



Response of Cassava (*Manihot esculenta* Crantz) to Different Soil Amendments in Rainforest Ecology of Southern Nigeria

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Abstract

Background: In Nigeria, cassava is considered one of the primary crops for ensuring food security, however the soil fertility be one of major problem.

Aims: The experiment aimed to evaluate the effect fertilization on growth and yield of cassava.

Methods: The field experiment was conducted at Akwa Ibom State University, Teaching and Research, Obio Akpa Campus. The experiment was laid out in randomized complete block design, replicated three times. Growth and yield data were collected. All growth and yield data collected were subjected to analysis of variance. Significant means were tested with LSD at 5% probability level.

Result: Among the fertilizer treatments, the treatment of 5t/h PM produced significant storage root yield of 32.18 and 31.16t/ha. Application of 5t/ha of EFBA produced 25.17 and 25.23t/ha of storage root yield in 2024 and 2025 cropping seasons, respectively. The treatment of 400kg/ha of NPK 15:15:15 fertilizer produced 27.24 and 28.80 t/ha storage root yield. The result showed that the treatment of poultry manure produced 15-43% and 9-47% higher storage root yield compared to the other treatments in both cropping seasons. PM treatment generated the highest economic returns across both cropping seasons, yielding N 4,020,700 and N 4,119,000 for the 2024 and 2025 seasons, respectively. The cost-benefit ratio for the PM treatment was recorded at 3.12 and 3.09, while the CD treatment had benefit ratios of 2.54 and 2.83.

Conclusion: For high yield and economic returns to management. The study therefore recommended the application of poultry manure, followed by Cow Dung (CD) and oil palm empty fruit bunch ash (EFBA).

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1. Introduction

Cassava (*Manihot esculenta* Crantz) is a tropical food crop that ranks just behind rice and maize in its significance for feeding the growing global population, particularly in the face of challenging

environmental conditions (FAO, 2024). Research conducted by Amelework et al., (2021) states that cassava (*Manihot esculenta*) is an important tuber crop grown globally in tropical and subtropical regions to supplement the starch supply for human and animal diets. In Nigeria, cassava is considered one of the primary crops for ensuring food security (Ikeh et al., 2025). Its widespread adoption can be attributed to its adaptability to a variety of agro-ecological zones, its ability to thrive in poor soil conditions, and its resilience to drought, pests, and diseases. Additionally, cassava is a major food crop in Africa because of its ability to thrive in arid, drought-prone soils where other crops struggle to grow (Loha et al., 2025).

Recently, production levels of cassava have increased significantly in sub-Saharan Africa (SSA) in response to food shortages stemming from a rapidly growing population in Nigeria and other parts of West Africa. In Sub-Saharan Africa, cassava is considered an important commodity due to its resistance to changing weather patterns and its important role as a staple food and source of income for small farmers (Guo, 2020). Despite the economic importance of cassava cultivation in Nigeria, its production faces numerous challenges. Among these are the low inherent fertility levels of many soils, particularly in the southeastern and South-South regions of the country. Cassava has complex nutritional requirements, which vary at each stage of growth and under different agroclimatic conditions where the crop is grown (Cock & Conor, 2021). Research by Adekiya et al. (2025) shows that organic amendments can sustainably close cassava yield gaps, improve starch content, and enhance farmer profitability. Soil fertility is dynamic, influenced by processes of accumulation and depletion that result from a complex interplay of physical, chemical, biological, and anthropogenic activities (Ikeh et al., 2023b).

Research has shown that smallholder farmers in sub-Saharan Africa, particularly in Nigeria, rarely consider fertilizer as a key input for increasing storage root yield. This trend is historically linked to the use of long fallow periods, which allowed natural replenishment of soil nutrients. However, due to growing pressure on land for both agricultural and non-agricultural purposes, fallow periods in southern Nigeria have significantly shortened. As a result, traditional shifting cultivation is no longer sustainable. The shortened bush fallow system has led to a decline in soil fertility, and soils can no longer supply the necessary nutrients for optimal crop growth. Consequently, cassava yields tend to decline rapidly once cropping begins.

Research conducted by Odedina et al. (2012) shows that the application of organic fertilizer alone significantly increases the content of Na, K, Mg and CEC, available phosphorus, Zn, and organic matter in the soil compared to treatments without organic fertilizer. According to Sampson et al. (2025) and Ikeh et al. (2025), organic manures offer a multitude of agronomic advantages, notably improving soil structure, enhancing water retention, and increasing organic carbon levels. Beyond nutrient supply, organic matter contributes significantly to soil health by enhancing tilth, reducing erosion, improving aeration, and fostering beneficial microbial activity.

