EFFECTS OF PLANTING DATES AND FERTILIZER APPLICATION ON SELECTED SOIL CHEMICAL PROPERTIES AND CASSAVA PARAMETERS

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ABSTRACT
This study aimed to investigate the impact of fertilizer application under two planting dates on soil chemical properties and cassava production. Field studies were conducted at the Federal University of Agriculture, Abeokuta (FUNAAB) and Psaltry International Limited (PSALTRY), Nigeria. The trials were laid out in a split plot arrangement with planting dates (early and late plantings) as main plot and fertilizer application (nill versus fertilized) as sub plot. The fertilized plots received 75 kg N, 20 kg P, and 90 kg K per hectare sourced from NPK 15:15:15, Urea and Muriate of Potash. The treatments were fitted into a Randomized Complete Block Design with four replicates. Soil textures were sandy clay loam (FUNAAB) and loamy sand (PSALTRY). Post-harvest soil properties were significantly affected by location. Total nitrogen was 40.2% higher for late planting at FUNAAB and 3.7% higher at PSALTRY compared to early planting. Potassium had similar trend as N but differs for organic carbon. Fertilized plots had higher soil nutrients than unfertilized plots, which was 36.3% and 18.2% higher at FUNAAB and 10.3% and 90.9% higher at PSALTRY for cation exchange capacity and organic carbon, respectively. Growth and yield parameters significantly differed with planting date at both locations, with higher root yield for late planting at FUNAAB and early planting at PSALTRY. Fertilizer application resulted in 62.3% and 24.7% increase in root yield for early and late plantings, respectively. Fertilizer application improved soil properties and cassava growth, but results varied by planting dates and locations. Thus, site-specific fertilizer recommendations are needed to boost cassava production.

Key words: Soil properties, Cassava, Planting dates, Fertilizer, Nutrient management

Introduction

Cassava (*Manihot esculenta* Crantz) is an important perennial shrub widely grown in the farming systems of Sub-Saharan Africa, Asia, and Latin America (Shackelford *et al*., 2018). The crop is a major staple food and produces high calories per hectare from its starchy tuberous root (Taiwo, 2006). It plays a vital role in food security, employment creation, and income generation for farmers (Mbanjo *et al*., 2021). The demand for cassava root is growing as a source of raw materials for agro-industries in the production of starch, alcohol, pharmaceuticals, gums, confectioneries, and livestock feed (Li *et al*., 2017).

Globally, Nigeria is the highest producer of cassava with an annual fresh root yield of about 59 million tonnes, followed by Thailand, Brazil, and Democratic Republic of Congo (FAOSTAT, 2021). The increase in cassava production was attributed to improving cassava varieties and increasing land demand for cassava production (Srivastava *et al*., 2023). However, the current root yield tends to be less than 10 t ha^{-1} fresh root mass, which is much lower than the Latin America and Asian counterparts, with average yield ranging from about 18 to 22 t ha^{-1} (FAOSTAT, 2021). The wide yield gap can be attributed to the fast-declining soil fertility of farming communities and erratic weather conditions in Sub-Saharan Africa (Bjornlund *et al*., 2020). More so, cassava is predominantly grown on infertile, light-textured soil, with little or no use of fertilizer by most farmers in Africa (Howeler, 2017). This is because it is considered to produce some root yield under low management practices and poor soil fertility (Imas & John, 2013).

Cassava cultivation can cause serious soil fertility depletion due to the excess nutrient removal by the crop (Howeler, 2017). According to Ayoola and Makinde (2007) cassava absorbs a large quantity of nutrients from the soil, mainly potassium, then nitrogen, and phosphorus. With a fresh root yield of 30 t ha^{-1}, cassava extracts 180 - 200 kg N, 15-22 kg P_2O_5, and 140-160 kg K_2O per ha from the soil (John *et al*., 2010), with an average removal of 55, 13.2, and 112 kg of N, P, and K per hectare, respectively (Howeler, 1991). Agronomic research has shown the possibility for significant increase in root yield when optimum fertilizer rates are applied (Cuvaca *et al*., 2017). Hauser *et al*. (2014) reported that 10 to 16 ton ha^{-1} increase in fresh cassava root yield is possible with the application of fertilizer. The application of external inputs is important to meet root yield beyond 12 Mg ha^{-1} with consideration of the fertility status of each location (Ezui *et al*., 2016). However, the response of cassava to fertilizer application may differ based on the date of planting (Enesi *et al*., 2022).

