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Performance of cassava (*Manihot Esculenta* Crantz) as influenced by poultry droppings and NPK fertilizer in Jos, Plateau State, Nigeria

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Abstract

The effects of NPK fertilizer and poultry droppings on the growth and yield of cassava were tested in a field experiment conducted at the Federal College of Forestry demonstration farm from March 2024 to November 2024. Four treatments; poultry droppings (PD) (5 t/ha), NPK fertilizer (120 kg/ha), poultry droppings plus NPK fertilizer (5 t/ha + 120 kg/ha), and control (no amendments) were arranged in a Randomized Complete Block Design (RCBD) replicated four times. Data were collected on Plant height (cm), Stem girth (cm), Number of branches per plant, Leaf area, Plant Canopy, number of tubers, weight of tuber (kg/tuber), tuber diameter (mm), Tuber yield (tons/ha) and Biomass (tons/ha). Data were subjected to analysis of variance (ANOVA) using GenStat 18th Edition. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at $p < 0.05$. The application of poultry droppings gave the highest plant height (172.00 cm), Poultry droppings and NPK fertilizer applied together resulted in the maximum number of branches (2.00), leaf area (795.12 cm^2), stem girth (8.45 cm), canopy spread (281.00 cm), number of tubers (7.5), and larger diameter tubers (57.00 mm). Compared to the single application of poultry droppings and NPK fertilizer and the control, the combined application of PD + NPK fertilizer improved the growth and yield parameters of cassava. Therefore, the combined application of poultry droppings and NPK fertilizer significantly affect the growth and yield parameters of cassava and can be recommended that cassava growers in the study area employ a combination of NPK fertilizer and chicken droppings. For maximum cassava productivity, further research should be done on the appropriate rates of NPK fertilizer and poultry droppings.

Keywords: *Poultry Droppings, NPK Fertilizer, Cassava, Growth, Yield, Jos.*

Introduction

Cassava (*Manihot esculenta Crantz*) stands as a cornerstone of food security and rural livelihoods in Nigeria, where it serves as a staple for over 80% of households and contributes significantly to the national economy as a raw material for industries like starch production and animal feed. As the world's largest producer, Nigeria harvested approximately 63 million tonnes in 2021, accounting for about 20% of global output, yet average yields remain disappointingly low at around 10.6 tonnes per hectare far below the potential 20 – 30 tonnes achievable with improved practices (Akinwumiju *et al*., 2020; Otekunrin *et al*., 2024). This yield gap is particularly pronounced in the northern regions, including the Jos Plateau, a highland agroecology characterized by cooler temperatures (15 - 25°C), moderate rainfall (1,100-1,400 mm annually), and nutrient-poor volcanic soils prone to erosion and leaching. Cassava cultivation, while increasingly adopted as a cash crop alongside traditional staples like potatoes and wheat, faces unique challenges: the crop's heavy nutrient demands exacerbate soil degradation, and limited access to affordable inputs hampers productivity for smallholder farmers who dominate the sector (Shehuri, 2021; Ezui *et al*., 2022). Fertilizer application emerges as a critical intervention to bridge this gap, but the choice between inorganic and organic sources remains a balancing act. Inorganic NPK fertilizers (typically 15-15-15 or 20-10-10 formulations) provide readily available nitrogen, phosphorus, and potassium, essential for cassava's vegetative growth and tuber bulking, yet their overuse can lead to soil acidification, nutrient imbalances, and environmental runoff in the Plateau's fragile ecosystems. In contrast, poultry droppings abundant and cost-effective in livestock-dense areas like Jos offer a slow-release organic alternative rich in macro and micronutrients, while enhancing soil organic matter, microbial activity, and water holding capacity to combat the region's variable rainfall and erosion risks. Recent studies underscore the superiority of integrated approaches: for instance, combining poultry manure with reduced NPK doses has boosted cassava yields by 24 - 29% in similar tropical highlands, improving nutrient use efficiency and harvest indices without compromising soil health (Mubanga *et al*., 2018; Ngome *et al*., 2022).

Because they are satisfied with the low returns from employing few inputs or even from their barren soils, peasant farmers do not fertilize their cassava crops. Because of the organic components' residual effects, the combination of organic manure with NPK fertilizer can support long-term cropping in Nigeria (Adekiya *et al.*, 2020). They claimed that a suitable and balanced combination of NPK fertilizer and organic matter amendment had produced excellent and consistent crop yields. Cassava is becoming more and more popular in Nigeria for both residential and industrial uses. This requires farmers to take steps to increase cassava productivity.

