

Performance Evaluation of Four Novel Cassava (*Manihot esculenta* Crantz) Accessions to Different Fertilizer Types in Awka, Anambra State, Nigeria

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ABSTRACT

The investigation was carried out on the effects of fertilizer and cassava variety on agronomic characteristics, yield, and disease incidence of four improved cassava accessions. The experiment was carried out at the Teaching and Research farm of Crop Science and Horticulture, Nnamdi Azikiwe University Awka, Anambra State. It was a 4×3 factorial experiment with treatments laid out in a Randomized Complete Block Design (RCBD) with three replications. Fertilizer types were NPK 15:15:15 at a rate of 400 kg/ha, poultry manure (PM) at a rate of 50 tons/ha and no application as control. The cassava accessions were TMS539, TMS092, TMS371 and TMS412, obtained from the International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria. Stems were cut to about 15cm and planted at a spacing of 0.5m apart. The parameters measured were the number of root tubers, total number of rot tubers, weight of tuber (kg), stem girth (cm), node per stand, branching interval, internode spacing (cm), number of branching, plant height (cm), age at branching, disease incidence. Normal agronomic practices were carried out. Results showed that all varieties responded to the application of inorganic and organic fertilizers. Cassava plants that did not receive any fertilizer application (no application) gave the highest number of root tubers (29.7) from TMS412, and the least was from TMS092. The result also showed that there was no significant difference in the effects of fertilizer type on diseases. Results also showed that there was a significant interactive effect of cassava varieties and fertilizer type on branching interval (7.009), Internode spacing (0.6195), number of branching (0.2822), and plant height (17.02) at six months after planting. From the investigation, it could be recommended that for farmers to obtain greater yields with little or no fertilizer application, these cassava accessions should be used, which are characterized by high yield and resistance to disease and pests, as shown from this research.

Keywords: Agronomic characteristics, Cassava accessions, Disease assessment, Fertilizer, Yield.

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I. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial, multi-use, subsistence crop domesticated in Brazil [1] and grown throughout the tropics (Food and Agricultural Organization of the United Nations [2]. It is produced almost exclusively by small-scale, resource-poor farmers [3] on nutrient-depleted soils in mono or polyculture [3]. Due to the ability of cassava to produce reasonable yields in areas with poor soil

fertility [4] where other crops would not thrive, most farmers in Africa under-fertilize or do not fertilize cassava [3]. Cassava is rarely grown as a main crop but instead fills the important niche of being a “hunger” crop or the crop of last resort. Cassava is produced extensively throughout most countries [5], almost entirely for household consumption [6]. The cassava cropping season is variable because the cropping season and harvest date are dependent upon the type of cassava grown [5] and household consumption needs.

Cassava is an excellent niche crop for subsistence households because it can be harvested almost continuously over several months and up to a couple of years [7]. Cassava is typically planted in November and harvested between July and October. For many varieties, maximum cassava yields occur after 10 to 12 months. There are some common diseases that affect cassava production in most countries. These include Cassava Brown Streak Disease (CBSD) and African Cassava Mosaic Disease (ACMD), which impact cassava production [4], [8]. To meet home and commercial demands, there is a need for research to offset the yield gap through work on improved cultivars and planting material, including determining fertilization rates to offset low soil fertility, developing appropriate farm tools, developing agronomic practices for cassava mono-and polyculture, and evaluating the cassava value chain including transport from rural areas [9]. Agronomic research demonstrates that a significant increase in cassava yield is possible when optimum fertilizer rates are applied [10]–[15]. [16] also reported that cassava response to an increased level of N, P and K fertilizer up to 150% over the normal recommended rate of 60-60-160 kg/ha $\text{NO}_3\text{-P}_2\text{O}_5\text{-K}_2\text{O}$ for optimum yields. According to [17], K deficiency in cassava can be corrected with an application of 50 to 100 kg $\text{K}_2\text{O ha}^{-1}$ (as KCl), but the rate is dependent upon soil fertility status. Therefore, the objective of this investigation is to carry out a performance evaluation of four newly bred cassava accessions to the effects of two fertilizer types in Awka Anambra State, Nigeria.

II. MATERIALS AND METHODS

Experimental Site: The experiment was carried out at the teaching and research farm of Crop Science and Horticulture in the Faculty of Agriculture, Nnamdi Azikiwe University Awka, Anambra state.

