supplement to the soil but offers insufficient nutrients (Chude, *et al*., 2012), therefore, inorganic fertilizer may be needed to supplement organic fertilizer for normal crop production. Carrot production potentials (quality and quantity) can be positively affected only when the supply of organic fertilizer is at an acceptable rate. For instance, supplies above the required levels may encourage too much vegetative production and may present roots with unmarketable appearances (cracked, uneven and forked) (Mbatha *et al*., 2014). The nutrient element (potassium) requirement of carrots is enormous although, the other two primary macro-nutrient elements (phosphorus and nitrogen) and trace elements obtained from the soil are necessary. The ultisols of the southern region of the country, is characterized by poor mineral reserve and low fertility as a result of severe leaching and slightly high acidity (Chude, *et al*., 2012) hence, carrot will therefore respond well to soil amendments.

The nutritional roles played by carrots in the daily maintenance of human body cannot be overstated. The need to make carrot a part of human diet has raised the demand for increased production and supply especially in the southeastern part of Nigeria where carrot production is not fully practiced. Most farmers in this region adopt the use of either organic or inorganic fertilizer for carrot production. However, the combined use of organic and inorganic fertilizers will address the challenges posed by infertile and slightly acidic soils of the southeast region. In addition, carrot supply along the food value chain is being confronted with a lot of pre-harvest factors ranging from choice of carrot variety, adequate demonstration of varieties to local adaptations, low soil fertility status, availability of suitable fertilizer materials, inadequacies in some of the field improvement practices. However, it is unknown whether different carrot varieties respond differently to different fertilizer rates. This necessitated a study to determine the impact of variety and four organic and inorganic fertilizer combinations on growth, yield and yield components in an ultisol of Southeastern Nigeria. The present study was therefore, designed to investigate the response of carrot varieties to combined fertilizer application and how it compares with sole applications. Several studies on fertilizer effect have reported significant improvement of test crops at different levels. Njoku *et al.* (2024) reported increase in some biochemical traits of carrots in response to fertilizer combinations. Muojiama et al. (2023), Ezeh *et al.* (2021) and Ihejiofor *et al.* (2020, 2022) reported significant increases in kale, watermelon and mungbean crops treated with different fertilizer combinations and rates. The objectives of the study were to; i) determine the effect of variety on growth, yield and yield component of carrot and ii) determine the effect of fertilizer rates on growth, yield and yield component of three carrot varieties.

MATERIALS AND METHODS

Experimental Location

This study was carried out from July to October, 2021 at the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka (UNN), Enugu State's Teaching and Research Farm. Nsukka is situated in the Derived Savanna Zone at latitude 06^0 51′ E, and longitude 07^0 29′ N, with an altitude of 400 m above sea level (Uguru *et al*., 2011). It is characterized by lowland humid tropical conditions. The area has a bimodal rainfall distribution which peaks in June/July and September/October. The early rains occur between late March to early April and end in July while the late rains occur from August to October. The annual rainfall distribution ranges from 1155 mm to 1955 mm with a mean annual temperature of 29 ^{0}C to 30 ^{0}C and relative humidity range from 69% to 79%. The soil has a characteristic sandy loam texture, slightly acidic, low organic matter content, highly degraded leached profiles thus, grouped as Ultisol and Vertisol (Edeh *et al*., 2013).

Sources of materials

The seeds of three carrot varieties (Graffas, Carrot Touchon and Nantes) were sourced from a reputable seed store in Jos, Plateau State, Nigeria. The organic manure was sourced in the month of June from a deep litter poultry (broilers) farm and pig (sow) farm of the Department of Animal Science, UNN.

Experimental design

The study adopted a 3 x 4 factorial design that was replicated three times using a randomized complete block design (RCBD). Factor A treatments (Graffas, Carrot Touchon and Nantes) and factor B treatments (10 t/ha of poultry manure + 200 kg of NPK 15:15:15 (PM (10 t) + NPK (200 kg)), 20 t/ha of pig manure + 200 kg of NPK 15:15:15 (PIG M (20 t) + NPK (200 kg)), 350 kg of NPK 15:15:15 (NPK (350 kg)) and 0 t/ha) were combined and this gave 12 treatment combinations.

