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ENHANCING YELLOW CASSAVA (*Manihot esculenta Crantz*) YIELD WITH FOUR LEVELS OF ORGANIC FERTILIZER: A TRIAL ON SAND-LOAMY SOIL FOR SUSTAINABLE FOOD SUPPLY

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Abstract
The common cassava (Manihot esculenta Crantz) is white in colour, but the yellow cassava also known as vitamin-A cassava is a special bred variety that contains significantly higher levels of beta-carotene, which is a precursor to vitamin A. It has the potential of transforming nutrition and health outcomes of staple food consumption. By incorporating yellow cassava into diets, individuals can boost vitamin A intake and reduce the risk of related health problems. Yellow cassava is a vital crop for food security, but its yield is often limited by inadequate soil fertility and there is insufficient data on the use of organic fertilizers in its production on sand-loam soil. Hence, a study was carried out on the effects of organic fertilizer on yellow cassava yield. It was a two season field experiments conducted at Kula farmland, Odomola, Epe Lagos State, Nigeria. The experimental plots were minimally tilled and four (4) levels of poultry manure (treatments- $L_0 – L_3$; 0, 2, 3, and 4t/ha were applied to the plots arranged in randomized complete block design-RCBD, replicated thrice). Each micro plot measured 24.0m^2, and cassava cuttings planted at 1.0m x 1.0m (16 cassava stands/24.0m^2; given 10,000 stands/hectare). The results showed that; the organic fertilizer (poultry manure) applied significantly increased yellow cassava yield by 25-35% compared to the control and other results obtained from similar trials with landrace cultivars. Besides, the storage roots yields under L_2 and L_4 were not significantly different as obtained (5.3 – 6.0t/h) under the three (3) application levels. Similar results were obtained in the second cropping season from the storage roots and garri; product yields from yellow cassava which showed the same patterns in their yields (L_1, L_2 and L_3; ranged from 1.0 – 1.1t/ha) as influenced by the different levels of poultry manure. In general, the soil parameters; soil pH, nitrogen, phosphorus, and potassium levels improved significantly with organic fertilizer application. Hence, it can be deduced that the poultry manure across the levels of application promoted sustainable soil fertility for yellow cassava production. In conclusion, these findings suggest that organic fertilizers are a viable option for enhancing yellow cassava yield while maintaining soil health. This application rate (3 – 4t/ha) of poultry manure can contribute to sustainable agriculture and food security, particularly for smallholder farmers in rural settings.

Keywords: organic fertilizer, sustainable food, yellow cassava, yield

Introduction

The local cassava cultivars are the most common cultivated stable root crop in Lagos farming zones. This serves as income and food to the ever-increasing population of the State. Many Scholars have extensive documentation on cassava-based cropping with and without other companion crops. The industrial utilization purposes of cassava for starch, alcohol, adhesive and livestock feed are presently minimal in Nigeria compared to other countries (Union of Concerned Scientists, 2022). The industrial utilization purposes of cassava for starch, alcohol, adhesive and livestock feed are presently minimal in Nigeria compared to other countries. Although, cassava has the potential to contribute to foreign exchange earnings and import substitution if its production increased with the use of improved cultivars and inputs (Iren, *et al*., 2015). In 2011 and 2012 International Institute of Tropical Agriculture released a cassava variety called yellow or vitamin-A cassava (IITA, 2014).

These cassava cultivars were first cloned from seedlings in Ibadan and were subjected to extensive field testing throughout Nigeria. Few among the cultivars are: IITA TMS 01/1368, IITA TMS 01/1371, IITA TMS01/1412 and IITA TMS 01/1593 among others (Olaiya & Salami, 2017).

The common or traditional cassava is white, but the yellow cassava, also called vitamin A cassava, is a specially bred variety that contains significantly higher levels of beta-carotene, which is a precursor to vitamin A (Olaiya & Salami, 2017). This natural pigment (beta-carotene) gives the root its bright yellow colour and makes it an excellent source of this essential nutrient. Yellow cassava is a nutrient-dense, wonderful foodstuff that's poised to make a significant impact on global health. With its high vitamin A content, improved flavour and texture, and disease-resistant properties, this vibrant yellow root crop is an excellent addition to a healthy diet (Adeniji, *et al*., 2005; Olaiya & Salami, 2017).