The majority of cassava farmers select the onset of the rainy season or when rainfall is fully established as the planting and harvesting dates of cassava because the production process is nearly entirely rainfed (Santisopasri *et al*., 2001). The high moisture during this weather condition allows for the better establishment of crops and root harvesting. However during this period, there is usually surplus of cassava roots and stems, which results in lower market prices and further deters farmers from harvesting in bulk and producing in subsequent seasons. Planting cassava just before the long dry season (late planting) is not well practiced due to the exposure of young stands to prolong drought, which may lead to poor sprouting (Polthanee & Srisutham, 2017). According to Enesi *et al*. (2022), cassava may be grown and harvested all year round to meet the growing demand of consumers and processors, however, there must be a carefully managed system and in-depth understanding of the response of cassava to seasonal variation, crop management practices, specific soil fertility status, and dynamics at different locations. The decline in soil fertility status, especially under cassava production necessity more researches on soil nutrient status (Biratu *et al*., 2019).

It is now evident that the application of fertilizer increase cassava root yield (Omondi & Yermiyahu, 2021; Rós *et al*., 2020; Wilson & Ovid, 1994). Largely, experiments on cassava response to nutrient managements were established onset of rainy season. However, the choice of planting period could result in the variability of cassava response to fertilizer management. The high soil moisture condition, resulting from high rainfall variability during the major rainy season could cause leakage or loss of applied fertilizer, thereby limiting plant nutrient uptake and increasing the required fertilizer rate (Guo & Chen, 2022). In contrast, late planting of cassava towards the end of the season, attributed with lower rainfall and water storage may be beneficial in improving fertilizer use due to even dissolution of fertilizer to the rooting zone and reduced leaching rate. Thus, the objective of this study is to investigate the effect of planting dates and fertilizer application on soil chemical fertility status, and cassava growth and yield cultivated in two locations with different textural classes.

Experimental

Description of experimental sites

The field experiments were conducted at the Directorate of University Farms of the Federal University of Agriculture, Abeokuta (FUNAAB) experimental site, Ogun state **(**7° 14' 21.49" N and 3° 26' 51.12" E**)** and Psaltry International Limited (PSALTRY), Ado - Awaye, Oyo state (7° 47' 36.96" N and 3° 23' 55.72" E). The experimental site at FUNAAB is located in the forest savanna transition zone of south-western Nigeria, and falls under the Forest-savanna zone. The research field at PSLATRY falls in the southern guinea savanna agro-ecological zone. The experimental plots had been under continuous cassava cultivation for the past 4 years at PSALTRY and 2 years at FUNAAB, prior to the establishment of the experiment in 2017. There was also incorporation of cassava peels in previous years at PSALTRY for soil amendment, though not consistent on yearly basis. The meteorological data during the experimental period at both locations from April 2017 to September 2018 were gotten from Climate Hazards Group Infrared Precipitation (CHIRPS, 2021). The experimental sites had two well defined seasons, rainy season (mid-March to mid-September) and dry season (mid-October to mid-March).

Experimental treatment and layout

The experiment was laid in split plot design with four replications. The main plot was planting date having two levels of early planting and late planting while sub-plot was fertilizer application (nill versus fertilized). At each location, the planting schedule (Table 1) was based on commencement of rainfall. The fertilizer treatment involved the application of 75 kg N, 20 kg P, and 90 kg K per hectare, in a split application of 153.5 kg ha^{-1} NPK 15-15-15 at 4 and 8 weeks after planting (WAP), 63 kg ha^{-1} urea at 10 WAP, and a split application of 52 kg ha^{-1} MOP at 12 and 16 WAP. In the case of late planting, the applications of urea and MOP fertilizer were postponed until the commencement of rainfall in 2018 (corresponding to 22 WAP) due to the initiation of the dry season in November 2017. The fertilizer was carefully applied about 10 cm around the cassava. A total of 16 plots were established at each location with plot size of 7 m by 5.6 m (39.2 m^2) for main plot.