Among various organic inputs, poultry manure stands out due to its nutrient richness. This is attributed to the simultaneous excretion of solid and liquid waste, which prevents nutrient loss through urine separation. Furthermore, studies have demonstrated that manure use can significantly boost the nutrient content of cassava (Ikeh et al., 2023a). Research by Bilong et al (2022) enhancing that poultry manures can contribute to maintaining the productivity and sustainability of cassava production systems due to their availability and cheapness. Application of poultry manures can improved soil physical properties by lowering soil bulk density, and increasing total porosity and water holding capacity.

This experimental study was conducted to evaluate the effects of different organic fertilizer sources on the growth, yield, and economic returns of cassava cultivated in an ultisol of southeastern Nigeria.

2. Methods

2.1 Site Information

The experiment was carried out at Akwa Ibom State University Mkpat, Akwa Ibom State Nigeria. The area is in the humid tropical region, characterized by two seasons; rainy and dry. The dry season spans from November through March, while the rainy season is experienced from April to October. There is a short dry spell in August, otherwise called “August break”. The Monsoon air mass blowing

over the Atlantic Ocean sweeps through this zone, resulting in heavy annual rainfall of 2000-2500mm in the wet season. The annual temperature range is 24°C- 30°C and the annual relative humidity range of 75-79% (Slus-Ak 1989). The vegetation of the area was originally tropical rainforest.

2.2 Treatments, Experimental Design and Experimental Layout

The treatments consisted of three (3) organic fertilizer sources—cow dung (CD), poultry manure (PM), and oil palm empty fruit bunch ash (EFBA) alongside the recommended dose of NPK fertilizer for cassava in Nigeria (400 kg/ha), and a zero-application control treatment.

The experiment was laid out in a randomized complete block design (RCBD), replicated three times. The experimental field, measuring 40 m × 22 m (880 m²), was cleared, marked out, and ridged. There were a total of 15 plots, with each replication containing 5 plots. Each plot measured 6 m × 5 m (30 m²), and each replication measured 40 m × 5 m (200 m²). The spacing between and within blocks was 1 m.

Data collection and analysis contain plant height (cm) was measured from the base of the plant to the tip using a measuring tape on ten (10) tagged plants per sub plot. The nodes were counted and recorded from the ten (10) tagged plant per sub plot. The numbers of petiole per plant was counted and recorded for Ten (10) tagged plant per sub plot. Number of roots per sample plant was counted, the total number of roots was divided by the number of plants harvested per sub plot to get the root mean value. The length of roots(cm) was taken from the sampled plants and the sum of the lengths were divided by the number of roots per plants sampled to obtain the mean root. Root yield in tonnes per hectare, was determined by calculation:

$$\text{Root yield (t/ha)} = \frac{\text{Root weight (kg/plant)} \times \text{number of roots/plant} \times \text{plant population/ha}}{1000}$$

The growth and yield data that were collected throughout the study underwent a comprehensive analysis of variance (ANOVA) to determine any significant differences among the treatments. Following the ANOVA, significant means were further assessed using the Least Significant Difference (LSD) test at a 5% probability level to identify which specific treatment differed from one another.

3. Results

3.1 Branches per plant

The number of branches per plant, as influenced by different fertilizer sources, varied significantly ($p < 0.05$) at 2, 4, 6, and 8 months after planting (MAP) across both cropping seasons (Table 1).

Table 1. Number of Branches per plant as Influenced by Fertilizer Sources

Fertilizer Source	2024				2025			
	Weeks after Planting				Weeks after Planting			
	2	4	6	8	2	4	6	8
5t/ha EFBA	2.81	5.26	10.36	15.63	2.60	5.30	11.60	16.25
5t/ha CD	3.23	5.40	12.35	18.36	3.14	5.60	13.91	20.60
5t/ha PM	4.01	6.75	18.36	26.61	3.93	6.67	18.60	28.11
400kg/haNPK	2.46	5.33	14.59	21.40	2.50	5.00	14.36	22.25
Control	0.36	1.86	4.30	7.33	0.00	0.51	3.25	6.13
LSD($P < 0.05$)	1.2	2.02	3.18	3.91	1.06	2.11	3.60	3.88

The treatment using 5 t/ha of poultry manure resulted in a significantly higher number of branches per plant. This was followed by the treatments utilizing inorganic fertilizer. In contrast, the control treatment consistently recorded the lowest number of branches per plant, irrespective of the cropping season.

