

Effect of different rates of poultry manure on cassava (*Manihot species*) variety on an ultisol in Rivers State, Nigeria

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ABSTRACT

Investigation on the effect of different rates of poultry manure on cassava (*Manihot species*) variety on an ultisol of Rivers State was conducted at the Faculty of Agriculture Teaching and Research Farm in the University of Port Harcourt. The experiment was laid out in a randomized complete block design with 4 replicates. The study involved the application of different rates of poultry manure (0 kg/ha, 1250kg/ha, 2500kg/ha, 5000kg/ha) on a cassava variety (TME 419). Data on growth and yield parameters were collected and subjected to analysis of variance. Results indicated that poultry manure led to a substantial increase in the soil pH from 5.25 to 5.90, available phosphorus and organic matter from 20.90 to 25.43 mg/kg and 1.62 to 2.14 % respectively as the applied poultry manure was increased from 0 ton/ha to 5000kg/ha. The highest yield of cassava (48.01tons/ha) and other growth parameters (leaf area, plant canopy, number of leaves, stem girth) were also obtained at 5000kg/ha of poultry manure application. Based on the result of this study, cassava farmers on Ultisols in southern Nigeria (the coastal plains sands of southern Nigeria) are advised to apply 5000kg/ha of poultry manure to cassava for increased yield and reduced soil acidity.

Keywords: Poultry manure, cassava, ultisol, soil acidity, tuber yield

INTRODUCTION

Cassava is one of the most widely cultivated and used tuber crops in Nigeria. Cassava plays an important role in terms of food security, employment creation and income generation for farming families in parts of the humid tropics where hunger and starvation prevail. In southern Nigeria cassava is unarguably a regular and staple food of the people. The area is dominated by ultisols, which are well drained, low base status sandy soils of low inherent fertility. Generally, ultisols are kaolinitic humid soils characterized by prevalence of moderate to high acid reaction and thus contain very low

levels of mineral nutrient such as Ca, Mg, K, and P (Van Wambeke, 1991). The soils are deep and without hard pans or impermeable layers, moderately acidic with a pH range of 5.2 to 6.2, and have been described as being very suitable for cassava (Kamalu *et al.*, 2014; Kamalu and Nwaonuala, 2015). The terrain characteristics of less than 3% slope and a dominant loamy texture also support sustainable cassava cultivation. The weak to moderate granular, subangular blocky and angular blocky soil structure and the friable soil consistency are favourable conditions for cassava cultivation in the study area (Kamalu *et al.*, 2014; Kamalu and

Nwaonuala, 2015). Jinadasa *et al.*, (1997) has reported that poultry manure application increased soil pH, organic matter content, available phosphorus, exchangeable cations and micronutrient and decreased soil salinity and extractable iron. Agboola *et al.*, (1975) reported that there is reduced acidification and increased contents of exchangeable cations when poultry manure is added to soil, thus enhancing crop root growth and uptake of phosphorus. The superiority of poultry manure over other organic manures has been confirmed by several researchers (Follet *et al.*, 1995; Hsich and Hsu, 1993).

Cassava being a heavy feeder removes as much as 55 kg/ha N, 132 kg/ha P and 112 kg/ha K in one cropping (Howeler, 1991). Sustainable production of the crop, especially in Southern Nigeria where scarcity of land militates against natural fertility build up by fallowing, necessitates replenishing the fast depleting soil fertility through application of organic and inorganic fertilizers (Udoh *et al.*, 2005). Organic fertilizer apart from releasing nutrient elements slowly to the soil has also been shown to improve other soil chemical and physical properties which enhance crop growth and development (Stevenson and Ardakani, 1972; Udoh *et al.*, 2005). The effect of poultry manure on performance of cassava and its suitable rate has not received adequate research attention especially on Ultisols of Southern Nigeria where cassava is a dominant crop. This forms the premise for this work which has compared the effect of different rates of poultry manure on growth and yield of cassava and maintenance of soil fertility.