TABLE 1

Schedule for planting and harvest at the experimental locations

Location (Factor)	Planting date (Factor)	Planting date	Harvest date
FUNAAB	Early	12/04/2017	15/03/2018
	Late	12/08/2017	20/07/2018
PSALTRY	Early	17/04/2017	20/03/2018
	Late	18/08/2017	16/07/2018

Agronomic practices

The experiment plot was cleared and double disc-ploughed twice to a depth or about 25-30 cm. Freshly cut cassava stem (TME 419) of 25 cm long was planted at slant position (about 45 degrees) having about two-third of the stem into the soil. The cassava was planted at a spacing of 1 m x 0.8 m (IITA, 1990), resulting into 49 cassava plant per plot (12,500 plants ha^{-1}). The non-sprouting cassava stems were replaced with fresh stem 1 WAP to obtain a full plant population per plot. Primextra Gold (400 gm L^{-1} S-Metolachlor and 320 gm L^{-1} Atrazine) was applied as pre-emergence herbicide at a rate of 4 L ha^{-1}. Manual weeding and the application of Touch down (500 gm L^{-1} glyphosate; rate of 3 L ha^{-1}) were employed at 8 WAP and 14 WAP, respectively.

Soil sampling and analysis

Soil samples were randomly collected (0-20 cm depth) with the aid of soil auger for pre-planting soil analysis. Likewise, soils were collected on plot basis at 0-20 cm depth for the post planting analysis. The soils were air-dried, ground and sieved with 2 mm mesh sieve. Soil samples were analyzed for pH in a 1:2 soil water suspension (Van Reeuwijk, 1993), total nitrogen by micro Kjeldahl digestion method (Nelson & Sommers, 1982), exchangeable cations were measured using the ammonium acetate replacement method (Thomas, 1982), organic carbon by chromic acid digestion in Walkley Black method (Nelson & Sommers, 2015) and particle analysis by hydrometer method (Gee *et al*., 2002).

Agronomic data collection

The agronomic data were collected immediately prior to harvest at 11 months after planting – harvest date in table 1. The harvesting exercise was conducted within the net plot areas of 5 m by 4 m by excluding the boarder rows. For growth parameter, 5 plants per plots within the net plot along the diagonal were used for the measurements. Plant height was measured from the soil level to the terminal end of the plant using a graduated measuring device. The stem girth was measured using Vernier caliper at 5 cm above the soil surface. The leaves and scars count were conducted on each plant tagged for growth parameters measurements. At harvest, the roots were sorted as good or marketable roots and the fresh weight was measured using a digital scale. The weight of fresh root recorded per plot was converted to hectare.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) and the significant means of treatments were separated using Least Significance Difference (LSD). These were done using GenStat statistical package (Twelfth Edition).

Results

Weather variation and pre-planting soil properties

The soil physiochemical properties differs at both locations (Table 2). The soil at PSALTRY had higher sand content and lower clay content compared to FUNAAB. The textural classes were Sandy clay loam and Loamy sand at FUNAAB and PSALTRY, respectively. The pH of the soils were near neutral with higher value at FUNAAB than PSALTRY. The soil organic carbon was moderate at both locations. Soil bulk density was higher at FUNAAB (1.37 g cm^{-3}) than at PSALTRY (1.17 g cm^{-3}) and were below critical densities that can impede root growth. The values of the exchangeable bases were low at both location, which followed the sequence of abundance; Ca>Mg>K>Na. During the study period, FUNAAB had rainfall of 1997 mm while PSALTRY had 1075 mm (Figure 1). The temperature ranged from 26 °C to 37 °C and 28 °C to 38 °C at FUNAAB and PSALTRY respectively.

TABLE 2

Physico-chemical properties of soil in the study area prior to planting

Location	Sand	Silt	Clay	Textural class	pH	Bulk density
		(g kg^{-1})				(g cm^{-3})
FUNAAB	685.40	209.00	105.60	Sandy clay loam	6.59	1.37
PSALTRY	840.30	119.0	40.70	Loamy sand	6.56	1.17

Location	OC	Total N	Avail. P	K	Ca	Mg	Na
	(%)		(mg kg^{-1})			(cmol kg^{-1})	
FUNAAB	1.79	0.07	0.62	0.78	3.78	1.24	0.17
PSALTRY	1.32	0.06	0.76	0.41	1.25	0.64	0.13

OC: organic carbon

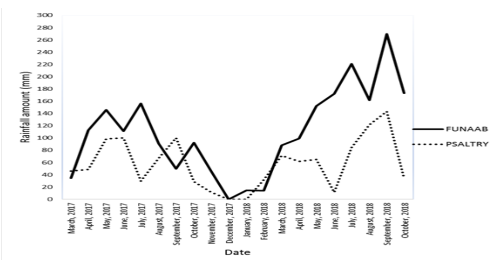

Fig. 1: Rainfall amount during the experimental period.

