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# Growth and Yield Responses of Cassava to Poultry Manure and Time of Harvest in Rainforest Agro-Ecological Zone of Nigeria

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## Abstract
To increase the yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer. A field experiment was conducted at Federal College of Agriculture, Akure in south western Nigeria to compare the effects of levels of poultry manure (PM) on growth, yield, time of harvest and plant nutrient contents of cassava. Five levels of PM manure (10, 20, 30, 40 and 50 tha$^{-1}$), a control treatment (0 tha$^{-1}$) and 120:120:120 kgha$^{-1}$ NPK (standard check) were compared in a randomised complete block design with three replicates. The growth data were subjected to analysis of variance (ANOVA). A combined ANOVA using a variation of a factorial design was used to assess the effects of time of harvest, levels of poultry manure and the possible interaction between time of harvest and levels of poultry manure on yield of cassava. The Duncan multiple range test (P=0.05) was used for mean separation. The test soil was sandy loam and deficient in organic matter and N (0.07%) with very low values in P, Ca, CEC and slightly acidic. Significant differences were observed in the growth parameters such as plant height (cm), stem girth (cm), length of internode (cm), number of leaves and branches/plant. The control, 10 tha$^{-1}$ PM and NPK produced similar result in plant height. Higher levels of PM increased leaf area (cm$^2$) and gave similar result with NPK. Time of harvest had significant effect on tuber weight (tha$^{-1}$) with 12 months after planting (MAP) giving a higher significant value. The 50 tha$^{-1}$ PM increased cassava root yield and biomass production by 39.8% and 24.5% compared to the control and NPK respectively, though these increases were not significant compared to other levels. The percent nutrient contents were highest in the tuber compared to the leaf and stem. The tuber accumulated more K than N, followed by Ca, Na and P. PM enhanced availability of nutrients to cassava. The results of this study have shown that PM levels increased growth parameters such as plant height, stem girth, number of leaves and branches/plant. The time of harvest (12 MAP) significantly increased tuber yield of cassava. Cassava planted using TMS 30572 can be harvested at 12 MAP using 10tha$^{-1}$ PM.

# 1. Introduction

Decline in soil fertility is an acute problem facing small holder farming in Nigeria. Due to the high cost and uncertain availability of inorganic fertilizers, it is important to provide alternative sources of nutrients such as organic materials. To maintain or improve soil fertility, cassava farmers in many countries apply farmyard manure (FYM), either alone or in combination with chemical fertilizers. While animal manures may contribute to improving the soil's physical conditions and are an important source of Ca, Mg, S, and micronutrients, they contain only low and highly variable amounts of N, P, and K. Large applications of manure are probably economical only in areas where manure is locally available. In many sandy soils, low in organic matter, cassava has shown symptoms of Mg deficiency, especially when only chemical fertilizers are applied (CIAT, 2006). Animals return in their dung and urine over 80% of the nitrogen, phosphorus and potassium they take in by grazing, so the net removal is very much less when grass is grazed and the bulk of the nutrients are returned to the same area (Ahn, 1993). Application of organic manures has various advantages like increasing soil physical properties, water holding capacity, and organic carbon content apart from supplying good quality of nutrients. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In fresh poultry excreta uric acid or urate is the most abundant nitrogen compound (40-70 per cent of total N) while urea and ammonium are present in small amounts (Krogdahl and Dahlsgard, 1981). Even though poultry manure contains more amount of nutrients than other manures, the research work on poultry manure is less when compared to farm yard manure, since poultry population is concentrated only in certain areas and hence the manure availability also. With this idea in view, the present study was formulated.

Cassava is cultivated in almost all the agro ecological zones in Nigeria and plays a prominent role in alleviating the food problem in the country because it thrives and produces stable yields under conditions in which other crops fail ( Alexandratos, 1995). To increase the yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer (Gomez *et al.*, 1980). Farmers do not fertilize cassava because they are contented with the minimal yields obtained from using limited inputs or even from their infertile soils. The indifference towards low productivity can be attributed to the low and unstable prices of cassava tubers. However, fertilizer requirement for optimum yield in cassava is determined by the following factors, soil fertility status of the farmland, cropping system adopted and rainfall pattern. However, research information is quite scarce on response of cassava to application of animal manure which is a major traditional source of nutrients. The objective of the research is: to determine the effect of levels of poultry manure as fertilizer on growth and yield of cassava.

