



EFFECTS OF VARIETY AND FERTILIZER RATES ON THE STEM AND ROOT DEVELOPMENT OF CASSAVA (*Manihot esculenta*) IN BALI AREA

RAJAB, Y. S.; DR. BASHIR, A. A.; & AUWAL, I.
N.

Department of Crop Production Technology, Federal
Polytechnic, Bali

Corresponding Author: yakubusamaila@gmail.com

DOI: <https://doi.org/10.70382/tijarbt.v10i1.028>

ABSTRACT

This research was carried out in the teaching and research farm of the School of Agricultural Technology, Federal Polytechnic, Bali to determine the effects of variety and fertilizer rates on the development of stem and tuber of cassava in Bali area. A complete Randomized Block Design (CRBD) was adopted and replicated three times. A zig-zag sampling method with 25% representative samples were used for data collections. Parameters

Introduction

Cassava (*Manihot esculenta* Crantz) is a perennial woody shrub which belongs to the Euphorbiaceae family. It is believed to have originated from South America but now an important source of food security for more than 800 million people in the tropics and subtropics. Cassava is a perennial Shrub that is primarily cultivated for starchy roots. It is one of the primary food sources in sub-Sahara Africa, providing an important source of calories, crucial to food security (Srivastava *et al.*, 2023). Cassava, described as the “golden crop of Africa”, plays a significant role in the supply of food and hunger eradication (Ogidi Olu Farms, 2019). Besides its role as a food crop, cassava is increasingly becoming an important industrial commodity for animal feed, starch, bioethanol, and value-added products. In Nigeria, production of the crop is essential and serves as a major caloric-intake source (Srivastava *et al.*, 2023). The root crop is processed into food such as gari, fufu as staples directly consumed at homes and restaurants, while is also used in industrial production of high quality flour; starch, ethanol and animal feed (OgidiOlu Farms, 2023; Sanginga and Mbabu, 2015). Abirami *et al.*, (2025)



assessed include Plant height at 3, 6 and 9 months after planting (MAP); stem girth, number of branches, number of tubers per plant, tuber length, thickness of the tuber and tuber weight at harvest. Data collected were subjected to Analysis of Variance (ANOVA) with the help of SPSS statistical package. Mean were separated using Tukey Honestly Significant Difference (HSD). The results showed significant differences among the two cassava varieties and the local cultivar and significant interactions between the two factors.

KEYWORDS: Variety, Cassava, fertilizer rates, tuber, stem

estimated that Africa contributed more than 65% of the world cassava output. However, global production exceeds 300 million metric tonnes annually, with Nigeria, Thailand, Ghana, and Brazil as leading producers.

Despite its importance, yields of the crop are very low. The yields of Nigeria and the other top African cassava producers are 37 to 64% below the global yield levels (Sanginga and Mbabu, 2015). These yields were 8, 14 and 14.7 t/ha in Democratic Republic of Congo, Nigeria and Cameroon respectively. The average farmers yield in Nigeria of 10 – 15 tonnes per hectare is low compared to countries like Brazil, India and Thailand, which were highly successful in commercial production, obtaining yields of between 25 and 40 tonnes per hectare (Agricdemy, 2023). The low cassava yields prevailing in Nigeria are caused by the use of inadequate agronomic practices (Sanginga and Mbabu, 2015, FFD, 2012). The current cassava yield levels can be increased by a factor of five by emphasizing that farmers adopt a “basket” of improved agronomic practices (FFD, 2012; Hauser., 2015).

Cassava varieties show significant genetic diversity in traits such as drought tolerance, canopy architecture, harvest index, root dry matter content, disease resistance, and post-harvest physiological deterioration. These characteristics directly influence how a plant captures resources (light, water, nutrients) and converts them into economic yield. Cassava is a heavy feeder, usually depleting soil nutrients, especially nitrogen (N) potassium (K), and phosphorus (P). While it can survive in poor soils, substantial yield responses to balanced fertilization are well-documented. However, optimal fertilizer regimes are not universal; they are associated with variety-specific nutrient demand patterns, soil type, climate, and desired end-use.