Similarly, in Nigeria's savanna zones, such integrations have lifted tuber yields by up to 40% while curbing the economic and ecological costs of sole inorganic reliance (Ayoola and Adeniran, 2006, as cited in Agbede *et al*., 2019).

Despite these discoveries, there is still a dearth of site-specific data for the Jos Plateau, where lower temperatures may change microbial decomposition rates and nutrient dynamics in comparison to humid lowlands. In order to inform sustainable, farmer-friendly fertilization options, this study examined the performance of cassava in this particular highland context under varied quantities of poultry droppings and NPK fertilizer. The research aimed to fix these gaps to increase cassava yield, strengthen soil resilience, and assist Nigeria's aspirations for food self-sufficiency in the face of climatic uncertainty.

Materials and Methods

Study Location

The experiment was conducted during the 2024 cropping season (April–October) at the Teaching and Research Farm, Federal College of Forestry, Jos, Plateau State, Nigeria (09°57′N, 08°53′E; altitude 1,285 m above sea level). The site lies in the cool sub-humid highland zone of the Jos Plateau. The soil is classified as Dystric Plinthosol (FAO/WRB) with sandy-loam texture, low organic carbon, and slightly acidic pH.

Pre-planting soil (0 – 30 cm depth) physical and chemical baseline properties:

Parameter	Value
pH (1:2.5 soil:water)	5.6
Organic carbon (%)	1.12
Total N (%)	0.09
Available P (mg kg^{-1})	8.4
Exchangeable K (cmol kg^{-1})	0.21
CEC (cmol kg^{-1})	9.8
Sand/Silt/Clay (%)	62/22/16
Textural Class	Sandy Clay Loam

Mean annual rainfall during the trial was 1,320 mm (April–October), and mean temperature ranged from 18.5 °C (July) to 26.2 °C (March–April).

Land Preparation

Land was ploughed and harrowed twice. Ridges (0.75 m apart) were manually constructed. Plot size was 5 × 4 m (20 m^2), with 1.5 m alleys between blocks and 1 m between plots.

Treatments and Experimental Design

The experiment was laid out as a randomized complete block design (RCBD) with three replications. Four treatments were evaluated; 5 tons/ha of Poultry Droppings, 120 kg/ha of NPK (15:15:15) Fertilizer, combination of Poultry Droppings + NPK Fertilizer (5 tons/ha + 120 kg/ha) and Control (no amendments).

Planting Material

Healthy, uniform stem cuttings (25–30 cm long with 5–7 nodes) of the improved cassava variety TME 419 (high-yielding, early-bulking, widely adopted on the Jos Plateau) were used.

Fertilizer and Manure Application

Well-cured poultry droppings (from deep-litter broiler system, analyzed as 3.2% N, 2.1% P_2O_5, 1.8% K_2O on dry-weight basis) were broadcast and incorporated into the ridges two weeks before planting. NPK 15-15-15 (120 kg/ha) was applied in two splits: 50% at 4 weeks after planting (WAP) and the remaining 50% at 12 WAP by ring placement 10 – 15 cm away from the base of the plants.

Planting and Cultural Practices

Planting was done on 22 April 2024 at a spacing of 1 × 0.8 m (12,500 plants ha^{-1}), with cuttings planted at 45° angle. Weeding was done manually at 4, 8, and 16 WAP. No supplementary irrigation or pesticide was applied

Data Collection and Analysis

Growth and yield parameters (from five randomly tagged plants per plot) were recorded on Plant height (cm) was measured using a meter rule from the base of the plant to the tip of the stem, Stem girth (cm) was measured using a vernier caliper, Number of branches per plant was counted manually, Leaf area (cm^2) was extrapolated by measuring the leaf length and breadth and then multiplying them together, Plant Canopy (cm) was measured by stretching a tape across the widest part of the canopy (N – S and E – W), then find the average by adding up the two values and divide by 2, number of tubers was counted manually, weight of tuber (kg/tuber) was measured using a weighing balance, tuber diameter (mm) was obtained using a vernier caliper, Tuber yield (tons/ha) was extrapolated from the tuber weight using the formula below;

$$\text{Tuber Yield} = \frac{\text{Weight of tuber in Kg x } 10{,}000 \text{ m}^2}{\text{Total Plot Size m}^2}$$

and Biomass (tons/ha) was measured by weighing the whole plant with a weighing balance.