# 2. Materials and Methods

The experiment was conducted at the Federal College of Agriculture, Akure, Ondo State, Nigeria during the 2006/2007 cropping season. Akure lies between latitude $7^0$ 30'N and longitude $3^0$ 52' E in the tropical rainforest belt. There are two rainy seasons, one from April to July (early season) and from mid-August to November (late season). Average annual rainfall ranges between 1100 mm and 1200 mm. Annual average minimum and maximum temperatures are 24.80 $^0$C and 28.10 $^0$C respectively. The mean relative humidity is about 75%. The experiment involved seven treatments compared in randomized complete block design with three replicates. The treatments include: 0, 10, 20, 30, 40, and 50 $tha^{-1}$ poultry manure (PM) and 400 $kgha^{-1}$ NPK 15:15:15 used as a reference treatment. Nine core samples were randomly taken using 5 mm soil auger at 0 -30 cm depth before planting. They were bulked, air-dried and 2 mm mesh sieved for analysis. The particle size analysis was done by pipette method (Gee and Bauders, 1986); soil pH in water was determined using soil: water ratio of 1:2 by a pH meter with a glass electrode. Organic matter was determined using the Walkey & Black method (Nelson and Sommers, 1996). Total N in the soil was determined by Kjedahl digestion and N determined colourimetrically (Bremner, 1996). Exchangeable bases in the samples were extracted in IM $NH_40AC$ at pH 7.0. Ca and Mg in the extract were read by atomic absorption spectrophotometer (AAS). Na and K were analyzed by using flame photometry. Exchangeable acidicity was determined by extracting with IN KCl and determined by NaOH titration (Sims, 1990). Available phosphorous was determined by Bray-1 extraction and determined colourimetrically by the molybdenum blue procedure (Bray and Kurtz, 1945). Leaf, stem (phelloderm) and root were collected at 4 months after planting for analysis. The samples were collected per plot, oven dried at 80 $^0$C and milled for chemical analyses. Total N was determined by micro–kjeldahl method (Jackson, 1962). For P, K, Ca and Mg, samples (0.5 g) were ashed, dissolved in 10% HCl and diluted to 50 ml. P was determined using vanado molybdate colourimetry. Ca and Mg were determined by EDTA titration, Na and K by flame photometry. The powdered forms of the poultry manure was analysed using wet digestion method based on 25 - 5 - 5 ml of $HNO_3$- $H_2SO_4$- $HClO_4$ acid: as described for leaf, stem and root.

Stem cuttings of TMS 30572 variety obtained from the Federal College of Agriculture, Akure was used. The stem cuttings were cut to a 25 cm length and planted at a spacing of 1m x 1m. The poultry manure was cured by air drying and later pounded in a mortar with pestle to increase their surface area for easy application and mineralization. Poultry manure (PM) rates were applied by ring method at 2 months after planting (MAP). Three hoe weedings were carried out at 3, 8 and 12 weeks after planting (WAP). Data collection commenced one month after treatment application and subsequently on a monthly basis for six months. The plot size each measured 5 m x 5 m. Five plants were randomly selected per plot for data collection after treatment application. Plant height was estimated with a tape measure at harvest, number of branches per plant and number of leaves/ plant and numbers of nodes/25cm cuttings were counted manually. Stem girth (cm), plantable stake (cm) and number of 1m cutting/stand were estimated with a tape measure. Leaf area ($cm^2$) was estimated using Spencer (1962). Leaf area index (LA1) was calculated as described by Wahua (1983). Yield data was collected at 9 and 12 MAP include: tuber girth (cm), length of tuber (cm), single root weight/plant (kg), weight of tuber ($tha^{-1}$), biomass production ($tha^{-1}$) by Boardman (1980) and number of tubers per plant. The harvest index was used as selection criteria for high yield. The mean values of leaf, stem and root nutrient contents of cassava were compared. The growth data were subjected to analysis of variance (ANOVA). A combined ANOVA using a variation of a factorial design (Brinson, 1977; Weider and Lang, 1982) was used to assess the effects of time of harvest, levels of poultry manure and the possible interaction between time of harvest and levels of poultry manure on yield of cassava. The Duncan multiple range test (P=0.05) was used for mean separation.