A. Land Preparation and Fertilizer Application

The experimental site was ploughed, harrowed, and later ridged with 50 cm space between rows. The poultry Manure

(50 kg/plot) was applied as a treatment after land preparation two weeks before cassava planting on the ridges. Normal agronomic practices were carried out. The plant spacing was 50 cm × 50 cm, which were combined to give 12 treatment combinations. The total land area used for this experiment was 20 m × 14 m (2805 m²), while each plot size was 2 m × 2 m (4 m²), and intra-row and inter-row spacing of 0.5m was adopted. Each block measured 7m × 7 m to give 49 m².

B. Data Collection

Data were collected on the following parameters, using the four middle plants to avoid border effect: Growth parameters, Sprouting percentage, Plant height (cm), Age at Branching, Number of branches per plant, Node per stand, Leaf area (cm²), Flowering percentage, Color of the flowers, Stem girth, Number of Roots, Number of rot Root and Fresh tuber weight/ yield) (kg).

C. Assessment of Incidence of Pests and Diseases Associated with Cassava Plants in the Field

Disease incidence was accessed in the farm during the field stage in the 6th month. Disease incidence was accessed by visual observation of the diseased cassava plants in the sample. The percentage disease incidence of cassava plant was determined according to [18] as follows:

Disease incidence=

$$\frac{\text{Number of diseased cassava plants}}{\text{Total number of cassava plants per plot}} \times 100$$

III. DATA ANALYSIS

Data collected were subjected to Analysis of Variance (ANOVA) using the procedure outlined by [19] for Randomized Complete Block Design (RCBD) using GENSTAT statistical software package. Separation of treatment means for statistical significance was done using the least significant difference (LSD) at 5% probability level.



Fig. 1. Cassava exposing branches.



Fig. 2. Cassava exposing flowers.



Fig. 3. TMS092.



Fig. 5. TMS371.



Fig. 4. TMS412.



Fig. 6. TMS539.

IV. RESULTS

Fig. 7 shows that the effect of inorganic fertilizer gave 100% of stem (Fig. 1) sprouting for all the four accessions at one month after planting. For flowering% (Fig. 2) TMS371 had the highest flowering% (70%) followed by TMS092 which had 50% flowering (Fig. 2) while the least (30%) was obtained in TMS539 at six months after planting.

Fig. 8 shows that in no fertilizer application, all four cassava accessions had 100% sprouting at one month after planting. It was also observed that TMS412 had a similar flowering (Fig. 2) percentage (80%) with TMS371 (Fig. 5) at six months after planting, followed by TMS092, which had 50% flowering (Fig. 2), while the least (40%) was obtained in TMS539.

Fig. 9 also shows that the effect of organic fertilizer application gave 100% sprouting in two improved cassava varieties (TMS371 and TMS539) and 87.5% in the other two varieties (TMS412 and TMS092) at one month after planting. But for flowering% at six months after planting, TMS371 had the highest flowering% (80%) followed by TMS412, which had 70% flowering (Fig. 2), while the least (25%) was obtained in TMS092.

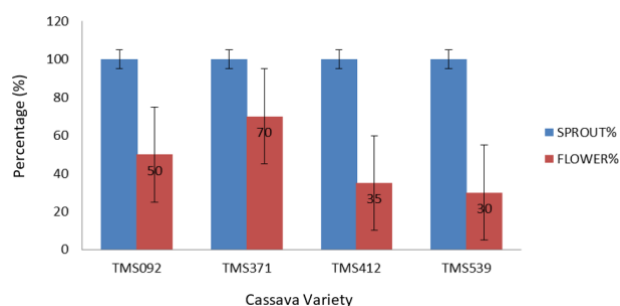


Fig. 7. Effects of inorganic fertilizer on sprouting % at one month after planting and flowering % at six months after planting. The vertical line on the graph indicates LSD bar.

