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Evaluation of Different Manure Sources in Soil Fertility Improvement and Yield of Fluted Pumpkin in an Ultisol of Southeastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author JCN designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors BAE, PEN and MOO managed the literature searches, analyses of the study performed the structural equation modeling and discuss the conclusion. All authors read and approved the final manuscript.

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ABSTRACT

Achieving food security for a rapidly growing population in Nigeria will require intensification of food production on existing cropland through improving soil fertility and agronomic practices. Use of chemical fertilizers has been attributing factor for the deterioration of soil and water resources and the environment as a whole. In an attempt to improve the fertility of the soil and crop yield with economically viable, environmental friendly and sound and socially accepted farm practice, a study was conducted to evaluate sole organo-minerals, inorganic fertilizer and their mixtures on the soil chemical improvement and leaf yield of fluted pumpkin in an ultisol of Southeastern Nigeria. Six treatments including the control (10 tons/ha of poultry dropping, 10 tons/ha of rice husk, 0.375 tones/ha of NPK fertilizer, 5 tons/ha of poultry dropping +5 tons/ha of rice husk, 5tons/ha of rice husk +0.188 ton/ha of NPK fertilizer, control) were built into a randomized complete block design

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(RCBD) replicated three times. The results showed that the amendments significantly ($p<0.05$) improved the soil pH, organic carbon, exchangeable calcium and magnesium within the period of study. The results indicated that the CEC, available phosphorous and base saturation were positively ($p<0.05$) improved by the soil amendments, while the exchangeable acidity was highly reduced significantly by the application of the amendments. The results revealed also the better performance of organic sources over the inorganic in improving most soil chemical properties and the crop leaf yield of fluted pumpkin.

Keywords: Organo-mineral; soil amendments; fluted pumpkin; soil properties; leaf yield.

1. INTRODUCTION

Telfaria occidentalis is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. The young shoots and leaves of the female plant are the main ingredient of a Nigerian soup [1].

The leaves and edible shoots of fluted pumpkin continue to be the primary source of protein, minerals and vitamins in African countries [2].

In the recent time, fluted pumpkin had gained medicinal recognition. It has been discovered to be blood purifiers [3] and could therefore be useful in the maintenance of good health most especially among poor resource ruralities in developing countries. In Nigeria, the herbal preparation of the plant has been employed in the treatment of anaemia, chronic fatigue and diabetes [4].

However, its supply can fall short of demand, even when grown with irrigation, partly due to low fertility of arable soils.

Low soil fertility is a constraint to crop production in the tropics [5–7]. According to Sanchez et al. [8], declining soil fertility in smallholder farms is a cause of declining food production. There is a need to increase productivity of crops through improving the soil in which the crop is grown. Unavailability of commercial fertilizers poses a barrier to crop production among smallholder farmers [9–10]. This also applies to those growing fluted pumpkin in tropical Africa [11], making identification of alternatives to synthetic fertilizers very important. Organic materials have advantages of being environmental friendly as reported by Yusoff, [12]. Residues from bio-energy processes may constitute a source of fertilizer and nutrient cycling in agriculture. In southeastern Nigeria, rice mills generate large quantities of fresh and partially burnt rice-mill wastes daily and these are either dumped to the detriment of the environment or burnt into ashes [6].

Use of turkey litter for growing fluted pumpkin in the low-fertility soils in this region has also been recommended [13].

However, complementary use of organic and inorganic fertilizers has been reported to be a sound soil fertility management strategy for crop production [14]. Stephen [15] obtained high and sustained yield of fluted pumpkin with the use of organic manure in combination with inorganic fertilizer. Makinde et al. [16] reported significant increase in melon yield with combined application of inorganic and organic fertilizers. Makinde et al. [17] also reported that combined application of organic and inorganic fertilizer significantly increased the uptake of N, Ca and Mg by amaranthus in a research conducted in Lagos, Nigeria.

Huang and Lin, [18] noted enhanced soil fertility status when inorganic fertilizer was applied in combination with organic manure. Zang and Fang [19] reported that combined application of inorganic and organic manure can correct nutrient deficits associated with application of either of the sources alone. As reported by Ossom et al. [20], a combined application of inorganic and organic manure is needed for increased leaf yield and growth of fluted pumpkin. Commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing crops, [21]. This is because they are easy to use, quickly absorbed and utilized by crops. However, these fertilizers are believed to contribute substantially to human, animal food intoxication and environmental instability/degradation.