A land area measuring 1,512 m^2 (63 m x 24 m) was divided into three blocks of 24 m x 20 m

each. Each block was further divided into 12 plots of 2 ridges per plot. Each plot measured 20 m x 1 m. The seeds of carrot were planted out in ridges by placing a pinch of carrot seeds in a shallow hole with a spacing of 70 cm (inter-row) x 25 cm (intra-row), which gave rise to 120 stands per plot but was later thinned down to 2 seedlings per stand. Point application of cured poultry and pig manure were done two weeks before planting. The inorganic fertilizer was applied two weeks after planting using ring method.

Data were collected on seedling emergence dates from the 8th day after planting when the first emergence was noticed and was subsequently collected at 2-day intervals for 21 days, survival count was taken at 8 weeks after planting (WAP) by taking count of survived plants per plot and expressed as a percentage of the total plants in a plot, fresh leaves weight per plant was taken in grams immediately after harvest with a weighing balance and recorded against each plot, fresh root weight per plant was taken in grams immediately after harvest with a weighing balance and recorded against each plot, whole plant biomass (this includes the root and the vegetative part) yield was taken immediately after harvest (g), data on harvest index (HI) on a fresh weight basis (%) were generated by calculation using the formula;

$$HI = \frac{Root\ Weight}{Whole\ plant\ biomass} \times \frac{100}{1},$$

root circumference per plant (cm) was taken 1cm from the shoulder by the use of rope and meter rule, root length per plant (cm) was recorded by measuring the length of the harvested roots using the rope and meter rule, yield per hectare (t/ha), marketable yield (%) was taken as the ratio of the total number of carrot roots that can be marketed to the total sampling roots (10) harvested from each plot expressed in percent. Marketable yield was considered as roots free from cracks, rot symptoms and misshaped roots. Data were generated on the number of sorting groups by physical observation and sorting according to the size and shapes. It was done by assigning the roots of similar length and size into groups, the number of such groups per plots were recorded, and root uniformity which was done through a visual examination of the roots following uniformity indices as shown below;

Table 1: Uniformity indices of carrot roots

Index	Description	
1	Not uniform	< 30% of the roots are similar in size and shape
2	Fairly uniform	> 30% < 50% of the roots similar in size and shape
3	Uniform	> 50% < 70% of the roots are similar in size and shape
4	Very uniform	> 70% < 90% of the roots are similar in size and shape
5	Highly uniform	> 90% of the roots are similar in size and shape

A proper index number was assigned to the corresponding uniformity observed.

The physicochemical properties of pre-planting soil, pig and poultry manure used for the study were carried out at the Department of Soil Science Laboratory, UNN to determine the fertility status of the soil and the nutrient composition of the organic fertilizers. Data were subjected to analysis of variance using SPSS version 12.0. Significant treatment means were separated with Fisher's least significant difference at 5% probability level. The R software version 4.2.1 GUI 1.79 High Sierra build and R Studio IDE version (2022.12.0+ 353) were used to construct the GG biplot.

Statistical analysis

Data were analyzed using Genstat Discovery 12.1 edition. The treatment means were compared using F-LSD at 5% probability level. The R software version 4.2.1 version was used to construct the GG biplot.

RESULTS

Physicochemical properties of the soil used for the experiment

The result of soil analysis of the experimental site gave higher proportion of coarse sand (47%) while silt (7%) had the least proportion. The textural class of the soil was sandy loam (Table 2). The result of the chemical analysis showed that poultry manure had the highest content value of most of the parameters analyzed; pH in H_2O (8.90), pH in KCl (8.90) compared to pig manure (6.80, 6.20) and soil (5.80, 4.40) respectively. Although, pig manure gave the highest nitrogen (2.03%) content compared to soil (0.112%) and poultry manure (1.54%). Poultry manure had higher content of organic matter (55.58%), total carbon (32.24%), and exchangeable cations in me/100 g of soil (sodium (0.19), potassium (0.24), calcium (5.60), magnesium (3.84), available

phosphorus (0.68%) compared to pig manure and soil.

Growth parameters

The result shows that at 18 and 20 days after planting (DAP) varieties did not differ significantly ($p > 0.05$) in their percentage emergence (Table 3). Among the varieties, Carrot Touchon significantly ($p < 0.05$) had higher number of emerged plants throughout the days under study compared to Nantes, although, it had similar effect ($P > 0.05$) with Graffas at 12 and 14 DAP while Nantes had the least percentage of emerged plants. Moreover, beyond 10 DAP, fertilizer application had no significant difference on the percentage emergence. At 8 and 10 DAP, NPK (350 kg) and zero fertilizer treatment produced similar effect and poorly supported plant emergence, while PG (20 t) + NPK (200 kg) produced more number of emerged carrot plants compared to all the fertilizer treatments.