## 3. Results and Discussion

The physico-chemical properties of the soil before planting are shown in Table 1. The soil which is sandy loam is deficient in organic matter and N (0.07%) with very low values in P, Ca, CEC and slightly acidic.

Increase in growth and yield of cassava is attributable to release of nutrients such as N, P, K, Zn, Fe, Ca and Mg which are contained in poultry manure (Table 2). These nutrients were available for crop uptake. Tissue analyses confirm that the nutrients were released for crop uptake which led to significant increases in growth parameters such as number of branches and leaves/plant, leaf area index, and ultimately the tuber yield.

Significant differences were observed in plant height, stem girth, number of leaves, branches and length of internodes/plant (Table 3) with the application of poultry manure levels and NPK. NPK gave highest significant mean value in number of branches/plant compared to other treatments. NPK was significantly different from control (0 $tha^{-1}$) and all levels of poultry manure. PM at10 $tha^{-1}$ was significantly different from control (0 $tha^{-1}$), 30 $tha^{-1}$ and NPK in length of internodes/plant. PM at 30 $tha^{-1}$ was significantly different from 50 $tha^{-1}$ in stem girth. PM at 20 $tha^{-1}$ and NPK were significantly different from control and 10 $tha^{-1}$ PM in number of leaves/plant. However, it is shown (Table 3) that NPK improved plantable stake with respect to control and poultry manure, 40 $tha^{-1}$ poultry manure improved number of 1m cutting/stand while 50 $tha^{-1}$ poultry manure improved the number of nodes/25cm cutting. The poultry manure and NPK fertilizer had positive effects on the growth of cassava and lower levels of poultry manure such as 10 and 20 $tha^{-1}$ gave better or similar effects compared with NPK fertilizer (Table 3). Similar results were obtained by Odedina *et. al*., (2011) with observations that PM consistently increased growth of cassava.

***Table 1.*** *Physico-chemical properties of soil before planting*

| Na | K | Ca | Mg | pH | H+ | CEC | Av. P | Zn | C | OM | N | Silt | Clay | Sand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ←Exchangeable cation ( Cmol/kg)→ | | | | ($H_2O$) | ← Cmol/kg→ | | ← mg/kg→ | | ← | | % | | → | |
| 0.17 | 0.32 | 1.09 | 0.72 | 6.07 | 0.12 | 2.14 | 6.01 | 5.40 | 0.68 | 1.22 | 0.07 | 9.33 | 18.67 | 72.33 |

***Table 2.*** *Chemical composition of poultry manure*

| Nutrient | amount |
|---|---|
| Na % | 0.28 |
| K % | 0.68 |
| Ca % | 2.09 |
| Mg % | 1.92 |
| P % | 1.28 |
| N % | 1.38 |
| Zn (mg/kg) | 1.38 |

***Table 3.*** *Effect of levels of poultry manure on growth of cassava*

| Poultry manure ($tha^{-1}$) | Plant height(cm) at harvest | Plantable stake (cm) | Number of 1m cutting/stand | Number of nodes /25cm cutting | Stem girth (cm) | Length of internodes (cm) | Number of leaves /plant | Number of branches/plant |
|---|---|---|---|---|---|---|---|---|
| 0 | 198.00a | 159.33 | 1.76 | 17.17 | 7.53ab | 1.93b | 78.65c | 2.01b |
| 10 | 178.50abc | 147.42 | 1.67 | 18.67 | 7.00ab | 3.67a | 82.22bc | 3.31b |
| 20 | 171.42bc | 145.25 | 1.87 | 17.58 | 7.50ab | 3.00ab | 110.28a | 3.87b |
| 30 | 160.58c | 139.17 | 1.70 | 16.17 | 8.13a | 2.07b | 97.62abc | 3.72b |
| 40 | 166.75c | 160.25 | 2.20 | 18.58 | 6.80ab | 2.40ab | 104.38ab | 3.14b |
| 50 | 163.08c | 153.25 | 1.44 | 19.25 | 6.33b | 3.33ab | 102.97ab | 3.89b |
| 0.4 (NPK) | 191.92ab | 184.50 | 1.72 | 16.75 | 7.43ab | 2.00b | 118.48a | 6.79a |
| SE± | 10.60 | ns | ns | ns | 0.58 | 0.61 | 9.18 | 0.8 |

Means followed by different lowercase letters in the same column are significantly different ($P < 0.05$)
ns – not significant.