Therefore, the study aimed at investigating the effects of sole organo-minerals, inorganic fertilizer and their mixtures on the soil chemical improvement and leaf yield of fluted pumpkin in an ultisol of Southeastern Nigeria.

2. MATERIALS AND METHODS

2.1 Location of Experimental Site

The study was conducted at the Research and Teaching Farm of the Federal College of Agriculture, Ishiagu. The area lies within latitude 05º 56´N and longitude 07º 41´E in the Derived Savannah Zone of southeastern Nigeria. The mean annual rainfall for the area is 1350 mm, spread from April to October with average air temperature being 29ºC.

The underlying geological material is shale with sand intrusions, locally classified as the Asu River group. The soil is a hydromorphic Ultisol and has been classified as Typic Haplustult [22]. The soil has moderate organic carbon (OC) concentration and is low in pH and cation exchange capacity, with Ca and Mg dominating the exchange complex site (Table 1).

2.2 Field Method

The field was cleared and prepared into seed beds measuring 2 m X 3 m which represents plot size. Six treatments including the control replicated three times were built into a randomized complete block design (RCBD). The treatments included; Poultry droppings @10 ton/ha, Rice husk @10 ton/ha, NPK fertilizer @ 0.375 tons/ha, 5 tons/ha Poultry droppings + 5 tons/ha Rice husk, 5 tons/ha Rice husk + 0.188 tons/ha NPK fertilizer and control.

The treatments were allocated into the plots and incorporated into the soil two weeks before planting except treatment NPK fertilizer which was applied 2 weeks after plant germination.

The test crop used was fluted pumpkin and the pumpkin seeds were planted directly into the field after a day shade drying to reduce mucilage cover on the seeds at the spacing of 75 cm x 75 cm. Weeding was carried out three weeks and six weeks after planting.

2.3 Data Collection on Plant Parameters

Measurements were taken from the following plant parameters.

1. Length of vine at 2, 3, 4, 5, and 6 weeks after planting (WAP). This was measured by using measuring tape/meter rule to measure from the base to the apex region or apical meristem of the plant.
2. Leaves number at 2, 3, 4, 5, and 6 weeks after planting. This was counted from 2 weeks after planting by counting the number of leaves on each of the tagged plant in each plot.
3. Stem girth at 2, 3, 4, 5 and 6 weeks after planting. It was measured from 2 weeks– 6 weeks after planting by using the rope and meter rule. The rope was tied around the vine girth and then the rope length twined round the stem girth and was placed at a meter rule.
4. Weight of fresh leaves at 6, 8, 10, 12, 14 and 16 weeks after planting. This was determined by weighing the harvested leaves at two weeks intervals and carried out from the 6^{th} week–16^{th}week after planting. The first harvest was cut after 20 cm distance from the base.

2.4 Collection of Soil Samples and Laboratory Analysis

A composite soil sample from different representative field location was collected from the experimental site, with soil auger at a depth of 0–20 cm for initial soil characteristics.

At harvest, another soil samples were collected from each of the plots to determine the changes that occurred due to treatments application.

The soil samples were air-dried and sieved with 2 mm sieve. Soil fractions less than 2 mm from individual samples were then analyzed using the following methods; Particle size distribution of less than 2 mm fine earth fractions was measured by the hydrometer method as described by Gee and Bauder [23]. Soil pH was measured in a 1:2.5 soil:0.1 M KCl suspensions [24]. The soil OC was determined by the Walkley and Black method described by Nelson and Sommers [25]. Total nitrogen was determined by semi-micro kjeldahl digestion method using sulphuric acid and $CuSO_4$ and Na_2SO_4 catalyst mixture [26]. CEC was determined by the method described by Thomas [27], while exchangeable acidity (EA) was measured using the method of McLean [24]. The available phosphorous was determined by the Bray 11 method [28]. Base saturation was determined by calculation as the percentage ration of total exchangeable bases to effective cation exchange capacity, using the procedure outlined in Tropical Soil Biology and Fertility Manual [29].