In spite its hardiness and low input demand, real cassava productivity in farmers' fields mostly falls greatly below its genetic potential. Two of the most essential, manageable factors limiting yield are the choice of genetic variety and soil fertility management, especially fertilizer use. The interaction between these factors forms a complex



agronomic matrix that dictates the crop's growth dynamics, distribution of assimilates, and ultimate root yield.

Effect of Variety on Cassava Growth and Yield

The genetic makeup of a cassava variety primarily dictates its phenology, growth pattern, and yield capacity. Recent breeding practices focused on developing varieties with specific adaptation to abiotic and biotic stresses coupled with maintaining or improving yield potential.

Canopy Patterns and Growth Habit: Varieties differ in canopy duration, leaf area index (LAI), and branching patterns. Erect, early-branching varieties with moderate leaf area index (LAI) show better weed suppression and higher light interception. Adiele et al. (2020) reported that canopy development traits are very much heritable and highly correlated with resulting root yield. Late-branching or compact canopy varieties may conserve moisture better in drought-stricken areas but could lead to accumulation of less total biomass.

Dry Matter Content (DMC) and Root Yield: The fundamental yield component is fresh root weight, but DMC (25-40%) is an important quality trait for food and industry. High-yielding varieties may not always have the highest DMC. Esuma et al. (2021) elucidated the genetic independence and trade-offs between these traits, stressing the need for targeted breeding. Modern genomic tools are now being used to identify quantitative trait loci (QTLs) for these complex traits, accelerating breeding cycles.

Harvest Index (HI): HI quantifies the proportion of total biological dry matter apportioned to the storage roots. Improved varieties mostly have a HI of 0.5-0.6, significantly higher than traditional cultivars (0.3-0.4). Kawuki et al. (2020) observed that high-HI varieties proved better in converting nutrients into harvestable product, which is good for fertilizer use efficiency.

Tolerance to stress: The choice of variety is a crucial adaptation strategy. Drought-tolerant varieties (e.g., TMEB 693) maintain root bulking under water stress, while pro-vitamin A biofortified varieties (e.g., UMCASS 38) address malnutrition. Resistance to cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) is more important in East and Central Africa, where these viruses are problematic. Ntawuruhunga et al. (2021) opined that adoption of disease-resistant varieties exclusively can multiply yields when compared to susceptible varieties, irrespective of fertilizer input.

Effect of Fertilizer on Cassava Growth and Yield

Cassava is a heavy feeder and removes large quantities of nutrients from the soil, which is estimated at approximately 7.5 kg N, 1.0 kg P, and 7.5 kg K per tonne of fresh roots. Continuous cultivation without replenishment causes nutrient mining and yield reduction.



Macronutrient Needs (N, P, K): Potassium (K) is constantly identified as the most yield-affecting nutrient for cassava, important for transport of assimilates, photosynthesis, and root development. Nziguheba et al. (2022) in a Pan-African study stated that K application resulted in the most effective and consistent yield responses across diverse environments. Nitrogen is important for leaf longevity, and vigorous canopy establishment. However, excess N can lead to excessive vegetative growth to the detriment of root bulking. Phosphorus is critical for early root development and energy transfer. Balanced application (e.g., site-specific formulations) is generally recommended.

Secondary/Micronutrient Requirements: Deficiencies of magnesium (Mg), calcium (Ca), zinc (Zn), and boron (B) are increasingly discovered as yield constraints, especially in highly cropped, acidic soils. Howeler (2021) stated that B deficiency in a soil severely restricts root formation, while Zn is vital for enzyme function and synthesis of starch. Integrated soil fertility management, including lime application to correct acidity, is gaining prominence.

Form of Fertilizer and Application Timing: Research on enhanced efficiency fertilizers (EEFs) such as urea deep placement or polymer-coated urea is emerging in cassava systems to improve N use efficiency which reduce losses. Omondi et al. (2023) discovered that split application of N and K (at planting and 3-4 months after) corresponds better with cassava's nutrient uptake pattern (low early demand followed by a massive demand during root bulking) compared to a single basal dose, which improves nutrient recovery and yield.