Declining organic matter in the soil is often a root cause of nutrient exhaustion and nutrient depletion. At the same time, its increase is hinged on availability and retention is based on types of farming systems. This can be amended with external nutrient inputs (FAO, 2014). Haines and Uren (1990) and Iren, *et al.* (2015) asserted that soil fertility can be improved through the application of organic manure which improves the storage roots yield of yellow cassava. Food sustainability faces significant challenges from climate and biodiversity loss to social and economic inequality. There are several means to combat these problems; ranging from effective healthy promotion of soil and biodiversity conservation through the use of natural inputs for crop production, to equitable and fair-trade practices that support small-scale farmers and local food production systems (Deytieux, *et al*., 2017; Nayana & Ritu, 2017).

Solving these problems will build a sustainable food system that is environmentally resilient especially with the available land for crop production among the small-scale farmers (Chavez, Petrie, Roth, 2005; and Atungwu, 2019). Hence, a two-season field study was conducted on the effect of organic fertilizer (poultry manure) on yellow cassava yield.

Purpose of the Study

The main purpose of the study was to assess yellow cassava (*Manihot esculentus Crantz*) yield performance with four levels of organic fertilizer on sand-loamy soil for sustainable food supply. Specifically, the objectives of the study are to:

i. assess the effects of four (4) different application rates or levels of poultry manure on yellow cassava; and
ii. evaluate the optimal yellow cassava storage root yield, yellow cassava cultivar, TMS01/1371, on sand-loam soil of Epe local government area of Lagos State, Nigeria.

Methodology

It was a field experiment conducted in the year 2021 and 2022 at Kula-nla farmland at Odomola (coordinates; 6.6104^0 N, 4.0032^0 E) Epe Lagos State, Nigeria. The experimental plots were manually cleared, no burning, tilled and were laid into three blocks for replication of treatments. Prior to planting, the soil sample were collected at the depth of 0 – 20 cm, air dried and sieved with (2 mm) for laboratory analysis.

The planting materials (cassava cuttings and poultry dung) were sourced from the Teaching and Research Farm of Agricultural Science Education Department, Lagos State University of Education Oto/Ijanikin, Noforija-Epe Campus. The organic fertilizer (poultry dung) was applied two weeks before planting to improve decomposition and mineralization.

The experimental plots and the treatments (four levels of poultry manure; 0, 2, 3, and 4 t/ha) were applied in randomized complete block design (RCBD) in three replications (Figure 1). Each micro plot measured 8.0m by 3.0 m with, cuttings planted at 1m x 1 m (16 cassava stands per 24.0 m^2 ; to give 10,000 stands/hectare) with

a metre gap in between the micro plots. The experiment was repeated the following planting season with the same layout, treatments and replications. The same cultural practice method was employed, which include; manual weeding within and around the experimental plots for weeds and pests (rodents) control.

Data collected are: cassava plant height, stem girth (circumference), number of stem and branch. While at harvest, data were collected on the storage roots length, girth, number of storage roots, fresh weight and storage root dry matter (garri).

The storage roots were processed for each treatment into *garri*. All data collected were analysed using Analysis of variance (ANOVA, $p \leq 0.05$) and significant treatment means were separated using DUNCANT Multiple Range test (DMRT).