Effect of Location, planting date and fertilizer on soil chemical properties

At FUNAAB, the soil chemical properties were significantly higher (P<0.05) than that of PSALTRY, except for OC which was not statistically different (Table 3). Total nitrogen and OC were significantly affected by planting date, which were 28.6% and 37.6% higher for late planting than early planting, respectively. The mean total nitrogen and CEC were significantly higher for fertilized plots compared to unfertilized plots.

TABLE 3

Effects of location, planting date and fertilizer application on soil properties

Variable	Total N (%)	K (cmol kg^{-1})	OC (%)	CEC (cmol kg^{-1})
Location				
FUNAAB	0.10	0.94	1.24	6.80
PSALTRY	0.06	0.16	1.17	2.75
LSD (p<0.05)	0.01	0.12	NS	0.16
Planting date				
Early	0.07	0.48	1.01	4.64
Late	0.09	0.62	1.39	4.92
LSD (p<0.05)	0.01	NS	0.21	NS
Fertilizer application				
Nill	0.06	0.54	1.10	4.32
Fertilized	0.09	0.56	1.30	5.23
LSD (p<0.05)	0.01	NS	NS	0.16
Interactions				
LOC × PLM	0.02	0.17	0.30	NS
LOC × FERT	NS	NS	0.30	0.64
PLM × FERT	NS	NS	NS	NS
LOC × PLM × FERT	NS	NS	NS	NS

OC: organic carbon; CEC: cation exchange capacity

Interactive effects of location and planting date on soil properties

The interaction of location and planting date significantly affected the nitrogen, potassium, and organic carbon (Table 4). Total nitrogen at late plating was significantly higher than early planting at FUNAAB but similar at PSALTRY. Moreover, there was 50.0% and 20.0% increase in total N at late planting than at early planting at FUNAAB and PSALTRY, respectively. The nitrogen content was significantly ($p < 0.05$) higher at FUNAAB than that of PSALTRY irrespective of the planting date. For late planting, N concentration at FUNAAB doubled that of PSALTRY and was 51.9% higher at FUNAAB for early planting. It was observed that K was significantly higher at FUNAAB than at PSALRTY, irrespective of the planting date. The K content was higher for late than early planting, which was 44.2% higher at FUNAAB and 28.6% at PSALTRY. At FUNAAB, OC at early planting was similar to that of late planting. However, significantly higher ($p < 0.05$) OC for late planting than early planting was observed at PSALTRY.

TABLE 4

Interactive effects of location and planting date on soil properties

Location	Planting date	Total N (%)	K (cmol kg^{-1})	OC (%)
FUNAAB	Early	0.08	0.77	1.24
	Late	0.12	1.11	1.23
PSALTRY	Early	0.05	0.14	0.78
	Late	0.06	0.18	1.55
LSD (p<0.05)		0.02	0.17	0.30

OC: organic carbon

Interactive effects of location and fertilizer application on soil properties

Organic carbon and CEC were significantly affected by the interaction of location and fertilizer application (Table 5). The fertilized plots had significantly higher ($p < 0.05$) organic carbon (OC), with increases of 0.22 times at FUNAAB and 0.78 times at PSALRTY compared to the unfertilized plots. There was 36.3% and 10.3% increase in CEC for fertilized plots over no fertilizer application, at FUNAAB and PSALTRY, respectively (Table 5).

TABLE 5

Interactive effects of location and fertilizer application on soil properties

Location	Fertilizer application	OC (%)	CEC (cmol kg^{-1})
FUNAAB	Nill	1.13	5.76
	Fertilized	1.34	7.85
PSALTRY	Nill	0.86	2.62
	Fertilized	1.65	2.89
LSD (p<0.05)		0.30	0.32

OC: organic carbon; CEC: cation exchange capacity

Effect of Location, planting date and fertilizer on cassava parameters

The cassava growth and yield parameters were significantly affected by location except for plant height and stem girth (Table 6). The number of leaves was 27.8% higher at FUNAAB than at PSALTRY. Whereas number of scars and root yield where 18.3% and 15.3% higher at PSALTRY than at FUNAAB, respectively. For planting date, late planting resulted into higher cassava growth and root yield, although not statistically different. The number of leaves and scars were not affected by the application of fertilizer. However, the plant height, stem girth and root yield were significantly affected by fertilizer application with higher values in the fertilized plots than the unfertilized plots. Additional 4.7 t ha^{-1} of root yield was obtained for the application of fertilizer compared to nill fertilization.