Interaction Between Cassava Variety and Fertilizer Rates

The core of precision cassava cultivation depends on understanding the Variety $\times$ Fertilizer (V $\times$ F) interaction. Different varieties have unique nutrient demand patterns and utilization.

Variety Differences in Nutrient Use Efficiency (NUE): Some varieties are naturally more effective at absorbing and utilizing nutrients. For example, Egesi et al. (2022) discovered cassava genotypes that maintain relatively high yields under Low-N conditions (i.e. high N uptake efficiency) and other varieties that respond efficiently to applied K (i.e. high K response efficiency). Therefore, breeding for NUE is a strategic approach to reduce fertilizer requirements.

Differential Responses to Fertilizer Levels: A high-yielding, photosynthetically effective variety may require a full, balanced fertilizer programme to express its potential. Conversely, a locally adapted, drought-tolerant cultivar might show a minimal response to N but a profound response to K and micronutrients. Agbona et al. (2023) showed that bio-fortified varieties require specific NPK ratios to maximize both yield and nutrient



concentration in the roots. Ignoring these interactions can cause underestimated returns on fertilizer investment or even yield reduction.

Site-Specific Recommendations: The Variety/Fertilizer interaction is further regulated by soil type and climate. The Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS) model, customized for cassava, is being used to develop balanced, site- and variety-specific nutrient recommendations. This moves beyond blind prescriptions toward precision agronomy.

Effects of improved agronomic Practices on Cassava yield:

Federal Fertilizer Department (FFD, 2012) reported that generally, yields obtainable by farmers in Nigeria was 10t/ha; but with improved agronomic practices the level could be raised to 25 t/ha. According to Agridemy (2017) the average yield of 10 – 15 mtha⁻¹ in Nigeria is low compared to countries like Brazil, India and Thailand were highly successful in commercial production, obtaining yields of between 25 and 40 tons per hectare. The low cassava yields are caused by pests and the use of inadequate agronomic practices (Sanginga and Mbabu 2015; FFD, 2012). Agridemy (2017) reported in Nigeria that cassava yield could reach 25 tonnes/ha and above.

Hauser et al (2015), FFD (2012) reported that cassava farmers in Nigeria can increase yield by adopting a “Basket” of improved agronomic practices. Agridemy (2017), IITA (2014), Haauser et al. (2015) listed the followings as contained in the package of improved agronomic practices to improve the yield of cassava in Nigeria – site selection, land preparation, varietal/planting materials selection, optimal spacing/planting density, optimal fertilizer application, pest/weed management and proper harvesting methods.

In spite of the introduction of improve varieties of cassava by the Research Institutes, farmers in the study area seem to retain the use of the low yielding local cultivars of cassava, coupled with adoption of poor agronomic practices, which grossly lower their production potentials. The escalation in the price of staple food items such as maize and rice as a result of increasing demand for animal feed formulation, forced the consumers' demand to shift to the cheaper substitute such as cassava, as such farmers in Bali are therefore, constraint to look for the best agronomic practices to adopt to improve the cassava production to meet the increasing market demand.

In spite of the introduction of improve varieties of cassava by the Research Institutes, farmers in the study area seem to retain the use of the low yielding local cultivars of cassava, coupled with adoption of poor agronomic practices, which grossly lower their production potentials. The escalation in the price of staple food items such as maize and rice as a result of increasing demand for animal feed formulation, forced the consumers' demand to shift to the cheaper substitute such as cassava, as such farmers in Bali are



therefore, constraint to look for the best agronomic practices to adopt to improve the cassava production to meet the increasing market demand.

The low cassava yields prevailing in Nigeria are caused by the use of inadequate agronomic practices (Sanginga and Mbabu, 2015, FFD, 2012). The current cassava yield levels can be increased by a factor of five by emphasizing that farmers adopt a “basket” of improved agronomic practices (FFD, 2012; Hauser *et al.*, 2015). There is therefore, a need to come up with the best yielding variety of cassava for cultivation under efficient fertilizer practice (manuring) which could be recommended to farmers in Bali and its environs. The objectives of this study are to:

- (i) determine the cassava varieties/cultivars that will best suit the condition of Bali;
- (ii) determine the fertilizer rate that will lead to increased yield of cassava in Bali.