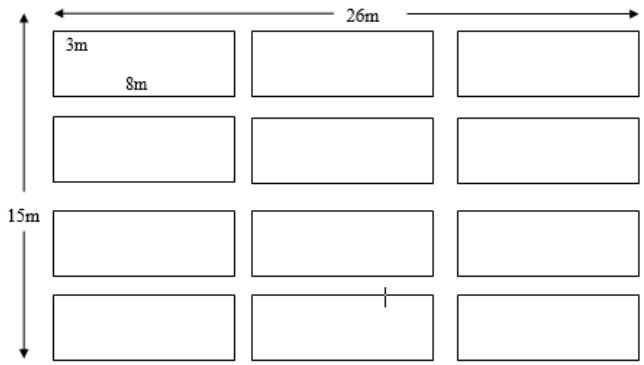


Figure 1: Experimental Plot Layout for the 2021/2022 Cropping Seasons

Results and Discussion

Table 1

Chemical Properties of the Soil and Poultry Manure used for the Experiments

Parameters	**Values**	
	Soil	**Poultry manure**
pH (Cl)	7.2	6.4
Organic C (g kg^{-1})	8.3	1.4
Total N (g kg^{-1})	3.7	3.4
Available P (mg g^{-1})	42.5	55.1
Exchangeable Bases (cmol kg^{-1})		
K	0.6	0.65
Ca	11.1	26.5
Na	0.5	0.38
Mg	3.2	2.82

Soil and Poultry Manure Constituents: From the soil analysis, the experimental plots' results showed that the soil fertility level was moderate and capable of responding to fertilizer treatments. The soil N, P and organic carbon were capable of sustaining cassava production with the application of any fertilizer. However, the exchangeable bases were low compared with their components in the poultry manure used to argument the nutrient levels of the soil (Table 1).

Table 2
Growth Parameters of Yellow Cassava at 6 Months after Planting

Levels of Poultry Manure (t/ha)	Plant Height (cm)	Stem Girth (cm)	Number of Stems/Plant	Number of Branch/Plant
		2021 cropping season		
L_0 (0.0 t)	136.5_b	6.7_b	4.0	29.3
L_1 (2.0 t)	175.8_a	7.2_b	4.0	37.0
L_2 (3.0 t)	177.1_a	8.2_{ab}	5.0	38.7
L_3 (4.0 t)	186.7_a	10.2_a	4.0	34.3
		2022 cropping season		
L_0 (0.0 t)	138.1_b	6.9_b	4.0	28.7
L_1 (2.0 t)	179.3_a	7.0_{ab}	5.0	37.3
L_2 (3.0 t)	184.2_a	8.5_a	5.0	38.5
L_3 (4.0 t)	189.5_a	9.9_a	5.0	34.8
SE (df=23)	±10.2	±1.3	±0.5 ns	±2.7 ns

ns = no significant difference (P≤0.05), SE = standard error
Values followed by the same alphabet(s) are not significantly different, as shown by DMRT (P≤0.05)

Growth Parameters: At the sixth month after planting, the yellow cassava growth parameters observed were significantly different under the poultry manure application rates of 2.0, 3.0, and 4.0 t/ha compared to where there was no application (0.0 t/ha). The plant height ranged from136.5±10.2 – 189.5±10.2 cm as average plant height throughout the two growing seasons. The least plant height value (136.5±10.2 cm) was obtained observed under (0.0t/ha) no poultry application, while the highest plant height values (186.7±10.2 and 189.5±10.2 cm; which were significantly higher (P≤0.005) compared with the control plots) were observed under application of poultry manure at 4.0 t/ha in both cropping seasons (Table 2).

The cassava stem circumference (girth) was significantly different (P≤0.005) under application rate of 4.0t/ha at both cropping seasons (10.2± 1.3 and 9.9± 1.3cm) compound with the control plots with the least values of 6.7±1.3 and 6.9±1.3cm, for the two seasons respectively (table 2). In terms of the number of branches and stems, there was no significant difference (P<0.05) in both cropping seasons when compared. This agreed with the findings from Nyana & Ritu (2017), and Ameeta and Ronak (2017). Showing that application of organic and or inorganic fertilizers increases cassava growth and yield performance.