3.2 Number of Lobes per Plant

Table 2. Number of Lobes per plant as Influenced by Fertilizer Sources

Fertilizer Source	2024				2025			
	Weeks after Planting				Weeks after Planting			
	2	4	6	8	2	4	6	8
5t/ha EFBA	5.00	6.35	9.00	7.00	5.00	6.31	9.00	8.31
5t/ha CD	5.00	6.31	9.00	7.00	5.10	6.33	9.10	7.16
5t/ha PM	5.00	7.00	9.30	7.31	5.13	6.91	9.20	8.20
400kg/haNPK	5.00	6.30	9.00	7.11	5.00	6.45	9.11	7.18
Control	5.00	5.00	9.00	5.70	5.00	5.11	6.20	5.00
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS	NS

The effect of fertilizer sources on the number of lobes per plant is presented in Table 2. The results indicate a gradual increase in the number of lobes per plant from 2 to 6 months after planting (MAP), followed by a decline at 8 MAP.

The highest number of lobes was recorded with poultry manure, while the control treatment showed the lowest. However, no statistically significant differences were observed across all months of observation, regardless of the cropping year.

3.3 Leaf area

The leaf area of cassava as influenced by fertilizer application demonstrated significant differences ($p < 0.05$) across both cropping seasons (Table 3).

Table 3. Leaf area as Influenced by Fertilizer Sources

Fertilizer Source	2024				2025			
	Weeks after Planting				Weeks after Planting			
	2	4	6	8	2	4	6	8
5t/ha EFBA	85.67	158.67	219.43	210.83	87.50	155.61	221.21	210.16
5t/ha CD	87.01	189.56	241.61	221.73	88.01	191.33	239.36	224.11
5t/ha PM	88.02	207.33	265.10	233.38	93.73	201.37	263.19	231.40
400kg/haNPK	78.45	181.45	239.03	215.64	77.17	193.16	237.25	219.37
Control	78.13	101.33	121.33	112.16	72.57	103.01	122.71	117.31
LSD(P<0.05)	2.07	3.22	5.41	4.34	2.12	3.19	5.33	4.28

Results indicated an increase in leaf area from 2 MAP to 6 MAP, followed by a decline at 8 MAP, regardless of the cropping season. The treatment with PM exhibited a notably larger leaf area. During the 2024 cropping season, the PM treatment recorded leaf areas of 88.02, 207.33, 265.10, and 233.38 cm² at 2, 4, 6, and 8 MAP, respectively. In the 2025 cropping season, the leaf areas for PM were 93.73, 201.37, 263.19, and 231.40 cm² at the same respective stages.

3.4 Plant Height

The effect of fertilizer on cassava height varied significantly ($P < 0.05$) at 2, 4, 6, and 8 months after planting (MAP) in both cropping years, as shown in Table 4.

Table 4. Plant height as Influenced by Fertilizer Sources

Fertilizer Source	2024				2025			
	Weeks after Planting				Weeks after Planting			
	2	4	6	8	2	4	6	8
5t/ha EFBA	15.80	42.61	120.71	215.91	16.71	42.81	125.33	211.39
5t/ha CD	18.00	49.39	130.16	226.36	18.15	52.64	128.49	236.81
5t/ha PM	18.36	56.44	145.18	229.81	18.41	56.44	141.82	231.80
400kg/haNPK	15.91	51.44	135.25	217.36	17.30	52.81	133.88	229.52
Control	14.12	31.18	75.33	115.09	14.61	30.67	110.39	120.01
LSD(P<0.05)	1.98	2.10	4.06	5.22	1.59	2.13	4.13	6.01

The PM treatment resulted in heights of 18.36 cm, 56.44 cm, 145.18 cm, and 229.81 cm at 2, 4, 6, and 8 MAP, respectively, during the first planting season. The cow dung treatment yielded plant heights of 226.36 cm and 226.81 cm at 8 MAP. The NPK treatment produced heights of 217 cm, 136 cm, and 229.52 cm at 8 MAP. In the 2024 planting season, the control treatment showed the shortest plants, measuring 14.12 cm, 31.18 cm, 75.33 cm, and 115.09 cm at 2, 4, 6, and 8 MAP. In the 2025 planting year, the control treatment had heights of 15.61 cm, 30.67 cm, 110.39 cm, and 120.01 cm at 2, 4, 6, and 8 MAP, respectively.

3.5 Yield and Yield Components

The impact of fertilization on storage root length demonstrated significant differences ($P < 0.05$) across both cropping seasons (Table 5). The application of poultry manure resulted in notable increases in storage root length per plant, measuring 32.33 cm and 33.10 cm, while cow dung treatments had storage root length of 30.40 cm and 29.20 cm. The shortest storage root lengths of 15.40 cm and 13.88 cm were recorded in the control treatment during the 2024 and 2025 cropping seasons, respectively.