Table 4 shows data on leaf area (LA), leaf area index (LAI) and harvest index. Poultry manure and NPK fertilizer treatments increased leaf area and leaf area index (LAI). The NPK fertilizer gave significantly higher values for leaf area and leaf area index (203.55cm$^2$ and 4.35 respectively) than 0, 10 and 20 tha$^{-1}$ poultry manure. Between 30 – 50 tha$^{-1}$ applications of PM manure, there was no significant difference in LAI. Leaf area and LAI increased with increase in the levels of poultry manure and increase was linear. The 50 tha$^{-1}$ poultry manure had the highest leaf area and LAI. This could have resulted in high biomass production at 9 months due to increase in the level of nitrogen in the high rate of poultry manure. This finding is in agreement with Ramanujam (1992). His study highlighted the influence of nitrogen on LAI, crop growth rate, net assimilation rate and yield of cassava.

At 9 and 12 MAP, harvest index (HI) values were 0.63 for all treatments except in 30 tha$^{-1}$ poultry manure at 12 MAP which gave a value of 0.73. The harvest index (HI) in both months was not affected by the addition of manures probably due to the fact that the variety used is one of high-yielding (Ikeorgu, 2000). Compared to the control (0 tha-$^1$); leaf area increased linearly as the level of poultry manure increased (Table 4).

***Table 4.*** *Effect of levels of poultry manure on leaf area, LAI and Harvest Index*

| Poultry (tha$^{-1}$) | Leaf area (cm$^2$) | LAI | Harvest Index | |
|---|---|---|---|---|
| | | | 9 months | 12 months |
| 0 | 158.15c | 2.36c | 0.63 | 0.63 |
| 10 | 163.66c | 3.05bc | 0.63 | 0.63 |
| 20 | 177.91bc | 3.55ab | 0.63 | 0.63 |
| 30 | 191.89ab | 3.49ab | 0.63 | 0.73 |
| 40 | 205.81a | 3.82ab | 0.63 | 0.62 |
| 50 | 210.79a | 4.18ab | 0.63 | 0.63 |
| 0.4 (NPK) | 203.55ab | 4.35a | 0.63 | 0.63 |
| SE± | 11.53 | 0.45 | | |

Values are means of triplicate readings
Means followed by different lowercase letters in the same column are significantly different ($P < 0.05$)

***Table 5.*** *Effects of level of poultry manure on yield of cassava in 9 and 12 months*

| Treatments | Number of tubers/stand | Tuber length (cm) | Tuber girth (cm) | Single root weight/plant (kg) | Tuber weight (tha$^{-1}$) | Biomass production (tha$^{-1}$) |
|---|---|---|---|---|---|---|
| Harvest time (Months) | | | | | | |
| 9 | 6.24 | 38.79 | 18.72 | 0.47 | 41.71 | 66.73 |
| 12 | 6.52 | 35.77 | 23.29 | 0.63 | 57.79 | 90.57 |
| SE± | ns | ns | 3.91 | ns | 19.92 | 32.22 |
| Poultry manure (tha$^{-1}$) | | | | | | |
| 0 | 6.29 | 31.67 | 18.00 | 0.44 | 37.33 | 59.72 |
| 10 | 6.46 | 36.39 | 20.83 | 0.61 | 52.12 | 83.40 |
| 20 | 6.83 | 37.14 | 22.08 | 0.55 | 54.25 | 86.80 |
| 30 | 6.62 | 37.21 | 20.93 | 0.53 | 46.40 | 67.59 |
| 40 | 6.33 | 41.79 | 21.17 | 0.52 | 49.33 | 78.98 |
| 50 | 6.08 | 33.81 | 23.11 | 0.71 | 62.00 | 99.20 |
| 0.4 (NPK) | 6.04 | 42.99 | 20.93 | 0.49 | 46.83 | 74.85 |
| SE± | ns | ns | ns | ns | ns | ns |
| Harvest time × Poultry manure | | | | | | |
| SE± | ns | ns | ns | ns | ns | ns |

Values are means of triplicate readings
ns – not significant.