Fig. 10 shows the Average number of sprouting% and flowering% as influenced by different fertilizer types, including non-fertilizer application. Where inorganic fertilizer and non-fertilizer application gave the highest sprouting% (100%) at one month after planting, followed by organic fertilizer (93.75%). Also, in flowering% at six months after planting, no-fertilizer application gave the

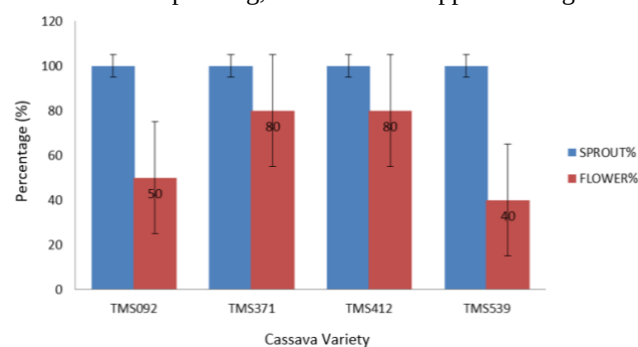


Fig. 8. Effects of no-fertilizer application on sprouting % at one month after planting and Flowering % at six months after planting. The vertical line on the graph indicates LSD Bar.

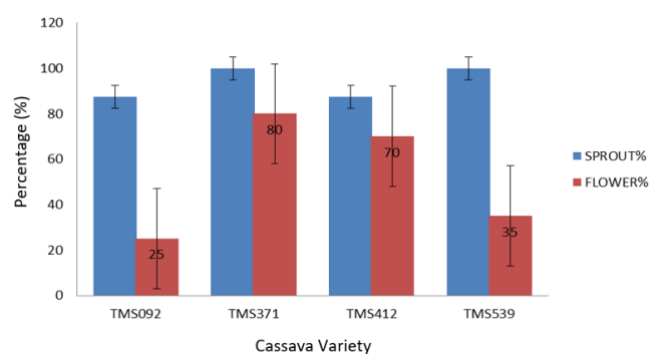


Fig. 9. Effects of organic-fertilizer application on sprouting % at one month after planting and Flowering % at six months after planting. The vertical line on the graph indicates LSD Bar.

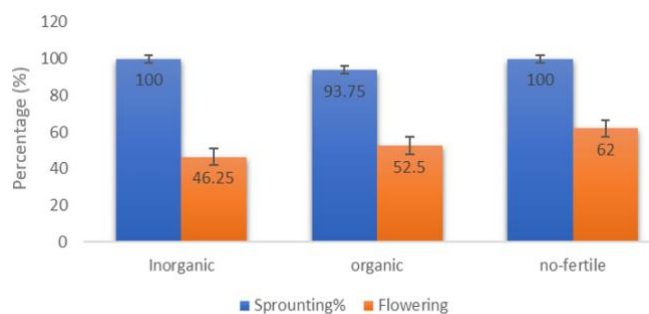


Fig. 10. Average sprouting % and flowering % on fertilizer type at one month and six months After planting. The vertical line on the graph indicates LSD Bar.

TABLE I: EFFECTS OF CASSAVA ACCESSIONS AND FERTILIZER TYPE ON SOME CHARACTERISTICS OF CASSAVA AT HARVEST

Treatments	Some characteristics of cassava at harvest		
	NTU	TNRO	WOTU
Cassava variety (CV)			
TMS 092	24.6	0.667	12.18
TMS 371	19.6	1.000	10.55
TMS 412	23.9	2.000	11.71
TMS 539	29.7	1.000	12.04
LSD (0.05)	6.59	0.5708	NS
Fertilizer Type (FT)			
Control (CO)	24.2	1.000	11.63
NPK	24.8	1.417	11.62
Poultry manure (PM)	24.2	1.083	11.61
LSD (0.05)	NS	NS	NS

NTU- number of tubers, TNRO-total number of rots, WOTU-weight of tuber, LSD-least significant difference, NS- Not Significant.

highest (62.5%) flowering Fig. 2, followed by organic fertilizer having 52.5%. While the least was obtained in inorganic fertilizer with 46.25% flowering.

Table I shows that there was a significant effect ($p < 0.05$) of cassava varieties and fertilizer type on some characteristics of cassava plants at harvest, where cassava variety TMS539 (Fig. 6) had the highest number of root tuber at harvest (29.7) followed by TMS 092 (Fig. 3) with root tuber number of 24.6 at harvest, while the least was TMS 371 (Fig. 5.) with root tuber of 19.6. TMS 539(Fig 6) tuber number (29.7) was significantly higher than TMS 371(Fig. 5) and TMS 412 (Fig. 4), with tuber numbers of 19.6 and 23.9, respectively.