TABLE 6

Effect of location, planting date and fertilizer application on crop parameters

Variables	Leaves count	Scars count	Plant height (cm)	Stem girth (cm)	Root yield (t ha^{-1})
Location					
FUNAAB	27.54	84.50	203.58	18.09	12.68
PSALTRY	21.43	100.00	183.40	18.44	14.62
LSD (p<0.05)	3.02	13.17	NS	NS	1.45
Planting date					
Early	15.38	97.04	192.01	17.7	13.38
Late	33.71	87.46	194.97	18.82	13.92
LSD (p<0.05)	3.02	NS	NS	NS	NS
Fertilizer application					
Nill	23.21	89.04	177.75	15.80	11.30
Fertilized	25.88	95.46	209.23	20.72	16.00
LSD (p<0.05)	NS	NS	22.68	1.67	1.45
Interaction					
LOC × PLM	3.80	16.38	32.07	NS	2.22
LOC × FERT	NS	NS	NS	NS	NS
PLM × FERT	NS	NS	NS	NS	2.22
LOC × PLM × FERT	NS	NS	NS	NS	NS

Interactive effects of location and planting date on crop parameters

The interaction of location and planting date significantly ($p < 0.05$) affected the number of leaves, number of scars, plant height and root yield (Table 6). At both location, the number of leaves was significantly higher for the late planting than the early planting, whereas the number of scars were higher for early planting date (Table 7). At FUNAAB, the plant height was significantly higher for late planting whereas it was higher for early planting for PSALTRY. The root yield for late planting at FUNAAB was similar to that of early planting at PSALTRY, which was significantly higher than that of other treatment combinations. The root yield difference between the two plant dates was 4.03 t ha^{-1} and 3.00 t ha^{-1} at FUNAAB and PSALTRY, respectively.

TABLE 7

Interactive effects of location and planting date on crop parameters

Location	Planting date	Leaf count	Scars count	Plant height (cm)	Root yield (t ha^{-1})
FUNAAB	Early	16.42	78.08	67.60	10.70
	Late	38.67	90.92	239.50	14.73
PSALTRY	Early	14.33	116.00	216.40	16.13
	Late	28.75	84.00	150.40	13.13
LSD (p<0.05)		3.80	16.38	32.07	2.22

Interactive effects of location and fertilizer application on root yield

Cassava root yield was significantly affected by the interaction of planting date and fertilizer application (Table 6). Fertilizer application significantly increased cassava root yield irrespective of the planting date. Fertilizer application increase cassava yield by 62.3% (6.35 t ha^{-1}) at FUNAAB and increased by 24.72% (3.06 t ha^{-1}) at PSALTRY, (Table 8). Comparing the planting dates, the root yield obtained for fertilized plot at early plating was similar to that late planting, likewise for the nill fertilizer application.

TABLE 8

Interactive effects of location and fertilizer application on root yield

Planting date	Fertilizer	Root yield (t ha^{-1})
Early	Nill	10.20
	Fertilized	16.55
Late	Nill	12.39
	Fertilized	15.45
LSD (p < 0.05)		2.22

Discussion

The research findings indicate significant differences in soil chemical properties, particularly in terms of organic carbon, total nitrogen, and cation exchange capacity (CEC) between the locations with higher concentrations at FUNAAB compared to PSALTRY. The difference in the available nutrients between the locations can be attributed to the inherent variation in soil properties, especially the soil texture. Soil texture, as defined by Buckman & Brady (1960) is the relative proportion of the clay, silt, and sand fractions in a specific soil sample that has a particle size lower than 2 mm. The soil at FUNAAB has a higher particle proportion of silt and clay compared to PSALTRY, which is predominantly sandy. The larger surface area of fine soil particles, especially clay, allows for higher adsorption of cations to their exchangeable cites, which may contribute to the higher CEC observed at FUNAAB compared to PSALTRY. Clay content have also been reported to allow for the aggregation of mineral constituents with organic materials, which are both responsible for the availability of nutrient for plant use (Kome *et al*., 2019; Schweizer *et al*., 2021). Our result aligns with the findings of Anaba *et al*. (2020) and Sorensen & Jensen (1995), who attributed variation in soil nutrient retention and availability to textural differences.

The soil chemical properties (total nitrogen, potassium, and organic carbon) were significantly higher for late planting date compared to early planting. On one hand, the higher nutrient could be attributed to the delayed fertilizer application necessitated by the onset of drought during late planting. Also, the antecedent environmental conditions prior to harvest date, which influences soil biochemical reactions could affect soil nutrient dynamics. Cassava planted at early date was harvested during the dry season, while the late-planted cassava was harvested during the rainy season. Therefore, the wet season likely fostered more microbial activity, supporting the decomposition and mineralization of soil nutrients. This finding aligns with studies of Chen *et al*. (2018) and Sonko *et al*. (2016), who reported that soil nutrient dynamics are controlled by weather variation and microbial actions.