Table 5 shows the data on yield and yield components of cassava as produced by different levels of poultry manure and NPK fertilizer in 9 and 12 months. The findings indicated that time of harvest had significant difference on the yield of cassava in tuber girth (cm), tuber weight and biomass production (tha$^{-1}$). The time, 12 MAP gave a higher significant value in the three parameters. Number of tubers/stand and tuber length were not significant. For most cultivars, the number of adventitious roots that develop into tuber is limited, and beyond the first 6-9 months planting, there will be no further addition of the number of tuberous roots (IITA, 1990). There were no significant differences in yield and yield components irrespective to poultry manure levels and NPK fertilizer treatments. There was no proportional increase in tuber yield characteristics and biomass production (tha$^{-1}$) to added poultry manure and NPK fertilizer treatments. The insignificant responses of cassava yield to NPK fertilizer at 0.4tha$^{-1}$ could be due to excessive availability of nutrients which gave luxuriant top growth at expense of tuber growth (Agbaye and Akinlosotu, 2004). The 50 tha$^{-1}$ poultry manure gave the highest yield in tuber weight and biomass production though not significant. The 50 tha$^{-1}$ increased cassava root yield and biomass production by 39.8% and 24.5% compared to the control and NPK respectively. Higher tuber yield due organic manures could be attributed to favourable changes in soil, which might have resulted in loose and friable soil condition and enabled better tuber formation. Moreover, positive influence of these treatments might be due to slow and steady availability of nutrients throughout the crop period from organic manures. The increase of cassava root yield could also be attributed to the increase in the single root weight per stand (Kogram *et al*., 2002; Evangeline *et al*., 2002). Significant differences were not observed in the interactions of harvest time × poultry manure in all the yield parameters.

Table 6 contains data on response of leaf, stem and tuber nutrient contents of cassava in relation to levels of poultry manure and NPK fertilizer. Significant differences were observed in the percent nutrient contents (N, P, K, Ca, Mg and Na) in the leaf, stem and tuber of cassava. Manures have been known to increase nutrient contents of cassava (Odedina *et al*., 2012). The percent nutrient contents were highest in the tuber compared to the leaf and stem. The tuber being the sink organ. The % leaf, stem and tuber nutrient contents increased in this order: tuber > stem > leaf in all nutrient parameters. The tuber generally accumulated more K than N, followed by Ca, Na, and P. Similar results were reported by Puttacharoen *et al*., (1998), Nguyen, *et al.,* (2001) and Howeler (2002). Percent N, P and K were highest in the tuber. The control, 0 $tha^{-1}$ increased tuber N by 38% and 47% in the stem and 10 $tha^{-1}$ of the leaf respectively. For % P, the increase was by 28% and 73% in the control and 50 $tha^{-1}$in the stem and 10 $tha^{-1}$ in the leaf respectively. PM at 40 $tha^{-1}$ increased tuber K by 26% and 52% in the 40 $tha^{-1}$ stem and 20 $tha^{-1}$ leaf tissue analysis. PM at 30 $tha^{-1}$ and 0.4 $tha^{-1}$ NPK increased tuber Mg by 3% and 14% in 20 $tha^{-1}$ stem and 10 $tha^{-1}$ leaf respectively.