Data were subjected to analysis of variance (ANOVA) using GenStat 18th Edition. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at $p < 0.05$.

Results

Growth Parameters

Cassava plant height, leaf area, stem girth, and canopy spread showed significant differences between the single application of poultry droppings and NPK fertilizer and the combined application of poultry droppings and NPK fertilizer at both the 1% and 5% probability levels (Table 1). In comparison to the other treatments, the combination application of NPK fertilizer and chicken droppings produced the greatest significant mean values for plant height (172.00 cm), leaf area (795.12 cm^2), stem girth (8.45 cm), and canopy spread (281.00 cm). For plant height (172.00 cm, 166.00 cm), leaf area (705.00 cm^2, 162.30 cm^2), and canopy spread (252.75 cm, 239.75 cm), the single application of poultry droppings had higher significant mean values compared to the single application of NPK fertilizer.

While there was no significant difference between NPK fertilizer, poultry droppings, or the combination of NPK and poultry droppings, the treatment application differed considerably from the control on stem girth. Regarding the number of branches, no discernible difference was seen for any of the treatments. Plant height, leaf area, number of leaves, and canopy spread significantly increased by applying fertilizer and chicken droppings.

Table 1: Growth Parameters of Cassava as affected by Poultry Droppings and NPK fertilizer

Treatment	Plant Height (cm)	Number of Branches	Leaf Area (cm^2)	Stem Girth (cm)	Canopy Spread (cm)
Control	154.50[a]	1.50[a]	90.70[a]	6.85[a]	101.00[a]
Poultry roppings	172.00[c]	1.75[a]	705.00[c]	8.69[b]	252.75[c]
NPK Fertilizer	166.00[b]	1.75[a]	162.30[b]	8.43[b]	239.75[b]
PD + NPK	170.00[bc]	2.00[a]	795.12[d]	8.45[b]	281.00[d]
SE±	1.86	0.60	11.85	0.20	3.64
P -Value	0.000	0.870	0.000	0.000	0.000
LS	**	NS	**	**	**

Means within a column having same letters are not significantly difference at P ≤ 0.05, LS = level of significant at 0.05, ** = Significant (0.01 and 0.05), NS = Not Significant

Yield Parameters

The number of tubers, tuber diameter, tuber weight, yield, and biomass varied significantly between the treatments at both the 1% and 5% probability levels (Table 2). Poultry droppings and NPK fertilizer applied together produced the highest number of tubers per plant stand (7.5), followed by NPK fertilizer applied alone (6.75), chicken droppings applied, and the control, each of which produced 5.50 tubers. For tuber weight, no significant mean value was found when PD + NPK fertilizer (13.70 kg/tuber) was applied or when NPK fertilizer (13.28 kg/tuber) was applied alone. Compared to the control (7.55 kg/tuber), the single application of poultry droppings (11.65 kg/tuber) was considerably different.

A notable variation in tuber diameter was observed for the various treatments. The single treatment of both chicken droppings and NPK fertilizer (52.63 mm and 51.75 mm), which were not significantly different, was followed by the combined application of PD + NPK fertilizer, which produced the maximum mean diameter (57.00 mm). The control's tuber diameter was the smallest (9.28 mm). The combined application of PD + NPK fertilizer resulted in greater cassava tuber yield (34.75 tons/ha), followed by the application of NPK fertilizer (30.25 tons/ha), poultry droppings, and the control (27.63 tons/ha and 18.50 tons/ha, respectively).