The same table 5 showed that at 8 weeks after planting (WAP), Nantes produced the least percentage number of survived plants (55%) while Graffas (85.9%) and Carrot Touchon (94%) were statistically ($p < 0.05$) similar in their response and the least affected in terms of seedling mortality. Fertilizer application had no significant effect ($P > 0.05$) on the number of survived plants

Yield parameters

The result showed that variety did not differ significantly ($p > 0.05$) in their responses to harvest index, root length, number of marketable yield, root uniformity and number of sorting groups (Table 4). Likewise, Graffas and Carrot Touchon did not differ significantly ($p > 0.05$) with respect to leave weight, root weight, whole plant biomass, root tip and root apex circumference and yield/ha. The two referenced varieties performed better than Nantes variety with respect to the mentioned parameters.

However, the same table 4 showed that the effect of fertilizer rate on root length was not significant ($p > 0.05$) among the four fertilizer rates. PIG (20 t) + NPK(200 kg), among the fertilizer treatments had the highest mean value for harvest index (61%) while control and NPK(350 kg) were statistically similar ($P > 0.05$) in their effect and were the poorest in response to harvest index with mean values of 54.39% and 55.28% respectively. PM(10 t) + NPK(200 kg) significantly ($p < 0.05$) performed better than the other fertilizer treatments in all the parameters [leaves weight (64.8 g), root weight (84.2g), whole plant biomass (148.9 g), root tip (11.0 cm) and apex circumference (5.77 cm) and yield/ha (3.37 t/ha)] considered. On the contrary, unfertilized plots poorly performed with respect to yield and yield component metrics when compared with the other fertilizer treatments. However, NPK (350 kg) and unfertilized plots did not differ significantly ($p > 0.05$) with respect to harvest index and herbage production. The interaction impact of the three varieties and the four rates of fertilizer on percentage emergence and survival count was not statistically significant ($p > 0.05$) (Table 5).

Figure 1 shows biplot of treatments (variety × manure rates) by yield and yield components. The biplot explained 80.4% of the variation in yield and yield components as a result of differences in the interaction between variety and manure rates. Graffas × poultry manure (Gpm) gave the best root apex circumference (C1) and Harvest index (H), although, Graffas × Pig manure (Gpg) and Carrot Touchon × Pig manure (Ctpg) also, gave C1 and root tip circumference (C2) more than other treatment combinations. Graffas × poultry manure (Gpm), Nantes × poultry manure (Npm), Nantes × Control (Nc), Graffas × NPK (Gnpk), and Carrot Touchon × poultry manure (Ctpm) are the vertex combination and are the most divergent of all the treatment combinations with respect to yield and yield components. Ctpm, Carrot Touchon × NPK (Ctnpk), and Graffas × NPK (Gnpk) gave higher Root weight (R), Yield/ha (Y), Leave weight (LW), Whole plant biomass yield (W), Root length (RL), Root tip circumference (C2), Root uniformity (RU), and Number of sorting groups (NSG) that was reason for the above mentioned combinations appearing in the same segment but Ctpm had the highest of all the mentioned yield and yield components. On the contrary, Ctpm, appearing on the reverse side of the section where Number of marketable roots (NMR) was located did not give NMR or rather had little or nothing of NMR. Carrot Touchon × Control (Ctc), Gnpk and Ctnpk, mostly gave higher NSG and RU than the other treatment combinations. The treatment combinations that appeared within the outer circle also gave reasonable proportion of all the yield and yield components but not as much as those that appear within the different section with the respective yield components

DISCUSSION

The study revealed significant differences in seedling emergence among carrot varieties. This finding is consistent with an earlier study that reported variations in seedling emergence patterns among different carrot varieties (Anozie and Baiyeri, 2022). Carrot Touchon and Graffas were found to have higher percentage seedling emergence and low seedling mortality rates compared to Nantes. This could be attributed to their native genetic adaptation to the prevailing environmental conditions. These

results are also in line with a previous report which showed that Graffas, an improved Kurado Chanteny

Table 2: Physico-chemical properties of pre-planting soil, pig and poultry manure used for the study