TMS 092 (Fig 3) and TMS 539(Fig 6) were statistically the same as the number of tubers at harvest. For the total number of tuber roots at harvest, there was a significant difference among the various varieties, where TMS 412 (Fig. 4) had the highest number of tuber rot (2.000) at harvest. This is significantly higher than all other varieties. TMS 371 (Fig. 5) and TMS 539 (Fig. 6) had a similar number of tuber roots (1.000), which is statistically the same as 0.667 from TMS 092. Table I also shows that there was no significant difference ($p > 0.05$) among the total weight of tubers from the four cassava varieties, although TMS 092 (Fig. 3) had the highest tuber weight (12.18kg), followed by 12.04 kg from TMS 539(Fig 6), while the least (10.55 kg) was obtained in TMS 371 Fig. 5). Also, Table 1 shows that there was no significant effect ($p > 0.05$) of fertilizer type on some characteristics of cassava at harvest (number of tubers, total number of roots and total tuber weight), but NPK fertilizer consistently produced highest number of tubers (24.8) and highest value in total root number (1.417) but not in total tuber weight, where the control (no fertilizer) gave the highest (11.63 kg) total tuber weight.

Table II shows that there was significant interactive effect ($p < 0.05$) of cassava varieties and fertilizer type on number of tubers and total number of roots but not on total weight of tubers, where TMS 539 $\times$ OM had the highest (32.0) number of tubers followed by TMS 539 $\times$ CO with value of 28.7, while the least (17.0) was obtained in TMS 371 $\times$ CO. TMS 539 $\times$ OM had a significantly higher total number of tubers than TMS 371 $\times$ CO and TMS 371 $\times$ OM with values of 17.0 and 18.7, respectively. Table II also shows a significant interactive effect on total number of roots, where TMS 412 $\times$ NPK had the highest total number of roots (3.667), which is significantly higher than the other interaction effects.

Other interaction effects are statistically the same. There was no significant interactive effect on total tuber weight, but the highest (12.21 kg) tuber weight was obtained in TMS 092 $\times$ CO, followed by TMS 092 $\times$ NPK with the value of 12.18 kg while the least (10.52 kg) was obtained in TMS 371 $\times$ CO.

Table III shows that there was no significant effect ($p > 0.05$) of cassava variety on disease severity but on pest severity, where Green- spider mites occurred most on TMS092 (4.667), which is significantly different from the other three varieties, followed by (3.667) which occurred in TMS412, being also significantly higher than 3.000 and 1.667 obtained in TMS371 and TMS539, respectively. The disease severity for CAD and CMD was statistically the same (1.000) in all the cassava varieties.

TABLE II: INTERACTIVE EFFECTS OF FERTILIZER TYPES AND CASSAVA ACCESSIONS ON SOME CHARACTERISTICS OF CASSAVA AT HARVEST

Cassava variety $\times$ fert-type	Ntu	TNRo	WoTu
TMS 092 $\times$ CO	26.0	1.000	12.21
TMS 092 $\times$ NPK	24.7	0.661	12.18
TMS 092 $\times$ OM	23.0	0.333	12.14
TMS 371 $\times$ CO	17.0	1.000	10.52
TMS 371 $\times$ NPK	23.0	0.333	10.60
TMS 371 $\times$ OM	18.7	1.667	10.54
TMS 412 $\times$ CO	25.0	1.000	11.77
TMS 412 $\times$ NPK	23.3	3.667	11.67
TMS 412 $\times$ OM	23.3	1.333	11.67
TMS 539 $\times$ CO	28.7	1.000	12.01
TMS 539 $\times$ NPK	28.3	1.000	12.04
TMS 539 $\times$ OM	32.0	1.000	12.07
LSD (0.05)	11.42	0.9887	NS

NTu-number of tubers, TNRo-total number of roots, WoTu-weight of tuber, LSD-least significant difference, NS-Not Significant.

TABLE III: EFFECT OF CASSAVA ACCESSIONS AND FERTILIZER TYPE ON PEST AND DISEASE SEVERITY AT SIX MONTHS AFTER PLANTING

Treatments	Disease incidence at six months after planting		
	CAD	CGSM	CMD
Cassava variety (CV)			
TMS 092	1.00	4.67	1.00
TMS 371	1.00	3.00	1.00
TMS 412	1.00	3.67	1.00
TMS 539	1.00	1.67	1.00
LSD (0.05)	NS	0.5708	NS
Fertilizer Type (FT)			
Control (CO)	1.00	3.25	1.00
NPK	1.00	3.25	1.00
Poultry manure (PM)	1.00	3.25	1.00
LSD (0.05)	NS	NS	NS

CAD-Cassava Anthracnose Disease, CGM-Cassava Green Spider-Mites, CMD-Cassava Mosaic Disease.