MATERIALS AND METHODS

The study was carried out in the Faculty of Agriculture Teaching and Research Farm, University of Port Harcourt, Rivers State, Nigeria. The University is situated at

latitude 04° 54' 538"N and longitude 006° 55' 329"E. The area is characterized by high rainfall with peaks in June and September which range from 2400mm to 3600 mm per annum, on an elevation of 18 m above sea level. Mean temperature varied from 25.6° C to 29.1° C (SERC, 1993; NMA, 2009). The cassava variety (TME 419) used was obtained from the Faculty of Agriculture Teaching and Research Farm, University of Port Harcourt. The site was cleared manually without burning; it was then tilled to a depth of 30cm to allow for easy penetration of the roots. The poultry manure with the liter component was obtained from the Faculty of Agriculture Demonstration Farm, Choba at University of Port Harcourt. The poultry manure was applied at the rates of 0 kg/ha, 1250 kg/ha, 2500 kg/ha, 5000 kg/ha prior to tilling. The experiment was randomized complete block design with four treatments and four replications. The experimental area was 17m x 17m (289m² or 0.0289 ha). The four poultry manure rates used were weighed out using a weighing balance and applied manually by broadcast uniformly on experimental plots of 4m x 4m and tilled into a depth of 30cm using spade, for control plot no poultry manure was applied. At planting, the 25 cm cassava stem cuttings were placed horizontally at a planting distance of 1 m x 1 m within and between rows at a depth of 3 – 5 cm. Planting was done in August, at field density of 16 stands per plot and a plant population of 256 stands in 289 m². The cassava cuttings were planted a week after poultry manure application. Weeds were kept under control by hand weeding every 3 to 4 weeks until the crop canopy spread to provide shade and suppressed the weeds.

Before the application of poultry manure, composite soil samples were taken from the top 0-15cm and from the subsoil 15-30cm and analyzed for routine properties and

nutrient contents. Soil pH was determined in a 1:1 soil water ratio using pH meter. Organic carbon was determined by the wet combustion method by Walkley and Black (1934). Percentage organic matter was derived by multiplying % organic carbon by Broadbent factor of 1.72. Available phosphorus was estimated by the Bray and Kurtz No.1 method as modified by Olsen and Summer (1994). The total nitrogen was determined by the macro-kjedahl method of Bremner and Mulvaney (1982). Potassium (K) was extracted using neutral normal ammonium acetate solution and analyzed using Atomic Absorption Spectrophotometer (AAS).

The poultry manure was analyzed for chemical nutrient status to ascertain the nutrient composition before its application. Soil samples from the depth of 0-15 and 15-30 cm were also taken at 12 months after planting (12 MAP) and analyzed for the same routine parameters.

During data collection, the following growth parameters were collected: plant height, plant canopy, number of leaves, stem girth (cm), and leaf area. The leaf area was calculated using the equation proposed by Akoroda (1993):

$$LA = 0.9467 + 0.2475LW + 0.9724LWN$$

Table 1. Mean Number of Cutting Sprouted at 8 and 17 Days After Planting (DAP)

Rates (Kg/ha)	8 Days	17 Days	Total Sprouted
0	10	13	23
12500	11	13	24
2500	11	14	25
5000	13	15	28
	45%	55%	100

Values are means from 256 plants; DAP = Days After Planting

Where:

LA= Leaf lamina area

L = length of central leaflet

W= Maximum width of the central leaflet

N=Number of leaflet in a leaf

Yield data was collected at 12 months after planting (MAP). The data collected includes: weight of tubers (t/ha); length of tubers (cm), girth of tubers (cm), and number of tubers per plant.

Statistical Analysis

All the data collected were subjected to Analysis of Variance (ANOVA). The Analysis of Variance (ANOVA) was used to compare the variability in the selected parameters, while the Duncan's Multiple Range Test (DMRT) was utilized to compare the treatment means as outlined by Gomez and Gomez (1984)

RESULTS

Effect of poultry manure on sprouting of cassava stems

Result of the days for sprouting of the stem cuttings are presented in Table 1. The cassava cutting started sprouting at 8 days after planting (DAP). It was observed that the highest mean number of sprouting was recorded at 17 days after planting.