MATERIALS AND METHOD

Experimental Site: Bali, in Bali Local Government Area, is located between latitude $7^{\circ}46'N$ and $7^{\circ}54'N$ of the equator and longitude $10^{\circ}30'E$ to $11^{\circ}00'E$ of the prime meridian (Jugulde *et al.*, 2020). It has mountainous geo-physical features and located in the dry guinea savanna (Jugulde *et al.*, 2020). The rainy season start around April, end in October, with about 1,350 to 1,500 mm of rainfall annually (Jugulde *et al.*, 2020). Majority of the soils occurring in the area are of the suborders Fluvents or recently deposited alluvial soils on river banks and other shallow rocky soils (FFD, 2012). Others are Ustults, the reddish brown low base status soils (FFD, 2012). Some chemical properties of the soils on average basis were 0.93% organic carbon, 1.7% organic matter with pH of 4.9 and EC 0.48 (Danladi *et al.*, 2019).

Materials – Experimental plot, pegs, line, NPK 15:15:15, hoe, cutlass, cassava cuttings, herbicide, weigh machine, record book.

Methods – the experiment was carried out at the teaching and demonstration plot of the School of Agricultural Technology, Federal Polytechnic, Bali. The design adopted was a Randomized Complete Block Design (RCBD) in which a plot of 32 m by 35 m was cleared at the onset of rainfall in the year 2025. The land was tilled and nine beds of size 5 m x 10 m were raised and three varieties of cassava (Danjalango, TMC 0066 and TMT 419) were planted at 1m intervals using 30 cm long stem cuttings. The certified improved cassava stem cuttings (i.e. TMC 0066 and TMT 419) were obtained from Agro-allied agent (farm) in Wukari, while the local cultivar (Danjalango) was obtained from Mutum-Biyu market. The sub-treatment was NPK (15:15:15) fertilizer applied at varying concentrations of 100 kg/ha, 200 kg/ha and 300 kg/ha. The nine beds were replicated three times giving a total of twenty-seven beds. Manual weeding and application of post-planting herbicides were alternately used to control weed at four weekly intervals. Data were recorded at 3 months



after planting (MAP), 6 MAP, 9 MAP and at harvest. Zigzag sampling method was adopted where nine cassava stands were tagged for data collection. The parameters assessed were plant heights at 3, 6, and 9 MAP; stem girth at 3 and 6 MAP; number of tubers per plant, tuber thickness and average weight of a tuber at harvest. Analysis of Variance (ANOVA) was used to analyze the data with the help of SPSS statistical package and mean were separated using Tukey honestly significant difference (HSD). Most of the data for the parameters assessed had conformed to the assumptions of ANOVA for parametric test, while the stem girth at 9 MAP, cassava branches at 3, 6 and 9 MAP and tuber length at harvest, whose data were not normally distributed were subjected to Kruskal-Wallis test.

Results -

Table 1: Mean squares from the analysis of variance (ANOVA) for growth and yield parameters of different cassava varieties treated with varying rates of NPK fertilizers.

Source of variation	df	PH@ 3MAP	PH@ 6MAP	PH@ 9MAP	SG@ 3MAP	SG@ 6MAP	TT@ HVST	NT/ PLT	AWT
Main Trt (a)	2	4632.3	2604.5	201.44	10.869	6.836	46.926	24.111	121100.9
Error (a)	18	103.667	32.481	37.296	0.221	0.605	0.778	0.556	2349.07
Sub-Trt (b)	2	8.444	0.259	7.000	0.114	0.105	0.593	1.444	3750.93
Error (b)	18	103.667	32.481	37.296	0.221	0.605	0.778	0.556	2349.07
AXB	4	106.778	39.593	17.611	0.127	0.084	0.759	0.389	2834.26

Keys: df = degree of freedom, PH@ = plant height at, AG@ = stem girth at, TT = tuber thickness,

NT = number of tubers per plant, AWT = average weight of tuber, MAP = months after planting,

HVST = harvest, PLT = plant, Trt = treatment,

Table 2: mean performance of the growth and yield parameters of different cassava varieties cultivated with varying rates of fertilizer in 2025 growing season.