***Table 6.*** *Effect of levels of poultry manure on % leaf, stem and tuber nutrient contents*

| Poultry ($tha^{-1}$) | N | P | K | Ca | Mg | Na |
|---|---|---|---|---|---|---|
| Leaf | | | | | | |
| 0 | 0.89bc | 0.21c | 2.28a | 0.13b | 0.33d | 0.04c |
| 10 | 1.08a | 0.27b | 2.17b | 0.19a | 1.07a | 0.12c |
| 20 | 0.92b | 0.22c | 2.29a | 0. 18a | 0.46bc | 0.07d |
| 30 | 1.06a | 0.28b | 2.21b | 0.18a | 0.52b | 0.15b |
| 40 | 0.88bc | 0.19d | 2.16b | 0.18a | 0.44bc | 0.18a |
| 50 | 0.85bc | 0.23c | 2.22b | 0.10c | 0.40cd | 0.04e |
| 0.4 (NPK) | 0.88bc | 0.31a | 2.19b | 0.11b | 0.40cd | 0.08d |
| S.E. ± | 0.26 | 0.10 | 0.29 | 0.10 | 0.39 | 0.03 |
| Stem | | | | | | |
| 0 | 1.25a | 0.72a | 3.42d | 0.75c | 1.13b | 0.88a |
| 10 | 1.21c | 0.66b | 3.50ab | 0.79abc | 1.20a | 0.81c |
| 20 | 1.23bc | 0.67b | 3.46c | 0.80ab | 1.21a | 0.84b |
| 30 | 1.21c | 0.63c | 3.49bc | 0.77bc | 1.20a | 0.87a |
| 40 | 1.24ab | 0.71a | 3.46c | 0.76bc | 1.15b | 0.85b |
| 50 | 1.22bc | 0.72a | 3.53a | 0.79abc | 1.14b | 0.87a |
| 0.4 (NPK) | 1.21c | 0.68b | 3.42d | 0.82a | 1.14b | 0.08 |
| S.E. ± | 0.09 | 0.12 | 0.14 | 0.17 | 0.21 | |
| Tuber | | | | | | |
| 0 | 2.02a | 0.98bc | 4.73a | 1.15a | 1.22ab | 1.05d |
| 10 | 2.01ab | 0.98bc | 4.73a | 1.12ab | 1.21ab | 1.08c |
| 20 | 2.00ab | 0.98bc | 4.72a | 1.11ab | 1.23ab | 1.11b |
| 30 | 1.97b | 1.00a | 4.73a | 0.98c | 1.25a | 1.14a |
| 40 | 1.98ab | 0.99abc | 4.74a | 1.06b | 1.22ab | 1.05d |
| 50 | 2.00ab | 1.00a | 4.28b | 1.13a | 1.23ab | 1.07cd |
| 0.4 (NPK) | 2.02a | 1.00a | 4.15b | 1.12ab | 1.25a | 1.05d |
| S.E. ± | 0.20 | 0.08 | 0.13 | 0.12 | 0.11 | 0.30 |

Values are means of triplicate readings
Means followed by different lowercase letters in the same column are significantly different ($P < 0.05$)

PM at 10 – 30 $tha^{-1}$ significantly increased leaf N and Ca though not significantly different from 20 and 40 $tha^{-1}$. A higher significant increase was observed in leaf Mg at 10 $tha^{-1}$ PM compared to other treatments. Leaf P was significantly enhanced by NPK.

The percent nutrient contents in the stem were not consistent with the increase in the levels of poultry manure and NPK. PM at 40 $tha^{-1}$ significantly increased N and P, though this was not significantly different from the control (0 $tha^{-1}$). Stem Mg was significantly increased at 10 – 30 $tha^{-1}$ PM while 10 and 50 $tha^{-1}$ significantly enhanced stem K compared to other treatments. The control (0 $tha^{-1}$) and 10 – 40 $tha^{-1}$ significantly increased tuber K compared to 50 $tha^{-1}$ and NPK. PM at 30 and 50 $tha^{-1}$ significantly increased tuber P compared to other levels. PM at 30 $tha^{-1}$ significantly gave a lower tuber N compared the control (0 $tha^{-1}$) and NPK treatments.

## 4. Conclusions

The results of this study have shown that the control, 10 $tha^{-1}$ PM and NPK produced similar result in plant height. The 50 $tha^{-1}$ PM increased cassava root yield and biomass production by 39.8% and 24.5% compared to the control and

NPK respectively, though these increases were not significant compared to other levels. The time of harvest (12 MAP) significantly increased tuber yield of cassava. Thus cassava can be harvested at 12 MAP using PM at 10 $tha^{-1}$. The tuber accumulated the most percent nutrient contents: K, N, Ca, Na and P in that order.

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