Studies on soil fertility have shown that the cultivation of cassava leads to the extraction of nutrients (Fernandes *et al*., 2017). Irrespective of the fertilizer treatment, our study shows that potassium was not statistically different, however, the CEC was significantly affected by fertilizer application. The similar effect of fertilizer application on K from our study could be attributed to the high demand for potassium for cassava root bulking and proliferation, which is in accordance with the findings of Makinde & Agboola (2002). The consistent increase in CEC and organic carbon for fertilized plots compared to unfertilized plot at both locations shows the potential of fertilizer application to improve soil fertility status under cassava production. However, our result differs from the findings of Biratu *et al*. (2019), who observed lower organic carbon and CEC for plots fertilized with inorganic fertilizer compared to unfertilized plots. The quick mineralization of inorganic fertilizer can enhance early vegetative growth of crops. Whereas, the leaf droppings during the developmental phase can serve as a source of organic matter, thereby returning nutrients to the soil. Also, soil chemical properties responded at different levels to the effect of fertilizer application, with higher organic carbon at PSALTRY while the CEC was higher at FUNAAB. This result corroborates the findings of Tovihoudji *et al*. (2023), which emphasized the importance of considering location-specific factors when implementing soil fertility management practices.

Although higher cassava growth parameters were obtained at FUNAAB, probably due to the inherent higher chemical fertility, physical fertility also plays a vital role in cassava root development. The higher root yield obtained at PSALTRY can be attributed to the higher proportion of the sand particles in the study location. Anikwe & Ikenganyia, (2018) and Onasanya *et al*. (2021) reported that relatively loose soil texture with higher proportion of macropores are better for cassava cultivation due to the provision of favorable environmental condition (better aeration) and ensure easy penetration and expansion of bulking roots.

A higher number of leaves was obtained at late planting, irrespective of the location. The presence of moisture from rainfall prior to harvest can be attributed to the vigorous vegetative growth. During the dry season (at harvest of early plantings), plants tend to shed older leaves, form smaller new leaves, and close stomata to reduce transpiration as an adaptive mechanism to the low water availability (Alves & Setter, 2004; El-Sharkawy, 2007; Sanusi *et al*., 2023). These attributes might have contributed to the higher number of scars and lower leaves obtained in our results for early planting compared to late plating. More so, the response of cassava root yield to the planting date differed between the study locations. This can be attributed to the varying management practices and external disruption during the growth stage. Apart from the higher infestation of weed observed at PSALTRY experimental field for late planted cassava, which resulted in more occurrences of weed control measures, there was evident disturbance from the cattle herders during grazing events. Earlier studies have revealed that weed infestation can significantly contribute to cassava yield loss, ranging from 25-100% reduction in root yield, depending on the severity of weed infestation, occurrence of weed control, and type of weed (Chikoye *et al*., 2004; Ekeleme *et al*., 2021; Kintché *et al*., 2017). Therefore, good agronomic and management practices are paramount to achieving maximum root yield, which can differ depending on the site specification.

The cassava growth and yield parameters responded positively to fertilizer application, with higher mean root yield for fertilized plots than plots without fertilizer. This indicates that the positive impact of fertilizer application is consistent across different planting times. Farmers seldom apply fertilizer to cassava due to the perception that substantial amounts of yield are produced, even in degraded soil (Chua *et al*., 2020). In support of our result, Enesi *et al*. (2022) reported high response of root yield to fertilizer application. Adiele *et al*. (2020) suggested appropriate nutrient management for cassava production as a strategy to bridge the root yield gap of cassava, most especially in Africa. Therefore, it is essential to tailor cultivation practices to local conditions and utilize proper nutrient management to optimize cassava growth and yield.

Conclusion

This study shows that available nutrients differ by soil type, with higher nutrients in sites with more of clay particles. There was a high nutrient concentration at the harvest time of late planted cassava compared to early planted, irrespective of the study site. Fertilizer application resulted in higher available nutrients in the soil compared to nill fertilizer application. The cassava growth parameters vary across the locations, however, the root yield was higher at PSALTRY compared with FUNAAB. Farmers should consider specific location planting dates and management practices, as the growth and yield parameters were not consistent for each planting date at both locations. Irrespective of the planting date, fertilizer application improved cassava growth and yield parameters.

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