2.5 Data Analysis

Data analysis was performed using GENSTAT 3 7.2 Edition, while the correlation-regression and graph were performed using SPSS stat. 17.0 and MATLAB R2007b. Treatment means were separated and compared using Least Significant Difference (LSD) and all inferences were made at 5% Level of probability

3. RESULTS AND DISCUSSION

3.1 Soil Initial Properties and Organic Amendments Nutrient Composition

3.1.1 Soil properties

The soil physical and chemical properties are reported in Table 1. Generally, the soils are sandy loam with 9% (90 g kg^{-1}) clay, 19% (190 g kg^{-1}) silt and 72% (720 g kg^{-1}) sand contents.

Soil inventory of the high rainfall region of southeastern Nigeria show that the major soil unit consists of deep, course textured, well-drained acidic sandy loam, largely derived from coastal plain sand sediments, sandstones and shales. The dominant soil has been classified as kaolinitic ultisols belonging to the soil taxonomy of Typic Paleudult [30].

Soil organic carbon concentration was 0.30% whereas the soil total nitrogen was 0.028% and the pH measured in water was 6.0 (Table 1). The analysis indicated that the soil was low in CEC.

3.1.2 Organic amendments nutrient composition

Soil amendments comprised of rice-mill wastes or rice husk dust (RHD) collected from a rice-mill industry near the study site. Others included poultry litter droppings (PD) and 15N–15P–15K. Chemical analysis of organic materials indicated that PD had the highest N (2.10%) and Ca (14.40%), phosphorous (2.55%) values; RHD had the highest OC value of 33.75% and C:N ratio of 48.21 (Table 2).

Table 1. Physical and chemical properties of the studied soil (0–20 cm) depth

Soil properties	Values
Clay (%)	9
Silt (%)	19
Total sand (%)	72
Textural class	Sandy loam
Organic carbon (%)	0.30
Total nitrogen (%)	0.028
pH (H_2O)	6.0
Exchangeable bases ($cmolkg^{-1}$)	
Sodium (Na^+)	0.802
Potassium (K^+)	0.420
Calcium (Ca^{2+})	4.0
Magnesium (Mg^{2+})	0.4
Cation exchange capacity (CEC) $cmolkg^{-1}$	9.60
Exchangeable acidity (EA) $cmolkg^{-1}$	1.8
Available phosphorous (mg/kg)	15.86

Table 2. Nutrient composition (%) of amendments

Property	Amendments	
	Poultry litter droppings	Rice husk dust
Organic carbon	16.52	33.75
Nitrogen	2.10	0.70
Phosphorous	2.55	0.49
Calcium	14.40	0.36
Potassium	0.48	0.11
Magnesium	1.20	0.38
Sodium	0.34	0.22
C:N ratio	7.87	48.21

3.2 Effects of Organic Manure Sources on the Soil pH, Organic Carbon and Total Nitrogen

The results (Table 3) showed that the soil amendments significantly ($p<0.05$) improved the soil pH, with the highest pH value obtained from plots treated with 5 tons of poultry dropping and 5 tons of rice husk. The increase in soil pH could be due to higher K, Mg and Ca contents in poultry dropping applied in T_2. This was followed by plots amended with rice husk and NPK fertilizer. The results showed a range value of 4.5–6.5. Generally, all the treated plots did improve the pH significantly ($p<0.05$) higher relative to the control.

The investigations indicate that organically amended plots and plots amended with integrated nutrients improved the pH better than the NPK. This improvement on the pH could be attributed to the high calcium and magnesium contents in the organic materials used, therefore, It is also necessary to integrate chemical fertilizers into the organic sources to reduce the quantity required and enhance nutrient release. This work was in line with the work of Huang and Lin, [18]; Zhang and Fang, [19] who stated that combined application of organic and inorganic fertilizers has agronomic benefits, including improved soil fertility and yield.

Table 3 revealed a statistical ($p<0.05$) improvement on the soil organic carbon due to the amendment application. The result shows that the best improvement on the soil organic carbon was recorded in plots amended with rice husk. This was followed by PD + RH treated plots, while the least improvement was obtained from plots without any amendment. The soil organic carbon values varied from 0.29–0.72%. The low OC in NPK treated plots may be explained by application of a single heavy dose of soluble fertilizers being inefficient in low-activity clay soils that require organic matter to impart appropriate physicochemical and biological properties [31]. In another Ultisol, elsewhere in southeastern Nigeria, Obi and Ofoduru [32] reported that mineral fertilizers (N–P–K, urea and ammonium sulfate) reduced soil organic matter level and quality. The results obtained here indicate that the low organic matter status of the typically low-fertility Ultisols needs to be compensated with combined application of two organic materials.