Table 3
Yield Parameters of Yellow Cassava at Harvest

Levels of Poultry Manure (t/ha)	Storage Root (Fresh tuber)		
	Length (cm)	Girth (cm)	Number of Root Storage per 24.0 m^2
		2021 cropping season	
L_0 (0.0 t)	29.1_b	14.9_b	10.3
L_1 (2.0 t)	34.5_{ab}	17.5_a	10.6
L_2 (3.0 t)	32.1_a	18.5_a	11.7
L_3 (4.0 t)	34.6_a	18.8_a	11.3
		2022 cropping season	
L_0 (0.0 t)	30.2_b	14.3_b	10.1
L_1 (2.0 t)	33.5_{ab}	17.8_a	10.0
L_2 (3.0 t)	34.3_a	19.1_a	10.7
L_3 (4.0 t)	35.2_a	18.7_a	10.6
SE (df=23)	±1.9	±0.9	±0.6 ns

ns = no significant difference (P≤0.05), SE = standard error
Values followed by the same alphabet(s) are not significantly different as shown by DMRT (P≤0.05).

Yield Parameters: The cassava root storage and *garri* yield were not significantly different under the three (3) application rates of 2.3 and if T/ha throughout the cropping seasons when compared but on the contrary, the yields obtained under the application rates were significantly different (P<0.05) in both seasons when compared with yields under no poultry manure application (0.00t/ha) in both cropping seasons (Figure 2). In the first cropping season (2021), the cassava storage root yield ranged from 3.3- 5.8 t/ha, while in the second cropping season it was 2.1- 5.8 t/ha under 2, 3 and 4 t/ha of poultry manure application. Both yields were significantly higher when compared to the control plots (Figure 2 and 3). Similar trends were observed in terms of *garri* (dry matter storage root) yield. In the first cropping season, the *garri* yield ranged from 0.6-1.1 t/ha. While in second cropping season, yield was 0.6-1.1 t/ha. On average, the values of both tuber and *garri* yields under 2, 3 and 4 t/ha poultry manure application rates were not significantly different (P≤0.005) throughout the two cropping seasons (Table 3).

Furthermore, the tuber (storage root) yield of the yellow cassava cultivar (TMS01/137) under poultry manure application rates corroborated with the findings of Olaiya and Sahum (2017), where the yield of cassava tuber ranged from 3.7 t/ha – 9.3 t/ha under application of NPK fertilizer. However, for a sustainable environment and healthy food production, the use of organic fertilizers as inputs for food crop production is handy considering the adverse effects of chemical fertilizers on biodiversity and the rhizosphere (Olugbemi, 2016). Preferably, small-holding farmers for sustainable food production, organic fertilizers (animal wastes and other organic household wastes) and natural inputs are recommended for crop production for healthy and friendly ecosystems for continuous food supply (Lal, 2018; Union of Concerned Scientists, 2022).

At the 2021 cropping season, the storage root length of yellow cassava ranged from 29.1 to 34.6 cm. However, there was no significant different between the storage root length obtained under poultry manure application of 2, 3, and 4 t/ha when compared; but values of storage root length (29.1±1.9 cm) under no application (0.0 t/ha) was significantly (P≤0.005) lower (Table 3).

Similar trends were observed in two cropping seasons under application rates of 2.0, 3.0, and 4.0 t/ha with values from the number of storage roots and the circumference (girth). The yield parameters showed that application of poultry manure within the range of 2.0 – 4.0 t/ha improved the cassava yields (Table 3). This is in agreement with the findings of Olugbemi, (2016), Olaiya and Salami (2017); the application of organic fertilizers improved cassava tuber yield.