Soil and Poultry manure analysis before planting and at 12 WAP

The results of the physical and chemical properties of the composite soil samples before planting for the site under study and the poultry manure before application are presented in Table 2. The soil was acidic with a pH of 4.3; organic matter was 1.5%; total nitrogen (0.08%); available

phosphorus (13.32 mg/kg); exchangeable K (0.09 cmol/kg) and ECEC (3.15 cmol/kg). The properties of the poultry manure are pH (5.8); organic matter (5.85); total nitrogen (0.276%); available phosphorus (35.0 mg/kg); exchangeable K (2.83 cmol/kg) and ECEC (15.20 cmol/kg).

Table 2. Chemical properties of composite soil (0- 30cm) and Poultry manure before Planting

Property	Soil	Poultry manure
pH (1:1 soil water)	4.3	5.8
Organic matter (%)	1.65	6.08
Total N (%)	0.08	0.276
Available Phosphorus (mg/kg)	13.32	35.0
Exchangeable Potassium (cmol/kg)	0.09	2.83
Exchangeable Calcium (cmol/kg)	1.25	3.85
Exchangeable Magnesium (cmol/kg)	0.24	2.71
Exchangeable Sodium (cmol/kg)	0.16	1.85
Base Saturation (%)	74	67.20
ECEC (cmol/kg)	3.15	15.2
Sand (%)	81.88	
Silt (%)	7.42	
Clay (%)	10.70	
Textural Class	Sandy loam	

The chemical properties of the soil at 12 months after planting (MAP) and application of the poultry manure was analyzed based on the different rates of poultry manure application. The results revealed that the pH at 0-30cm depth was

slightly acidic and increased as the rate of application increased (Table 3). Other properties of the soil showed a slight increase as the rate of poultry manure application increased.

Table 3. Soil chemical properties as affected by Rate of Poultry Manure at 12 MAP

Depth of soil sample (0 – 30cm)				
Property	0 kg/ha	1250 kg/ha	2500 kg/ha	5000 kg/ha
Soil pH (1:2 soil: water)	4.5	5.5	5.7	5.9
TOC (%)	1.62	1.67	2.11	2.14
Total N (%)	0.08	0.109	0.078	0.109
Available Phosphorus (mg/kg)	20.9	28.52	31.20	34.43
Potassium (cmol/kg)	0.09	0.15	0.19	0.25
Exchangeable Calcium (cmol/kg)	1.25	1.40	1.45	1.52
Exchangeable Magnesium (cmol/kg)	0.24	0.32	0.36	0.32
Exchangeable Sodium (cmol/kg)	0.16	0.15	0.19	0.17
Base Saturation (%)	55.24	56.58	56.29	55.26
Exch. Acidity (cmol/kg)	1.41	1.55	1.70	1.83
ECEC (cmol/kg)	3.15	3.57	3.89	4.09

Growth parameters

The results of poultry manure on the growth parameters like plant height, leaf area, plant canopy, stem girth and the number of leaves in Tables 4 and 5 were measured at 4, 6, 8, and 10 WAP. At 4 and 6 WAP the results revealed that the plant height was not significantly different ($P > 0.05$) as the rate of application increased but showed a significant difference ($p < 0.05$) at 8 and 10 WAP. At 5000kg/ha the plant height was

94.65cm while the control gave 64.0cm. Poultry manure at different rates of application in 6, 8, and 10 WAP was significantly different ($P < 0.05$) from the control (0 kg/ha) on the leaf area measured. Other parameters measured (plant canopy, stem girth, and number of leaves) did not show any significant difference as the rate of application increased at 4, 6, 8 and 10 WAP, though there were increase in value at different rates of poultry manure application.