Physico-chemical	**properties**	**Values**	
Sample description	Soil	Pig manure	Poultry manure
Textural class	Sandy loam	-	-
% clay	14.00	-	-
% silt	7.00	-	-
% fine sand	36.00	-	-
% coarse sand	47.00	-	-
pH (in H_2O)	5.80	6.80	8.90
pH (in KCL)	4.40	6.20	8.90
% Nitrogen	0.112	2.03	1.54
% Organic carbon	0.597	22.16	32.24
% Organic matter	1.029	38.21	55.58
Exchangeable calcium (me/100g of soil)	1.00	4.80	5.60
Exchangeable magnesium (me/100g of soil)	0.60	1.92	3.84
Exchangeable sodium (me/100g of soil)	0.03	0.16	0.19
Exchangeable potassium (me/100g of soil)	0.005	0.21	0.24
Cation exchange capacity (me/100g of soil)	10.20	-	-
Exchangeable hydrogen (me/100g of soil)	0.60	-	-
Exchangeable aluminum (me/100g of soil)	-	-	-
Available phosphorus	7.53 ppm	0.48%	0.68%
% base saturation	16.47	-	-

ppm = parts per million, me = milli equivalent, H_2O = water, KCl = potassium chloride, % = percentage

Table 3: Effect of variety and fertilizer rates on percentage emergence and survival count

	Percentage emergence in days after planting							**%Survival count in weeks after planting**
Variety (V)	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**8**
Graffas	42.7	65.8	81.0	87.1	87.8	90.0	91.8	85.9
Carrot Touchon	61.9	81.4	88.1	91.3	94.0	94.9	95.8	94.0
Nantes	10.5	38.6	58.2	69.1	76.3	78.8	80.5	55.5
$LSD_{(0.05)}$	**13.4**	**16.1**	**16.4**	**18.21**	**17.08**	**NS**	**NS**	**15.75**
Manure (M)								
$PM_{(10\ t)}$ + $NPK_{(200\ kg)}$	41.3	53.9	67.4	73.6	78.0	79.8	80.6	75.9
$PG_{(20\ t)}$ + $NPK_{(200\ kg)}$	63.5	81.9	86.5	89.3	91.5	92.3	92.3	89.0
$NPK_{(350\ kg)}$	22.5	51.3	69.1	77.3	80.8	82.7	84.7	71.2
Control	26.2	60.6	79.9	89.8	94.0	96.9	99.9	77.7
$LSD_{(0.05)}$	**15.4**	**18.6**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Interaction								
V × MR	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

PM = Poultry manure, PG = Pig manure, NS = Not Significant, LSD = Least significant difference

carrot type, is well adapted to hot tropical environments (Bradeen *et al*., 2001).

Moreover, the addition of pig manure as part of the fertilizer combination {PG(20 t)} + NPK(200) kg)} may have facilitated early seedling emergence. The massive seedling emergence (> 60%) observed just eight days after planting could be due to the higher nitrogen content of pig manure as revealed by the chemical analysis. The ammonia arising from pig urine may have accounted for higher nitrogen content of pig slurry. Pig dung is always mixed up with urine in the pen and thus become inseparable during collection of pig manure. The nitrogen in pig manure may have promoted vigorous vegetative growth and development of the young carrot shoots. This finding is consistent with Olaniyan (2019), who reported that growth metrics of *Telferia occidentalis* were favoured by higher levels of nitrogen application. The present study revealed that carrot variety significantly influenced both yield and yield components. This finding can be attributed to the variations in the genetic materials of the carrot varieties used. The observed dissimilarities in yield parameters (such as leaf weight, root weight, root length, and harvest index) can be explained by the differences in the genotypes considered. Nantes variety performed poorly in terms of carrot yield, which may be due to its incomplete adaptation to the study environment. Amadala (2016) reported the adaptability potential of a high-yielding Nantes variety to a higher pH range of 6 – 6.8 compared to the lower pH (5.8) of the study soil. The report further emphasized that a pH value below the reference range of 6 – 6.8 could compromise the quality of the root. Furthermore, Tandzi and Mutengwa (2020) reported that the prevailing conditions of the environment of an area and factors such as soil type, crop variety, climatic conditions, and agronomic management practices have a strong influence on the yield and yield quality of crop.