The results (Table 3) indicated that there was no significant ($p<0.05$) difference among the treatments in the soil total nitrogen percent. It was obtained that though, PD and PD + RH treatments had similar and among the highest total nitrogen, while the control plots yielded the least values within the period of study. The results indicated that the amended plots increased the soil total nitrogen higher than the control.

The overall non-significant enhancement of soil total N by amended plots compared to the control in the soil can be attributed to a high level of topsoil N volatilization and denitrification occurred during the period of study [33].

3.3 Effects of Organic Manure Sources on the Soil Exchangeable Sodium, Potassium, Calcium and Magnesium

The results (Table 4) showed that exchangeable sodium was not significantly ($p<0.05$) increased by the soil amendments for the period of study.

Table 3. Effects of manure sources on the soil pH, organic carbon and total nitrogen (0–20cm) soil depth

Soil amendments	Soil properties		
	Soil pH	Soil organic carbon (%)	Soil total nitrogen (%)
NPK	5.9	0.37	0.066
PD	6.1	0.33	0.095
RH	6.0	0.72	0.068
PD+RH	6.5	0.49	0.093
RH+NPK	6.4	0.38	0.061
CT	4.5	0.29	0.047
$LSD_{(0.05)}$	0.6624	0.1860	NS

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; NS = not significant

The results (Table 4) indicated a higher increase in exchangeable sodium, though not significant, in soils where 5 t/ha of poultry dropping and 5 t/ha rice husk were applied, followed by plots treated with poultry dropping. The values varied from 0.68 cmolkg^{-1}–0.84 cmolkg^{-1}.

Exchangeable potassium (K^+) was not significantly influenced by the soil amendments within the period of study. However, NPK fertilizer treated plots improved this exchangeable K higher than other treated plots including the control. Generally, all the amended plots did perform better than control plots. The results showed ranged values of 0.302 cmolkg^{-1}to 0.465 cmolkg^{-1}.

The results (Table 4) observed that soil amendments significantly ($p<0.05$) increased the exchangeable magnesium in the soil of the studied area.

It was recorded that exchangeable Mg^{2+} was statistically improved higher in plots treated with PD + RH within the period of study. This was followed by NPK fertilizer treated plots, while the control plots gave the least values. It was obtained that the values ranged from 1.6 to 4.1 cmolkg^{-1} (Table 4). It was generally observed that all the amended plots significantly ($p<0.05$) increased the exchangeable magnesium higher than the control within the period. The results implied that the combination of organic amendments stand better chance of improving soil fertility indices than sole forms.

Exchangeable calcium was significantly improved by soil amendments within the periods of study (Table 4). It was obtained that among the treatments including the control, poultry droppings gave the highest significant ($p<0.05$) values of exchangeable calcium in the study period. The result indicated that it was only the poultry dropping and rice husk treated plots significantly improved the exchangeable calcium higher than the control. The values ranged from 1.4 to 5.3 cmolkg^{-1}. This result agrees with the submissions of Adeniyan and Ojeniyi, [34] who reported that organic materials are considered as right sources of macro-nutrients.

3.4 Effects of Organic Manure Sources on the Soil Cation Exchange Capacity, Exchangeable Acidity, Available Phosphorous and Base Saturation

The results (Table 5) indicated a significant ($p<0.05$) improvement on the soil cation exchange capacity (CEC) due to treatments application. It was obtained that the highest significant ($P<0.05$) increase on cation exchange capacity was made in plots treated with poultry dropping. This was followed by soil amended with NPK fertilizer, while the control plots recorded the lowest values of cation exchange capacity within the period. The mean values of CEC varied from 7.6 cmolkg^{-1}–15.9 comlkg^{-1}. Generally, all the amended plots did increase the CEC higher relative to the control except the RH + NPK treated soils. Hulugalle and Maurya [35], reported increases in soil CEC and soil nutrient on residue treated soils compared to the untreated ones.