TREATMENT	PH@ 3MAP	PH@ 6MAP	PH@ 9MAP	SG@ 3MAP	SG@ 6MAP	TT@ HVST	NT/ PLT	AWT
A. VARIETY								
Danjalingo	55.111	144.78	186.67	3.1333	8.0889	20.444	3.0000	306.6667
TMC 0066	92.444	164.33	190.89	5.3222	8.4444	23.000	5.1111	388.3333
TMT 419	96.111	178.67	196.11	4.4000	9.7444	25.000	6.2222	535.5556
Mean	81.222	162.59	191.22	4.2852	8.7592	22.815	4.7778	410.1852
Probability of F	44.685	80.184	5.401	49.157	11.303	60.333	43.400	51.553
Tukey (mult. Comparis.)	103.67	32.481	37.296	0.221	0.605	0.778	0.556	2349.074
B. FERTILIZER RATE								



TREATMENT	PH@ 3MAP	PH@ 6MAP	PH@ 9MAP	SG@ 3MAP	SG@ 6MAP	TT@ HVST	NT/ PLT	AWT
100 kg/ha	81.667	162.44	190.56	4.3556	8.6667	22.667	4.6667	386.6667
200 kg/ha	81.889	162.56	190.89	4.1556	8.7333	23.111	4.4444	420.5556
300 kg/ha	80.111	162.78	192.22	4.3444	8.8778	22.667	5.2222	423.3333
Mean	81.222	162.59	191.22	4.2852	8.7593	22.815	4.7778	410.1852
Probability of F	0.81	0.008	0.188	0.514	0.173	0.762	2.600	1.597
Tukey (mult. Comparis.)	103.67	32.481	37.296	0.221	0.605	0.778	0.556	2349.074
A X B	*	*	*	*	*	*	*	*

KEY: * = significant at 0.05

Table 1 showed the mean squares, the degree of freedom and the error terms for the all the parameters assessed and the interactions of the two factors (cassava varieties and rates of fertilizer) involved in the experiment. While table 2 showed the mean distributions or performance of the response variables as influenced by the two interacting factors (cassava variety and fertilizer rates) at $p = 0.05$.

Discussions

Some of the few morphological differences observed on the cassava varieties are that while the local cultivar (Danjalingo) possessed red colored leaf petiole the improved varieties remain green, while the difference between the two improved varieties is that at all the growth stages, the newly emerged apical leaves initially looked reddish brown for TMT 419 and greenish for TMC 0066.

The results generally showed that there were significant differences among the varieties for all the parameters assessed, but the differences exerted by the fertilizer rates were not significant for both the growth and yield parameters. This could be attributed to the acidic nature of the soils in the study area and consequently lead to immobilization of some nutrients (especially micronutrients like Mg, Ca, Zn and B) which render them unavailable for the crop consumption. It is further observed that for all the parameters observed, except the stem girth at 3 MAP, TMT 419 recorded the highest mean value. However, no cases of diseases or pests were observed on all the varieties under the study.

CONCLUSION

It is therefore concluded that under improved agricultural practices, improved variety TMT 419 offered itself as the best variety in terms of stem length and tuber size and weight. Followed by TMC 0066, then the local cultivar (Danjalingo). The study also revealed the dominance of the effect of variety over that of fertilizer, even though there is significant interaction between the two factors in the results.



RECOMMENDATIONS

It is recommended that cassava farmers within Bali and its environs should opt for the variety TMT 419 over TMC 0066 or Danjalingo, except for stem girth. Further studies under non-acidic soil environment is required to ascertain the effect of varying the fertilizer rates.

ACKNOWLEDGEMENT

The research team wishes to acknowledge and thank the Tertiary Education Trust Fund (TETFund) for providing the financial backing for the research and the Management of Federal Polytechnic Bali for cooperation and provision of enabling environment for the smooth conduct of the research work.