Table 4. The effect of different rates of poultry manure at 4 & 6 WAP

Rates (kg/ha)	4 WAP					6 WAP				
	Plant height	Plant canopy	Leaf area	No. of leaves	Stem girth	Plant height	Plant canopy	Leaf area	No. of leaves	Stem girth
0	27.20 ^a	45.18 ^a	302.42 ^a	9.75 ^a	2.85 ^a	45.01 ^a	66.71 ^a	455.20 ^a	16.50 ^a	4.25 ^a
1250	26.44 ^a	42.43 ^a	308.48 ^a	8.75 ^a	2.65 ^a	37.83 ^a	69.48 ^a	556.38 ^{ab}	16.75 ^a	3.85 ^a
2500	28.38 ^a	43.44 ^a	360.67 ^a	9.75 ^a	2.75 ^a	52.93 ^a	70.58 ^a	591.95 ^{ab}	16.25 ^a	4.18 ^a
5000	30.81 ^a	49.42 ^a	385.45 ^b	10.75 ^a	3.05 ^a	61.17 ^b	74.36 ^a	692.81 ^b	19.50 ^a	4.70 ^a

Columns with the same lower case alphabet are not significantly different at $p > 0.05$

Table 5. The effect of different weight of poultry manure at 8 & 10 WAP

Rates (kg/ha)	8 WAP					10 WAP				
	Plant Height (cm)	Plant canopy (cm)	Leaf area (cm ²)	No. of leaves	Stem girth (cm)	Plant height (cm)	Plant canopy (cm)	Leaf area (cm ²)	No. of leaves	Stem girth (cm)
0	64.00 ^a	66.92 ^a	508.00 ^a	30.50 ^a	4.43 ^a	105.40 ^a	71.47 ^a	517.50 ^a	33.50 ^a	4.78 ^a
1250	80.87 ^{ab}	74.75 ^a	655.70 ^b	31.25 ^a	5.09 ^{ab}	114.35 ^{ab}	84.86 ^a	743.90 ^b	36.80 ^a	5.78 ^{ab}
2500	87.98 ^{ab}	74.75 ^a	748.60 ^b	30.25 ^a	5.33 ^{ab}	118.65 ^b	79.06 ^a	781.80 ^b	38.00 ^a	5.80 ^{ab}
5000	94.65 ^b	79.60 ^a	770.00 ^b	31.00 ^a	5.48 ^b	119.71 ^b	83.73 ^a	797.5 ^b	39.30 ^a	6.30 ^b

Columns with the same lower case alphabet are not significantly different at $p > 0.05$