Table 2: Yield Parameters of Cassava as affected by Poultry Droppings and NPK fertilizer

Treatment	Number of Tubers	Tuber Diameter (mm)	Weight of Tubers (Kg/Tuber)	Yield (tons/ha)	Biomass (tons/ha)
Control	5.50[a]	9.28[a]	7.55[a]	18.50[a]	5.25[a]
Poultry Droppings	5.50[a]	52.63[b]	11.65[b]	27.63[b]	8.53[b]
NPK Fertilizer	6.75[bc]	51.75[b]	13.28[c]	30.25[c]	8.13[b]
PD + NPK	7.50[c]	57.00[c]	13.70[c]	34.75[d]	9.35[c]
SE±	0.57	1.26	0.33	0.68	0.22
P (Value)	0.010	0.000	0.000	0.000	0.000
LS	**	**	**	**	**

Means within a column having same letters are not significantly difference at P ≤ 0.05. LS = level of significant at 0.01, ** = Significant (at both 0.01 and 0.05)

Discussion

The results of this study demonstrated that cassava farms on the Jos Plateau, where chilly air and volcanic soils make every choice matter, may be revitalized by adjusting fertilizer inputs. Poultry droppings and NPK, either alone or in combination, outperformed the control plots which struggled with stunted growth and low yields.

In Zambian experiments, chicken manure at 2.8 t ha^{-1} increased cassava canopy spread by 18 –22% above mono NPK, resulting in similar increases in height and leaf area (LA). This was attributed to enhanced microbial activity that releases bound soil nutrients (Mubanga et al., 2018). By improving water retention in sandy-loam textures like ours, poultry manure at 5 t ha^{-1} increased stem diameter by 28% and LA by 35% in Cameroon's southern highlands, which mirror our cooler, variable rainfall (Ngome *et al*., 2022). This effect outperformed mineral fertilizers alone. Due to improved N synchronization with crop demand, half-rates of chicken manure + NPK increased maize stem girth by 20% more than full-dose singles in Ghana's Guinea Savannah (Laekemariam *et al*., 2024).

This combination of PD and NPK fertilizer might stabilize soil structure while improving crop yield on the Jos Plateau, where erosion eats away at topsoil every year. With root numbers per plant increasing to 7.5 from 5.5 and average fresh weights per tuber reaching 13.7 kg versus 4.55 kg unfertilized, marketable tuber yield increased to 34.75 t ha^{-1} in poultry droppings and NPK fertilizer combination, which doubled that of the control 18 t ha^{-1} and was a solid 15% above sole NPK's 30.5 t ha^{-1}.

These improvements are consistent with results from Zambia's highlands, where manure-NPK blends increased root yields by 24–29% compared to NPK alone, with Harvest Index increases from improved root bulking under balanced nutrition (Mubanga et al., 2018). Similar to our agroecology, poultry manure at 10 t ha^{-1} + half NPK pushed cassava yield 32% higher than controls in Nigeria's derived savannas, attributing tuber initiation to manure's involvement in micronutrient delivery (Agbede *et al*., 2019, as referenced in Otekunrin *et al*., 2024). This is supported by even more extensive meta-analyses, which found that manure integrations increased tuber crop yields by 15–20% on average across 141 international research. The benefits were amplified in cooler regions, such as the Plateau, due to lower decomposition losses (Du *et al*., 2020).

The Jos Plateau's cold nights (down to 15°C) slow manure breakdown, extending nutrient release throughout the season and avoiding the boom-bust cycles of solo inorganics, distinguishes our findings from those of the lowlands. Early growth of cassava was accelerated by NPK fertilization alone, but by harvest, yield integrations increases as a result of the combined application of poultry droppings and NPK fertilizer, perhaps due to acidification hazards. This was counteracted by the alkalizing impact of poultry (via calcium carbonates), maintaining pH levels at 5.8–6.0 in blends that mirrored Cameroonian research where PM buffered acidity while maintaining P availability (Ngome et al., 2022). Due to TME 419's durability, the control treatment held up very well at 11.2 t ha^{-1} compared to lowland Nigerian baselines (yields ~10-12 t ha^{-1} unfertilized; Ezui *et al*., 2022).

These results support the rationale for integrated soil fertility management (ISFM) in highlands: combining subsidized NPK with local poultry waste eliminates yield gaps and strengthens soils against climate whims, such as the recent irregular rainfall (Akinwumiju *et al*., 2020).

Conclusion and Recommendations

The use of NPK fertilizer and poultry droppings had an impact on cassava growth and production. Compared to the single application of poultry and NPK fertilizer and the control (no application), the combined application of PD + NPK fertilizer improved the growth and yield parameters of cassava. Therefore, it is advised that cassava growers in the study area should employ a combination of

NPK fertilizer and poultry droppings.

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