The soil exchangeable acidity (EA) was significantly ($p<0.05$) lowered by the application of the treatments. This shows that EA was significantly ($P<0.05$) reduced in all the amended plots relative to the control plots. The results (Table 5) indicated that the PD + RH treated plots statistically decreased the exchangeable acidity more than other treated plots including the control.

Table 4. Effects of manure sources on the soil exchangeable bases (sodium, potassium, calcium and magnesium) (0–20 cm) soil depth (cmolkg^{-1})

Soil amendments	Soil properties			
	Exch. na	Exch. K	Exch. ca	Exch. mg
NPK	0.76	0.465	2.33	3.5
PD	0.82	0.432	5.3	3.1
RH	0.77	0.399	3.8	2.7
PD+RH	0.74	0.395	2.7	4.1
RH+NPK	0.84	0.404	2.8	3.0
CT	0.68	0.302	1.4	1.6
LSD $_{(0.05)}$	NS	NS	1.518	1.138

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; NS = not significant; Exch. Na, K, Ca, Mg = exchangeable sodium; exchangeable potassium; exchangeable calcium; exchangeable magnesium

The highest EA value was obtained from the control plots (3.6 $cmolkg^{-1}$). The results (Table 4) observed that the EA mean values varied from 1.80–3.60 $cmolkg^{-1}$).

The results (Table 5) showed that the application of the soil amendments did increase the available phosphorous significantly (p<0.05) high. It was obtained that all the amended plots improved the available phosphorous significantly (p<0.05) better than the control except the plots treated with rice husk for the period of study. The results indicated that the highest value was obtained from plots amended with poultry dropping, followed by plots treated with NPK fertilizer. The values ranged from 13.1–57.7 $mgkg^{-1}$. The increased available P in the amended soils could be attributed to increase in the soil pH which must have released the fixed P in the soil colloids.

The results of the base saturation (Table 5) showed that soil amendments significantly (P<0.05) improved the soil base saturation differently within the period of study. The result indicated that the best statistical improvement on the base saturation was obtained from plots treated with RH + NPK, followed by plots treated with PD + RH, while least base saturation value was recorded in plots treated with NPK fertilizer. The values ranged from 47.6–81.4%. The result is in line with the submission that, complementary use of organic and inorganic fertilizers has been reported to be a sound soil fertility management strategy for crop production [14].

3.5 Effects of Organo-mineral and Inorganic Fertilizer on Vine Length at Various Weeks after Planting

The results of the vine length (Table 6) showed that the soil amendments significantly (p<0.05) improved the vine length of the *telfairia* in all the weeks studied, except on the 4th week after planting. The mean vine length obtained at 2 weeks after planting indicated that poultry dropping + rice husk produced the longest mean vine length of 19.17cm, followed by NPK fertilizer which had 16.75cm, while control had the shortest mean vine length of 12.83 cm. The result at 3 WAP showed that poultry dropping at 10 t/ha gave the highest mean significant (P<0.05) value of vine length. This was followed by poultry dropping + rice husk at 5 t/ha each. At 5 and 6 weeks after planting, poultry dropping produced the longest significant (P<0.05) vine length, while the control produced the shortest vine length.

3.6 Effects of Orgno-mineral and Inorganic Fertilizer on Number of Leaves at Various Weeks after Planting

Table 7 showed that there were significant difference among the treatments on the number of leaves at 2, 3, 4, 5, and 6 WAP. The result (Table 7) indicates that at 2 WAP, PD + RH treated plots did significantly increase the number of leaves (8.00). This was followed by plots treated with PD (7.75), while the controlled plots gave the least (3.83) number of leaves.

In 4, 5 and 6WAP, poultry drooping produced the highest significant (P <0.05) mean number of leaves followed by plots amended with NPK in the 5th and 6th WAP, while the control had the smallest mean number of leaves.

3.7 Effects of Organo-mineral and Inorganic Fertilizer on Stem Girth at Various Weeks after Planting

The results presented in Table 8 showed that the soil amendments statistically (P<0.05) increased the stem girth (cm) at 2, 3, 4, 5 and 6 WAP. At 2 and 3 weeks after planting, RH + NPK amended plots produced the largest significant increase of stem girth (2.225 cm and 2.250 cm), respectively. The result indicated that all the treated plots were better statistically than the control.