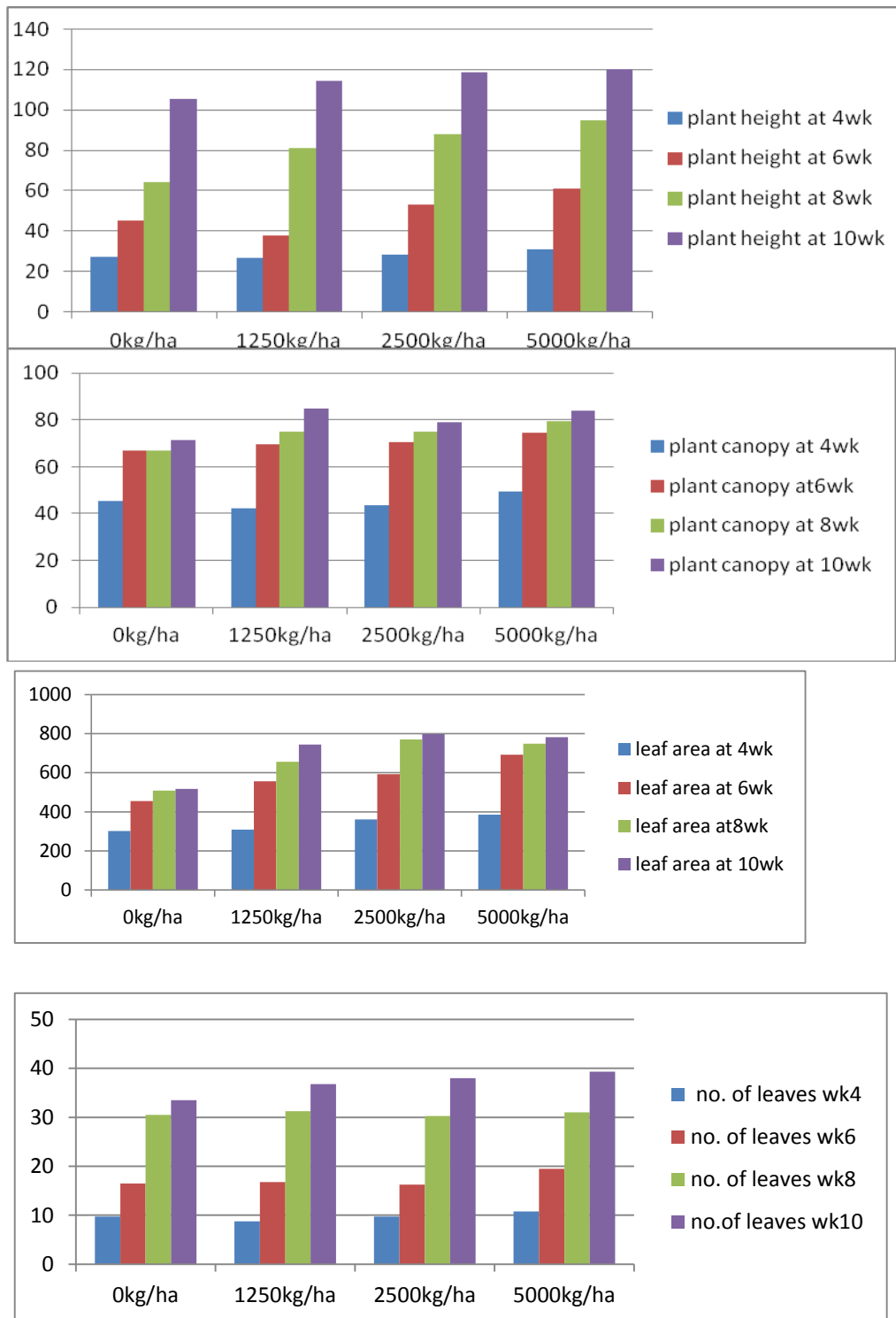


Figure 1. Relationship between rates of poultry manure and yield parameters of cassava

Yield parameters

The results presented in Table 6 showed the yield parameters as influenced by the different rates of poultry manure application. The data observed were on weight of tuber (t/ha); length of tuber (cm), girth of tuber (cm), number of tubers per plant. The number of tubers increased as the rate of poultry manure increases, though there was no significant effect at $P > 0.05$. The length of cassava tubers

increased with the rate of poultry manure, but the control (0kg/ha) recorded a lowest figure of 20.20cm compared to the 28.78cm obtained at 5000kg/ha application. The length of cassava tubers, tuber girth (cm) and fresh weight of tubers (kg/ha) increased as the rate of poultry manure application increased and significant difference ($p < 0.05$) was observed at 2500kg and 5000kg/ha in the parameters.

Table 6. Effects of different rates of poultry manure on yield of cassava at 12 MAP

Rates (kg/ha)	Number of tuber/plant	Length of tuber (cm)	Tuber girth (cm)	Fresh weight of tubers (t/ha)
0	6.12 ^a	20.20 ^a	16.01 ^a	40.08 ^a
1250	6.23 ^a	24.85 ^a	17.52 ^a	42.06 ^a
2500	6.41 ^a	27.08 ^{ab}	17.26 ^{ab}	46.43 ^{ab}
5000	6.55 ^{ab}	28.78 ^{ab}	18.05 ^{ab}	48.01 ^{ab}

Columns with the same lower case alphabet are not significantly different at $p > 0.05$