Moreover, fertilizer application significantly influenced the yield and yield components of the carrots. The combination of PM(10 t) + NPK(200 kg) and PG(20 t) + NPK(200 kg) produced a better yield response than the control, presumably due to the poor inherent fertility status of the study soil as indicated by the physico-chemical analysis. This finding is consistent with Muojiama *et al*. (2023), in a cabbage study reported that the combination of organic and inorganic fertilizers in a balanced ratio produced higher and quality yields when judiciously applied to crop. Furthermore, the combined fertilizers {PM(10 t) + NPK(200 kg) and PG(20 t) + NPK(200 kg)}produced higher yield than NPK(350 kg). This may be attributed to the release of ample organic matter by the organic manure, which conditioned the soil and subsequently increased yield. This finding is in line with Zongo *et al*. (2024), who reported that the incorporation of organic manure into the soil was beneficial and resulted to improvements in the soil's physical properties, such as structure, water infiltration, microbial activities, aeration, bulk density, and subsequently, a higher yield.

Table 4: Interaction effect of variety and fertilizer rates on percentage emergence and survival count

		Percentage emergence in days after planting							%Survival count in weeks after planting
Variety	**Manure**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**8**
Graffas	**$PM_{(10\ t)}$ + $NPK_{(200\ kg)}$**	4.33	6.67	7.00	7.67	8.33	9.33	9.33	8.67
Graffas	**$PG_{(20\ t)}$ + $NPK_{(200\ kg)}$**	6.67	9.00	9.67	10.33	10.67	11.33	11.33	11.00
Graffas	**$NPK_{(350\ kg)}$**	5.33	6.67	7.67	8.33	9.67	10.33	10.33	9.33
Graffas	**Control**	5.67	8.33	9.00	9.33	9.67	9.67	9.67	9.00
C/Touchn	**$PM_{(10\ t)}$ + $NPK_{(200\ kg)}$**	3.33	6.00	7.33	7.33	7.67	8.00	11.00	10.33
C/Touchn	**$PG_{(20\ t)}$ + $NPK_{(200\ kg)}$**	6.00	8.67	10.33	11.00	11.00	11.33	11.33	10.00
C/Touchn	**$NPK_{(350\ kg)}$**	5.33	6.67	8.67	9.33	9.67	11.00	11.00	8.33
C/Touchn	**Control**	6.00	9.33	9.33	10.33	10.33	11.00	11.00	10.33
Nantes	**$PM_{(10\ t)}$ + $NPK_{(200\ kg)}$**	5.33	6.33	7.33	6.67	7.00	7.00	10.00	10.00
Nantes	**$PG_{(20\ t)}$ + $NPK_{(200\ kg)}$**	7.33	10.33	10.33	10.33	11.67	11.67	11.67	11.33
Nantes	**$NPK_{(350\ kg)}$**	7.33	8.67	9.33	10.00	11.00	11.00	11.00	9.33
Nantes	**Control**	5.00	8.33	8.67	9.67	9.67	9.67	9.67	8.33
LSD $_{(0.05)}$		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

PM = Poultry manure, PG = Pig manure, C/Touchon = Carrot Touchon, NS = Not Significant, LSD = Least significant difference

However, the plots treated with PM(10 t) + NPK(200 kg) produced higher yield than those treated with PG(20 t) + NPK(200 kg). This may be due to the higher nutrient content (P, K, Ca, Mg, C, organic matter, etc.) of poultry manure compared to pig manure, as revealed by the chemical analysis. This result is in line with Usman (2015), who reported better performance by poultry manure over cow dung

and goat manure on yield parameters considered in a tomato study. Additionally, the combination of PG(20 t) + NPK(200 kg) had the highest harvest index. The higher nitrogen content of the pig manure, as revealed by the chemical analysis, may have favoured vegetative growth at the expense of root biomass, but this was not observed. Therefore, the higher harvest index could be due to the efficient utilization of food materials and the accumulation of dry matter in the root, which is of great interest to carrot growers.

Table 5: Effect of variety and manure rate on yield and components of yield of carrot