The result (Table 8) at 4 WAP indicated that PD + RH treated plots produced the largest (2.542 cm) mean value of stem girth. At 5 and 6WAp poultry dropping gave the largest significant value of stem girth (2.750 cm and 2.810 cm), respectively, followed by plots treated with RH + NPK, while the control plots gave the least mean value of stem girth.

3.8 The Effect of Organo-minerals and Inorganic Fertilizer on the Fresh Leaf Weight of Fluted Pumpkin at Various Stages of Growth

The effect of organo-minerals and inorganic fertilizer on the fresh leaf weight of fluted pumpkin at various stages of growth was presented in Table 9.

Table 5. Effects of manure sources on the soil cation exchange capacity, exchangeable acidity, available phosphorous and base saturation (0–20 cm) soil depth

Soil amendments	Soil properties			
	CEC (cmol/kg)	Exch. EA (cmol/kg)	Avail. P (mg/kg)	BS (%)
NPK	12.4	2.87	37.1	47.6
PD	15.9	2.33	57.7	63.6
RH	11.6	2.00	19.1	58.1
PD+RH	12.1	1.80	30.5	77.1
RH+NPK	9.9	3.00	31.8	81.4
CT	7.6	3.60	13.1	52.9
LSD $_{(0.05)}$	2.779	0.853	11.49	10.45

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; CEC = cation exchange capacity; exch. EA = exchangeable acidity; avail. P = available phosphorous; BS = base saturation

Table 6. Effects of manure sources on the mean vine length per plant (cm)

Amendments	2WAP	3WAP	4WAP	5WAP	6WAP
NPK	16.75	22.92	46.8	74.8	92.1
PD	16.67	27.67	54.7	85.3	99.2
RH	14.33	23.33	61.0	81.7	96.6
PD+RH	19.17	27.50	51.8	80.1	99.2
RH+NPK	16.33	23.3	47.4	73.8	86.3
CT	12.83	19.83	32.7	54.0	65.2
LSD $_{(0.05)}$	2.371	4.213	NS	13.59	14.27

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; WAP weeks after planting; NS = not significant

Table 7. Effects of manure sources on the mean number of leaves per plant

Amendments	2WAP	3WAP	4WAP	5WAP	6WAP
NPK	6.42	11.92	15.42	19.92	23.3
PD	7.75	11.58	18.17	22.08	25.5
RH	6.25	9.42	12.42	18.25	21.4
PD+RH	8.00	13.58	17.33	19.92	22.6
RH+NPK	7.00	10.75	12.75	19.25	20.1
CT	3.83	6.25	7.00	8.83	9.8
LSD $_{(0.05)}$	1.621	NS	4.249	6.789	8.11

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; WAP weeks after planting; NS = not significant

Table 8. Effects of manure sources on the mean stem girth per plant (cm)

Amendments	2WAP	3WAP	4WAP	5WAP	6WAP
NPK	1.792	2.125	2.367	2.583	2.633
PD	1.975	2.158	2.458	2.750	2.810
RH	1.767	2.00	2.083	2.407	2.500
PD+RH	2.017	2.092	2.542	2.708	2.833
RH+NPK	2.225	2.250	2.308	2.592	2.883
CT	1.133	1.217	1.423	1.723	1.582
LSD $_{(0.05)}$	0.3040	0.2736	0.3921	0.4949	0.2558

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; WAP weeks after planting

The results showed a significant variation on the fresh leaf weight at the different weeks studied. It was obtained that poultry dropping at 6, 10 12 and 14 WAP significantly ($p<0.05$) gave the highest fresh leaf weight of fluted pumpkin in the studied area.

At the 6 WAP, PD gave the highest mean weight of 1.43 t/ha fresh leaf, while the least mean fresh leaf weight value (0.33 t/ha) was obtained from the control plot (Table 9). The result in the week 6 indicated that all the treated plots significantly ($p<0.05$) performed better than the control. On the 8 WAP, though did not significantly improve the fresh weight leaf of fluted pumpkin, but PD amended plots did perform better relative to other amended plots including the control. However, on the 10, 12 and 14 WAP, PD was followed by PD + RH treated plots in the improvement of the fresh leaf weight; while the lowest fresh leaf weight was obtained from plots with no treatments. Generally, the leaf yield trend in most amended plots increased progressively and reached its peak on the 12 WAP, after which started going down.