DISCUSSION

From the soil analysis carried out at the study site before planting, the soil was acidic, low in organic matter, N, K and Mg. Cassava has a critical nutrient levels and pH as pH 5.2 – 7.0, N - 0.2%, available P – 7.3 mg/kg, exchangeable K – 014 -1.20 cmol/kg and exchangeable Mg – 3 – 8cmol/kg (Howeler, 1991). It is also reported that the critical level of organic matter for crop production in Nigeria ecological zones were 3.0%, and the value of exchangeable Ca was 2.2cmol/kg (Akinrinade and Obigbesan, 2000). In addition, poultry manure has also been reported to increase soil pH (Udoh *et al.*, 2005) thereby positively affecting the availability of nutrient elements to the crops. This increase in soil pH with increased poultry manure rate of application as observed in this study agrees with Pitram and Singh (1993), who reported an increase in soil pH with the application of poultry manure. The mechanism responsible for this

increase in soil pH was due to ion exchange reactions which occur when terminal OH^- of Al or Fe^{2+} hydroxyl oxides are replaced by organic anions which are the result of poultry manure decomposition (Hue and Amiens, 1989, Besho and Bell, 1992; Van *et al.*, 1996; Pocknee and Summer, 1997). The 5000kg/ha poultry manure rate significantly ($P = 0.05$) increased soil pH from 5.3 (control) to 5.9 (pH in water). The ability of organic manure to increase soil pH was due to the presence of basic cations contained in the poultry manure (Natsher and Schwetnmann, 1991) such basic cations are released upon microbial decarboxylation.

The analysis of poultry manure indicates that it contains considerable amount of N, P, K, Ca, and Mg. This indicates that the nutrients contained in the poultry manure should have contributed to improving nutrient availability to cassava on the Ultisols in the Choba area, hence supported

the higher growth parameters and yield. On the effect of poultry manure on number of sprouting of the cassava, it was observed that the rate of application did not affect the sprouting of cassava stems especially at its early stage. At 8 days after planting, the number of cassava stems that sprouted at each rate of poultry manure application was 45% and after 17 days another counting was taken and about 55% sprouting was recorded. It was observed that the sprouting at 17days recorded the highest. This means that the poultry manure has no effect on the sprouting of the stems in their early stage of growth.

The chemical property of the soil at 12 MAP was presented in Table 3. At 12 months after planting a composite top soil samples were collected from the 16 plots and analyzed. The soil pH, Total Nitrogen and Available phosphorus increased in the plots with 1250kg, 2500kg, and 5000kg rates of poultry manure than the control where poultry manure was not applied. Increase in poultry manure resulted to improvement in the soil chemical properties.

Poultry manure at the rate of 5000kg/ha was significantly different from control (0 kg/ha) in the plant height, plant canopy, leaf area, number of leaves, stem girth, and yield components. Similar results were obtained by Odedina *et. al.*, (2011) with observations that poultry manure consistently increased growth of cassava. Increase in growth and yield of cassava is attributable to release of nutrients such as N, P, K, Ca and Mg which are contained in poultry manure (Table 2). These nutrients were available for crop uptake. The tuber yield and other components of yield also responded as the growth parameters resulting from the increase in rate of application of poultry manure on cassava. Moreover, poultry manure contains essential nutrient elements

associated with high photosynthetic activities and thus capable of promoting roots and vegetative growth (Jahn *et al.*, 2004). This could be attributed to improved soil conditions (moisture retention, soil structure and aeration and increase nitrogen availability) following the poultry manure application. Nitrogen's ability to promote vigorous growth, increased meristematic and physiological activities in crops probably resulted in the production of more assimilates used in the formation of cassava tubers observed in this study (Aliyu and Yusuf, 1991).

CONCLUSION

The increase in growth parameters measured (plant height, plant canopy, leaf area, number of leaves, and stem girths) and in yield components (number of tubers, length of tubers, tuber girth, and tuber weight) with increasing rates of poultry manure application could be attributed to release of nutrients such as N, P, K, Ca and Mg which are contained in poultry manure. The application of poultry manure has shown to improve soil fertility and reduced soil acidity. Poultry manure is a good soil amendment but it takes time to release its nutrient to the plant. It should be applied early (about 3 to 4 weeks before planting). In this study the rate of 5000 kg/ha of poultry manure increased growth and yield of the cassava compared to other rates of application, therefore it is recommended that cassava farmers on Ultisols in southern Nigeria (the coastal plains sands of southern Nigeria) apply 5000kg/ha of poultry manure to cassava for optimum yield and reduced soil acidity.

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