Table 5. Yield and Yield Components of Cassava as Influenced by Fertilizer Sources

Fertilizer Source	2024			2025		
	Storage Root Length (cm)	Storage Root Circumference (cm)	Storage Root Yield (t/ha)	Storage Root Length (cm)	Storage Root Circumference (cm)	Storage Root Yield (t/ha)
5t/ha EFBA	27.81	16.33	25.17	26.11	16.75	25.33
5t/ha CD	20.4	17.48	27.25	29.20	17.72	28.74
5t/ha PM	32.33	20.60	32.18	33.10	20.29	31.16
400kg/haNPK	29.75	18.22	27.24	29.51	19.59	28.80
Control	15.40	14.31	18.21	13.88	13.82	16.58
LSD($P < 0.05$)	3.12	3.16	4.26	2.89	2.89	3.88

In terms of storage root circumference, measurements ranged from 17.95 cm to 18.18 cm in the 2024 cropping year, whereas the circumference recorded during the 2025 cropping season varied between 16.78 cm and 17.48 cm. The circumference was significantly influenced by fertilizer application in both cropping seasons (Table 5). Treatments receiving poultry manure exhibited the largest storage root circumferences, measuring 20.60 cm and 20.29 cm in the 2024 and 2025 cropping seasons, respectively. This was followed by measurements of 18.22 cm and 18.59 cm for treatments that received inorganic fertilizer, while the control treatment recorded the smallest circumferences at 14.31 cm and 13.82 cm in 2024 and 2025, respectively.

The effects of fertilization on cassava storage root yield showed significant differences throughout both planting seasons (Table 5). The treatment with 5 t/ha of poultry manure produced impressive storage root yields of 32.18 t/ha and 31.16 t/ha. For treatments with 5 t/ha of cow dung, yields of 27.25 t/ha and 28.33 t/ha were recorded. Applying 5 t/ha of EFBA resulted in a storage root yield of 25.17 t/ha and 25.23 t/ha in the 2024 and 2025 cropping seasons, respectively. Furthermore, the application of 400 kg/ha of NPK 15:15:15 fertilizer led to storage root yields of 27.24 t/ha and 28.80 t/ha. The control treatment yielded the least, with values of 18.21 t/ha and 16.58 t/ha in the 2024 and 2025 cropping seasons, respectively.

3.6 Cost of Production and Economic Returns to Management (N) Influenced by Fertilizer Application

The findings indicated that the highest production costs were ₦ 1,569,500 and ₦ 1,615,000 for the two cropping seasons. In contrast, the lowest production costs were observed in the control treatment, which amounted to ₦ 1,164,000 and ₦ 1,209,000 during the respective seasons (see Table 6).

A detailed analysis of the impact of fertilizer application on production costs and economic returns is presented in Table 6. It was determined that the PM treatment generated the highest

economic returns across both cropping seasons, yielding ₦ 4,020,700 and ₦ 4,119,000 for the 2024 and 2025 seasons, respectively. Following this, the CD treatment reported economic returns of ₦ 3,227,250 and ₦ 3,715,000 for the same years. Conversely, the control treatment showed the lowest economic returns at ₦ 1,840,650 and ₦ 1,692,500. The cost-benefit ratio for the PM treatment was recorded at 3.12 and 3.09, while the CD treatment had cost-benefit ratios of 2.54 and 2.83. The control treatment had the lowest cost-benefit ratios, recorded at 1.86 and 1.40. The Benefit Cost Ratio maintains a direct correlation with the net return. In other terms, a higher Cost Benefit Ratio signifies a greater net return

Table 6. Cost of Production and Economic Returns to Management (₦) as Influenced by Fertilizer Application