3.9 The Relationship between Soil Cation Exchange Capacity, pH and Plant Leaf Yield

Fig. 1a to 1d showed the relationship between cation exchange capacity (CEC) and fluted pumpkin leaf yield at harvest. It was obtained that between the 8–14 weeks after planting (WAP), CEC correlated positively with the leaf yield of fluted pumpkin. However, higher correlations were observed at week 12 and 10 (r=0.976* and r=0.902*), respectively, compared to leaf yield correlation recorded at week 8 (r=0.881*).

Fig. 2a to 2d showed the relationship between the soil pH and fluted pumpkin leaf yield between 8–14 WAP. It was recorded that at 14 weeks after planting (WAP), soil pH correlated positively higher with the leaf yield of fluted pumpkin (r=0.864*) compared to other weeks of harvest. However, the least correlations effect were observed at week 12 (r=0.515*). Generally, there were stronger correlations between the plant leaf yield and cation exchange capacity compared to their relationship with soil pH within the period of study. This means that fluted pumpkin respond more to changes in cation exchange capacity of the soil than pH.

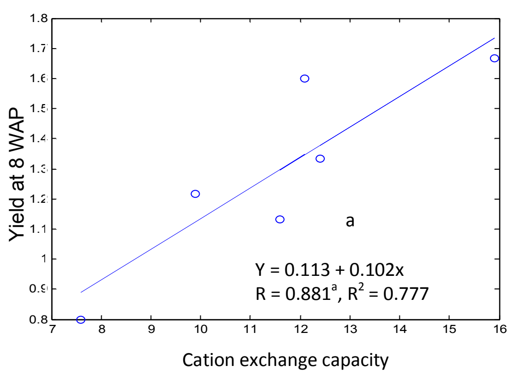

Fig. 1a. Relationship between CEC and mean yield at 8WAP

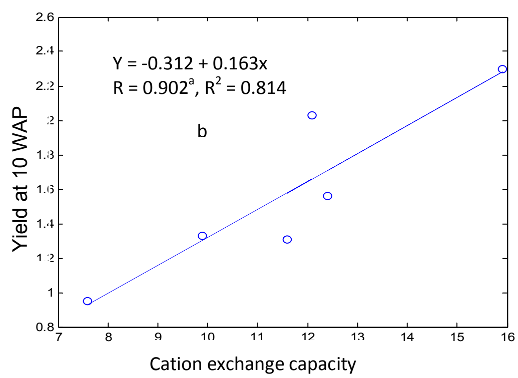

Fig. 1b. Relationship between CEC and mean yield at 10 WAP

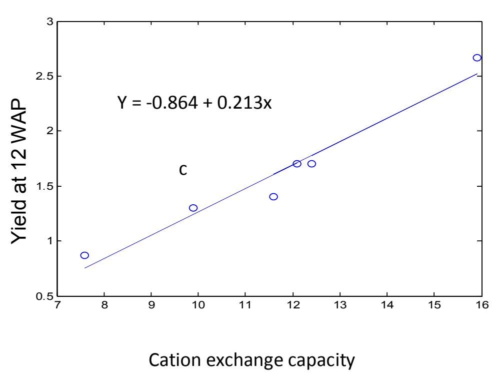

Fig. 1c. Relationship between CEC and mean yield at 12 WAP

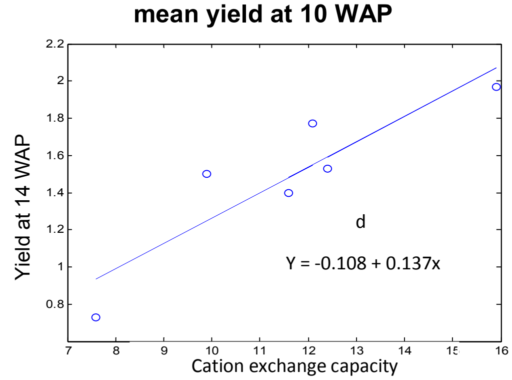

Fig. 1d. Relationship between CEC and mean yield at 14 WAP

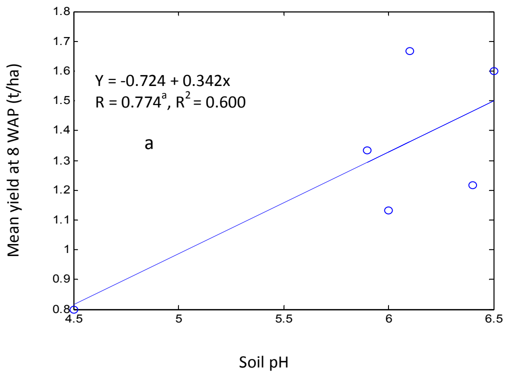

Fig. 2a Relationship between soil pH and mean yield at 8 WAP

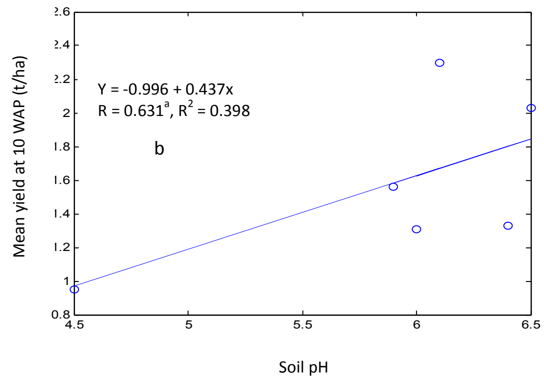

Fig. 2b. Relationship between soil pH and mean yield at 10 WAP