Variety (V)	L Wt	Rt Wt	WPBY	(%)HI	Rt C1	Rt C2	Rt Lt	Yld/ha	NMY	RU	NSG
Graffas	52.70	69.20	121.80	57.21	10.40	4.97	17.00	3.69	4.42	4.08	4.50
Carrot Touchon	58.40	73.10	131.50	55.22	10.90	5.28	17.10	3.90	3.75	4.67	4.67
Nantes	26.10	41.30	67.40	58.70	7.30	4.26	16.00	2.20	4.50	4.00	4.33
$LSD_{(0.05)}$	18.40	23.30	40.60	NS	1.40	0.62	NS	0.93	NS	NS	NS
Manure rate (MR)											
$PM_{(10\ t)} + NPK_{(200\ kg)}$	64.80	84.20	148.90	57.50	11.00	5.77	17.10	3.37	4.22	3.44	4.11
$PG_{(20\ t)} + NPK_{(200\ kg)}$	47.20	72.20	119.40	61.00	10.10	4.92	18.00	2.89	4.33	4.33	4.00
$NPK_{(350\ kg)}$	42.90	53.80	96.70	55.28	9.09	4.61	16.40	2.15	4.00	4.89	5.00
Control	28.00	34.70	62.70	54.39	7.97	4.06	15.30	1.39	4.33	4.33	4.89
$LSD_{(0.05)}$	21.20	9.20	46.9 0	4.80	1.60	0.72	NS	1.08	NS	NS	NS
Interaction											
V × MR	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

L Wt = Leaf Weight (g), Rt Wt = Root Weight (g), WPBY = Whole Plant Biomass Yield (g), HI = Harvest Index (%), Rt C1= Root apex circumference (cm), Rt C2 = Root tip circumference (cm), Rt Lt = Root Length (cm),Yld/ha = Yield/hectare (t/ha), NS = not significant, LSD = Least significant difference.

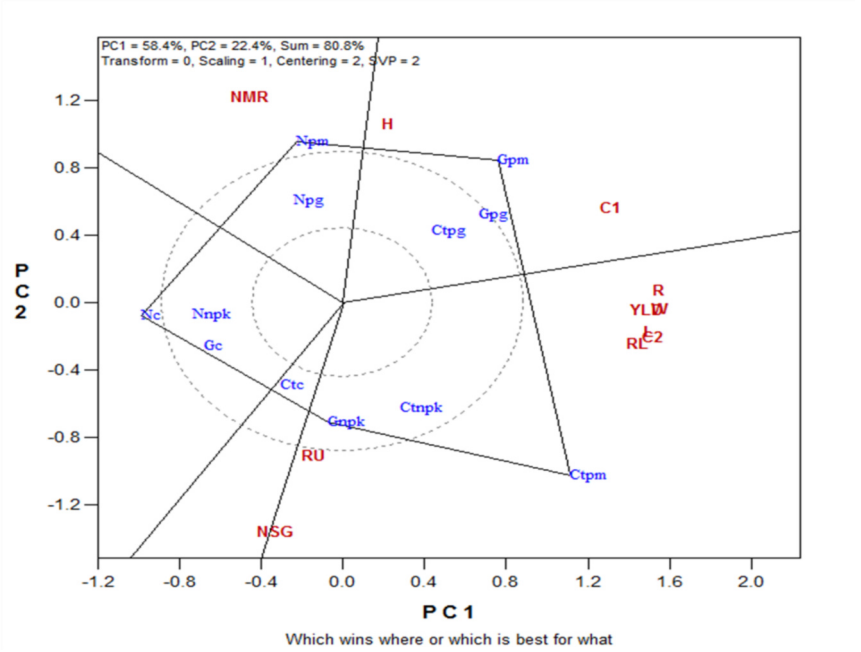

Figure 1: Biplot analysis of variety and fertilizer by yield and yield components *L = Leaf weight (cm), R = Root Weight (g), W = Whole Plant Biomass Yield (g), H = Harvest Index (%), C1= Root apex circumference (cm), C2 = Root tip circumference (cm), RL = Root Length (cm), Y = Yield/hectare (t/ha), NMR =Number of Marketable Root, RU = Root Uniformity, NSG = Number of Sorting Group, Gpm = Graffas × Poultry manure, Gpg = Graffas × Pig manure, Gnpk = Graffas × NPK, Gc = Graffas × Control, Ctpm = Carrot touchon × Poultry manure, Ctpg = Carrot Touchon × Pig manure, Ctnpk = Carrot Touchon × NPK, Ctc = Carrot Touchon × Control, Npm = Nantes × Poultry manure, Npg = Nantes × Pig manure, Nnpk =Nantes × NPK, Nc = Nantes × Control*

CONCLUSION

The two varieties; Carrot Touchon and Graffas have the inherent ability to yield optimally with good management. Application of PM (10 t) + NPK (200 kg) and PG (20 t) + NPK (200 kg) increase yield significantly, should be utilized in carrot production in Southeastern Nigeria.

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