Cost of Production	2024					2025				
	EFBA	CD	PM	400	0	EFBA	CD	PM	400	0
Land	220,000	220,000	220,000	220,000	220,000	230,500	230,500	230,000	230,500	230,000
Preparation										
Soil Analysis	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Planting materials										
Planting	224,000	224,000	224,000	224,000	224,000	224,000	224,000	224,000	224,000	224,000
Fertilizer	85,000	85,000	85,000	85,000	85,000	95,000	95,000	95,000	95,000	95,000
Fertilizer Application	41,500	80,000	100,000	320,000	-	41,500	80,000	100,000	320,000	-
Weeding (3x)	15,000	25,000	25,000	85,500	-	15,000	25,000	25,000	85,500	-
Harvesting	340,000	340,000	340,000	340,000	340,000	360,000	360,000	360,000	360,000	360,000
Miscellaneous	175,000	175,000	175,000	175,000	175,000	180,000	180,000	180,000	180,000	180,000
Total Cost	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	1,220,50	1,269,00	1,289,00	1,569,50	1,164,00	1,266,00	1,314,50	1,334,00	1,615,00	1,209,00
	0	0	0	0	0	0	0	0	0	0
Storage	25.17	27.25	32.18	27.24	18.21	25.33	28.74	31.16	28.80	16.58
Root Yield										
Gross Revenue	4,153,05	4496250	5,309,70	4,494,60	3,004,65	4,432,75	5,029,50	5,453,00	5,040,00	2,901,50
Net Revenue	0	0	0	0	0	0	0	0	0	0
Net Revenue	2,932,55	3,227,25	4,020,70	2,925,10	1,840,65	3,166,75	3,715,00	4,119,00	3,425,00	1,692,50
Cost Benefit	0	0	0	0	0	0	0	0	0	0
	2.40	2.54	3.12	1.86	1.58	2.50	2.83	3.09	2.11	1.40

4. Discussion

The findings of this study highlight the significant impact that different soil amendments have on the growth and yield of cassava. The result showed a substantial increase in storage root yields associated with the application of poultry manure. This observation agreed with the report [Ikeh et al., \(2023a\)](#) that application of poultry manure enhances the vigorous growth and improved storage root yield in the rainforest ecology of southeastern. The results showed that PM treatments yielded between 15-43% and 9-47% higher storage root yields compared to other amendments in the two cropping seasons.

Integrated fertilization using organic amendments (such as poultry manure, compost) and mineral fertilizers, as well as a combination of both, can significantly improve the growth, yield, and fertility of cassava crops ([Nassy et al., 2020](#)). Research by [Jindaluang et al. \(2025\)](#) shows that application of organic amendments (especially poultry manure) significantly increased above-ground biomass and fresh tuber yield as well as cassava starch.

This finding aligns with existing literature that emphasizes the importance of organic amendments in improving soil structure, enhancing nutrient availability, and promoting microbial activity, which collectively contribute to better plant performance (Ikeh *et al.*, 2023b). The significant productivity boost provided by PM underscores its potential as a sustainable amendment for smallholder farmers, especially in regions characterized by low soil fertility (Essien *et al.*, 2018). The application of poultry manure and microbes increases soil biological activity and nutrient balance, thereby improving nutrient uptake especially potassium. The application of NPK combined with poultry manure can be used as the most effective strategy to increase cassava productivity (Essien *et al.*, 2025).

The varying effectiveness of different fertilizer sources further illustrates the complexity surrounding soil amendments. While the application of 400 kg/ha of NPK 15:15:15 showed moderate yield increases, the comparatively lower yields from other chemical fertilizers (EFBA and CD) suggest that some fertilizer sources could be attributed to less nutrient content which may not adequately meet the nutritional requirements of cassava, particularly in the nutrient-poor soils typical of southern Nigeria. This reinforces the argument that organic fertilization is the most effective soil fertility management practice which resulting to high crop yield and maximum return to smallholder farmers (Ndaeyo *et al.*, 2013; Idem *et al.*, 2012; Akata *et al.*, 2024).

The high economic returns to management recorded in the poultry manure treatment, followed by the treatment of cow dung and EFBA revealed that even when high storage root yield was recorded NPK, the economic benefit from CD and EFBA were still higher compared to NPK treatment. Other studies conducted by Bilong *et al.* (2022) shows that application PM was the most profitable and cost-effective treatment, with a good benefit cost ratio. These results advocate for a shift in agricultural practices towards more economical and sustainable approaches, which prioritize organic inputs like poultry manure, cow dung, and oil palm empty fruit bunch. The adoption of organic fertilization could enhance soil fertility and ultimately result in improved food security for a growing population in Nigeria and beyond.

5. Conclusions

The study findings revealed that organic fertilization significantly improved the yield cassava in rainforest ecology of southern Nigeria. The treatment of poultry manure produced highest storage root yield, followed by NPK fertilizer and cow dung. The least was recorded in control (no soil amendment). The outcome of the study showed that Cassava farmers could achieve higher economic returns if the adopt organic fertilizer application in their farm. The study therefore recommended the adoption of organic fertilization to cassava especially poultry manure which is locally available and a sustainable soil fertility strategies. By prioritizing organic amendments, farmers can potentially achieve improved crop yields, contributing to food security and more income to farmers.

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