REFERENCES

- Abirami V., Velmurugan M., Thangamani C., Natarajan S.K., Davamani V., Indu R. C. and Venkatachalam S. R. (2025). Cassava Intercropping Systems for enhanced land productivity and farmer livelihoods: A Review. *Plant Science Today*. Vol 12, No. 3, DOI.org/10.14719/pst.8409.
- Adiele, J. G., Schut, A. G., van den Beuken, R. P., et al. (2020). Towards understanding factors influencing cassava canopy development. *Field Crops Research*, 255, 107870.
- Agbona, A., Peteti, P., Teeken, B., et al. (2023). Fertilizer response and nutrient accumulation in the cassava genotype-by-environmental context. *Scientific Reports*, 13(1), 1123.
- Agricdemy (2017), Cassava Farming Techniques. Online Farm Advisor.
- Danladi S., Ojeaga I. and Abdulmumini A. (2019). Evaluation of Fertility Status of Soils for Sustainable Productivity of Crops in Bali, North-Central.Taraba State-Nigeria. *International Journal of Inovative Science and Research Technology*. ISSN 2456-2165. 665-702
- Egesi, C., Kawuki, R., Ozimati, A., et al. (2022). Breeding cassava for nutrient use efficiency: A review. *Frontiers in Plant Science*, 13, 939289.
- Esuma, W., Ozimati, A., Kulakow, P., et al. (2021). Genetic analysis and association studies of yield and yield-related traits in cassava (*Manihot esculenta* Crantz). *Agronomy*, 11(2), 282.
- Federal Fertilizer Department-FFD (2012); Fertilizer use and Management Practices for Crops in Nigeria, 4th edition. Federal Ministry of Agriculture and Rural Development, Abuja.
- Hauser S., Weiregi L. Asadu C. L. and Ugbe U (2015). Cassava System Cropping Guide. Africa Soil Health Consortium, Nairobi.
- Howeler, R. H. (2021). Sustainable Soil and Crop Management of Cassava in Asia. CIAT Publication No. 452. International Center for Tropical Agriculture.
- ITTA – International Institute of Tropical Agriculture (2014). Growing Cassava in Nigeria ITTA, Ibadan.
- Jakusko, B. B. (2017). *Field Crop Production for Sustainable Food Security*. ABU Press Limited, Zaria. ISBN: 978-978-8536-49-9. Pp 135-145
- Jugulde A. D., Abdulkadir A. and Danladi S. (2020). Evaluation of Soil Fertility Potentials of some Soils of Bali Local Government Area. TETFUND
- Kawuki, R. S., Agaba, R., Kanaabi, M., et al. (2020). Harvest index and trait correlations in elite cassava genotypes evaluated in Uganda. *Journal of Plant Breeding and Crop Science*, 12(2), 54-63.
- Ntawuruhunga, P., Ngoma, K., & Ezui, K. S. (2021). The role of disease-resistant varieties in sustaining cassava productivity in sub-Saharan Africa. *Crop Protection*, 145, 105641.



**NOVEMBER, 2025 EDITIONS. INTERNATIONAL JOURNAL OF:
AGRICULTURAL RES. & BIOTECHNOLOGY VOL. 10**

Nziguheba, G., Kantengwa, S., Diels, J., et al. (2022). Potassium fertilization is key to improving cassava yield in Central Africa: A meta-analysis. *Agronomy for Sustainable Development*, 42(4), 68.

OgidiOlu Farms (2019). Cassava Farming Techniques. Online Farm Advisor

Omondi, J. O., Yermenon, K., & Dutta, S. (2023). Timing and splitting of nitrogen and potassium application in cassava: Effects on yield, quality, and nutrient use efficiency. *Journal of Plant Nutrition*, 46(5), 789-804.

Sanginga N. and Mbabu A. (2015). Root and Tuber Crops. United Nations Commission for Africa.

Srivastava A. K., Ewert F., Akinwumiju A. S., Zeng W. and Adebayo A. (2023). Cassava Yield Gap – A Model – Based Assessment in Nigeria. *Front Sustain. Food System* Vol. 6.