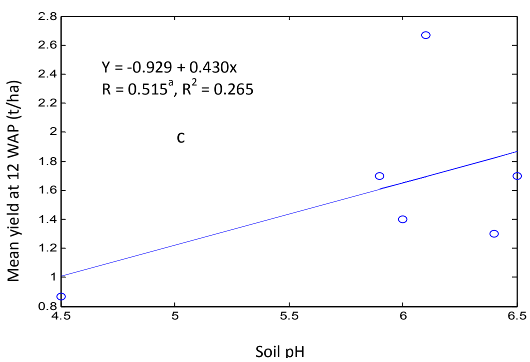

Fig. 2c. Relationship between soil pH and mean yield at 12 WAP

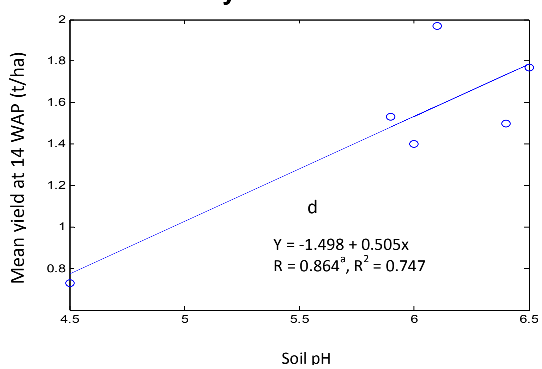

Fig. 2d. Relationship between soil pH and mean yield at 14 WAP

Table 9. Effects of manure sources on the fresh leaf weight of the fluted pumpkin (ton/ha)

Amendments	6WAP	8WAP	10WAP	12WAP	14WAP
NPK	1.133	1.333	1.56	1.70	1.53
PD	1.433	1.667	2.30	2.67	1.97
RH	1.083	1.133	1.31	1.40	1.40
PD+RH	1.150	1.600	2.03	1.70	1.77
RH+NPK	0.733	1.217	1.33	1.30	1.50
CT	0.333	0.800	0.95	0.87	0.73
LSD $_{(0.05)}$	0.6001	NS	0.829	1.034	0.854

NPK = nitrogen, phosphorous, potassium; PD = poultry droppings; RH = rice husk; CT = control; WAP weeks after planting; NS = not significant

4. CONCLUSION

The results obtained from the study showed that soil chemical properties were significantly improved by the application of Organo-mineral and Inorganic fertilizer. It is therefore concluded that Organo-mineral application could enhance vegetative growth and development of fluted pumpkin. It was noted that integrated nutrient management as the combination of Organic and Inorganic manures or integration of two organic sources as poultry dropping and rice husk dust can be better approaches in quick restoration of degraded soils and vegetable crop yield in southeastern Nigeria.

Generally, there were stronger correlations between the plant parameters and cation exchange capacity compared to their relationship with soil pH within the period of study. This means that fluted pumpkin respond more to changes in cation exchange capacity of the soil than pH.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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