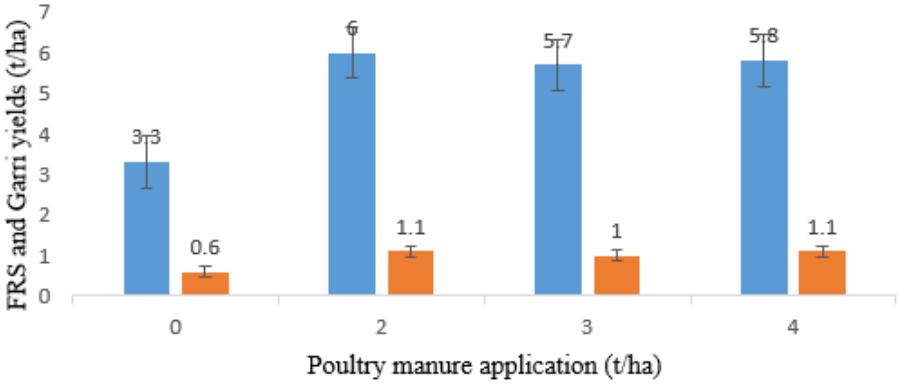


Figure 2: Cassava root storage and Garri yields under different poultry manure application in 2021 cropping season

Legend: FRS weight (t/ha) Garri weight (t/ha)
Bars represent standard error
FRS = Fresh root storage (cassava tuber)

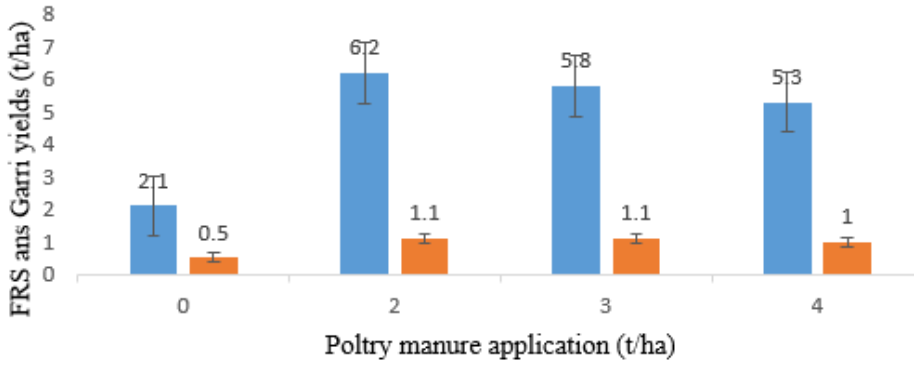


Figure 3: Cassava root storage and Garri yields under different poultry manure application in 2022 cropping season

Legend: FRS weight (t/ha) Garri weight (t/ha)

Bars represent standard error

FRS = Fresh root storage (cassava tuber)

At the 2021 cropping season, the cassava root storage yield ranged from 3.3 – 6.0 t/ha, and the *garri* yield followed a similar trend of 0.6 – 1.1 t/ha under 2 and 4 t/ha of poultry manure application (Figure 2).

At the second cropping season, 2022, the yielding pattern was different; the optimal yields were obtained under 2 and 3 t/ha of poultry manure application. The root storage and *garri* yields recorded were 6.2, 5.8t/ha and 1.1t/ha, respectively (Figure 3).

Conclusion and Recommendations

Considering the nutritional benefits of yellow cassava, especially, its ability to resist various health challenges and issues. In this, yellow cassava becomes handy for all small-hold farmers to improve man's diet and health with this staple root food crop. Besides, the menace of poultry dungs or wastes in poultry farming communities can be reduced if the wastes are subjected to constant use for crop production, among other uses. However, it is a natural input that improves soil fertility and encourages the ecological soundness of soil micro-organisms for healthy crop production and food sustainability. Moreover, the use of poultry manure is a means of reducing the uptake of toxic elements that are injurious to man's health when compared with the quantity of toxic elements that are inherent with most synthetic inputs (chemical fertilizers) for crop production.

Therefore, from this trial, it was recommended that yellow cassava cultivars (TMS01/1371), among other cultivars with poultry manure, be made available for small-holding farmers for food production. It can also be recommended that poultry manure be applied at rates between 2.0 – 4.0 t/ha for yellow cassava production. It must be noted that the recommended rate of poultry manure application is a function of the fertility level of the soil to be used for cassava production.

Further research is required to assess the performance of other yellow cassava cultivars under various rates of poultry or other organic sources of fertilizers.

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