V. DISCUSSION

The result from Figs. 8, 9, and 10 show that flowering percentage (Fig. 2) is dependent on the cassava accessions. This is in agreement with [20], who reported that flowering between 6 and 18 months after planting is typical for some cassava species. This result equally corroborates with [21] and [22], who stated that the number of flowers produced by a plant varies, and some genotypes have never been observed flowering. The result also showed that inorganic and non-fertilizer applications gave 100% sprouting at one month after planting. This is in agreement with [23], who observed that cassava cultivation requires fertilizer to stimulate growth and production. The reduction of sprouting percentage in organic fertilizer may be due to the late decomposition of the poultry manure at the early stage of the cassava plant development. The result also shows that there was a significant effect of cassava accessions on the number of root tubers under different fertilizer types where no application (control) had the highest number of root tubers at harvest. This result corroborates the earlier work of [24], who reported that improved cassava cultivars were modified for high yield. This could equally be a result of the moderate nutrient status of the experimental field. This is in disagreement with [25], who observed that all rates of fertilizer applied as treatments significantly performed better than the control (No application). The results also showed that there was a significant interactive effect on cassava varieties and fertilizer types on the number of tubers and total number of roots. This is in agreement with FAO 2013, which stated that cassava yield in Africa could be increased markedly if farmers had access to mineral fertilizer at a reasonable price. It was also observed by [26] that in the Democratic Republic of Congo, per hectare cassava yield increases from 12–25 tones with moderate application of NPK fertilizer and reaches more than 40 tones with higher application rates, including stem yield. [27] also reported significant yield increases due to N and K fertilization. This report is similar to what was observed in this investigation. [28], reported that N increases the chlorophyll of leaves, thereby promoting the plant. This could have been the reason for the increased yield of cassava plants that was influenced by the application of mineral fertilizer (NPK) in this study. It was also observed that there was a significant interactive effect on cassava varieties and fertilizer types on Age at branching, internode spacing, number of branching and plant height. This collaborates with the result of [29], who reported that cassava plant height, number of leaves, branches, and stem girth were significantly increased by the application of NPK fertilizer. This result is also in harmony with the findings of [30]–[32], who reported that earlier branching, an increase in the number of branches per cassava plant with the application of inorganic fertilizer.

A. Effect of Cassava Accessions and Fertilizer Types on Disease and Pest Incidence on Cassava Plants

It was shown that there was no significant effect of fertilizer on the disease severity of cassava plants. This is in disagreement with [33], who reported that NPK fertilizer application significantly increases CMD incidence and severity compared to trials without fertilizers. The disagreement observed in this investigation could have been as a result of high resistance of the improved cassava varieties

used in this experiment to disease and pests. This is in agreement with the reports of [34], who observed that cassava varieties that are being bred in recent times are very resistant to diseases and pests. This is similar to Earlier work of [24], who reported that improved cassava cultivars such as TMS30572 and TMS 30555 were modified for high yield, pests/disease resistance, good product quality and early maturity, among other desired attributes, while the TMS4(2)1425 is moderately resistant to these pests and diseases. Also, [35] reported that the improved cassava cultivars were more resistant than the local cultivars to common diseases such as cassava mosaic virus and bacterial blight and more tolerant to such pests as green mites and mealy bugs.

VI. CONCLUSION

From this investigation, it was observed that cassava variety and fertilizer types had a significant interactive effect on some of the growth and yield parameters, such as girth, node per stand, plant height, number of root tubers, and weight of tubers. From the research, it was also observed that no fertilizer application had the highest number of root tubers. This could have been a result of the fact that cassava varieties released in recent times were bred for very high yield potentials that give high yield with little or no fertilizer application, as was observed in this study. The result also showed that there was no significant effect of fertilizer types on disease and pests which could be attributed to high resistance to diseases and pests by the accessions of cassava used in this research.

RECOMMENDATIONS

From this study, it could be, therefore, recommended that these improved accessions used in this experiment could be cultivated with little or no fertilizer application and still have a bountiful yield. These improved accessions are very good for farmers because they will help them to reduce the cost of production and maximize profit occasioned by the fact that they could have a very high yield without incurring the cost of fertilizer and its applications. Farmers should adopt these cassava accessions, which are very resistant to disease and pests, as was observed in this study.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest in this investigation.

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