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Research Article

Comparative Performance of Old and Newly Released Cassava Varieties in An Organic and Inorganic Amended Soils Over Two Farming Seasons

Chukwunalu OSSAI*[1], Smart OJOBOR[2], Thankgod OGWUCHE[3], Stephanie AKPEJI[4], Hilary ODEH[5] Elohor DIEBIRU-OJO[6]

[1,2]Department of Agronomy, Delta State University, Abraka, Delta State, Nigeria
[3,6]GoSeed Unit of the International Institute of Tropical Agriculture, IITA, Ibadan, Nigeria
[4]Department of Biological Sciences, Novena University, Ogume, Delta State, Nigeria
[5]Department of Crop Science, Delta State University of Science and Technology, Ozoro, Delta State, Nigeria

[1]https://orcid.org/0000-0002-1924-5855, [2]https://orcid.org/0000-0002-6835-6797, [3]https://orcid.org/0009-0004-9086-7579
[4]https://orcid.org/0000-0003-2191-8032, [5]https://orcid.org/0000-0002-0140-9700, [6]https://orcid.org/0000-0002-7399-3870

*Corresponding author email: ossaichukwunalu1@gmail.com

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Abstract: The multi uses of cassava plant (*Manihot esculenta* Crantz) has increased its demand and value. However, the production rate is far below the potential as a result of use of unimproved varieties and lack of soil amendment to enhance productivity. This study thus compared the performances of some old and newly released cassava varieties in both organic, inorganic and unamended soil at Ogbagu Ogume. Stems of newly released (Obasanjo2, Baba70, and Game changer) and old (TME419 and Give-Me-Chance-GMC) were planted in farmlands amended with 400 kg/ha NPK 15:15:15, 4.2 t/ha poultry manure and 5-year old fallowed land (control) for 2023 and repeated in 2024 planting seasons. The experimental design was a 5(varieties) x 3(nutrient source) x 2(seasons) factorial arranged in a randomized complete block design and replicated three times. The soil and leaf macro and microelements were also determined using standard procedures. Data were taken on the fresh tuber weight (FTW) at harvest. Data collected were analysed using ANOVA and means were separated using least significant differences at 5% significance level. The macro and micro elements of the soil decreased from the pre to post status while the leaf nutrient content were insignificant across the genotypes. The FTW differed significantly across the varieties, nutrient source and year and ranged from 21.33±0.59 (TME419) to 34.33±0.59 (Obasanjo2), 26.95±0.46 (Fallowed soil) to 29.22±0.46 (NPK 15:15:15), and from 25.95±0.37 (year two) to 29.96±0.37 (year one), respectively. Planting improved varieties in a NPK 15:15:15 amended soil at 400 kg/ha enhances cassava output, thus recommended.

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1. Introduction

Cassava (*Manihot esculenta* Crantz) is a valuable food crop belonging to the Euphorbiaceae family with several species, and generally propagated by stem (Dimkpa et al., 2021). In Nigeria, cassava can be processed into different products such as garri, tapioca, bread, starch etc, while the root peels can be used in making animal feeds (Nweke, 2005). Cassava is one of the major source of carbohydrate for about 500 million people in the tropics and substropical countries of the world (Immanuel et al., 2024). Nigeria is currently the largest producer of cassava worldwide with Thailand ranking as the largest exporter of cassava (Aluko et al., 2019). This shows that majority of the cassava output in Nigeria is consumed locally, and presents an opportunity for farmers in terms of income generation through local sale and as an export commodity. However, the current yield of cassava in Nigeria is far below the potential yield (Ogisi et al., 2013).

The above constraint is caused by the low productivity of the local cassava landraces that the local subsistence farmers have been using due to their lack of willingness to adopt new improved varieties and lack of adequate dissemination of improved and newly release cassava varieties to the end users (Udensi et al., 2011; Wossen et al., 2017; Mwebaze et al., 2024). Another factor that hinders the optimum production of cassava in Nigeria is the cultivation of cassava in soils without adequate amount of nutrient necessary for the growth and yield of cassava (Kintche et al., 2017; Munyahali et al., 2024) as the belief of many farmers that cassava thrives well in a marginal soil prevents the farmers from supplying the appropriate amount of nutrient required to enhance cassava productivity (Pypers et al., 2011) which is the major causes of yield gap even with the improved cassava varieties (Ezui et al., 2016). Although cassava can give considerable amount of yield in a marginal soil, the plant also contribute in depleting and degrading the soil nutrient content and texture further, hence the need to constatntly monitor the soil nutrient content for appropriate enhancement with either organic or inorganic nutrients (Ngome et al., 2013).

Studies have shown that poor nutrient status of the soil is the most important constraint facing cassava production (Kintche et al., 2017). In bid of addressing this challenge, different fertilizer and manure application rates have been advocated as some farmers adopt the organic method of nutrient replenishment and others adopt the application of synthetic fertilizers like NPK, since the nitrogen, phosphorus and potassium has been implicated as major elements required by cassava for growth and bulking (Pypers et al., 2011; Vanlauwe et al., 2015; Munyahali et al., 2024). Through the organic method, farmers rely on the application of manures like the poultry manure, cow dungs, composts (Dayan, 2024) etc or the adoption of natural nutrient replenishing method through the farming system like the shifting cultivation or bush fallowing, while fertilizers like NPK 15:15:15 and NPK 20:10:10 has also been widely used in enhancing cassava production (Munyahali et al., 2024). The use of inorganic fertilizers has reportedly increased cassava output by releasing the adequate amount of required mineral elements to the soil in time (Budiono et al., 2021), however, the imbalance application rate can further lead to nutrient loss and soil degradation (Adinurani et al., 2021) while the excessive application can lead to the pollution of the environment (Muhammad et al., 2021). To circumvent the issue of soil pollution and degradation arising from the use of synthetic fertilizers, researchers have advocated the use of organic manures either solely or in combination with small amount of synthetic fertilizers (Badewa et al., 2020). This helps to reduce the environmental impact of excesive use of synthetic fertilizers, provide adequate amount of nutrients to plants in time and aid the microbial activities in the soil, thereby improving the soil structures (Howeler et al., 2013)

To validate the assertion that the cassava potential yield will mostly be attained by the use of synthetic fertilizer, this study thus evaluates the productivity of three newly released and two locally preferred cassava varieties under the application of NPK fertilizer, poultry manure and a 5 year fallowed soil. This study thus hypothesized that if cultivating farms for the cassava varieties are ammended with either synthetic fertilizer or an organic manure, the yield of the cassava varieties will be improved relative to the 5 year fallowed farmlands.

2. Material and Methods

2.1. Experimental location

This study was carried out at Ogbagu Ogume located at Latitude 5.74737009 and Longitude 6.35451690 in 2023 planting season and repeated in 2024 early planting season. In 2023, the annual rainfall of Ogbagu Ogume Community was 249.47 mm and the annual temperature was 26.75 ºC, while in 2024, the annual rainfall of the Community was 108.4 mm and the annual temperature was 27.33 ºC (WWO, 2025).

2.1.1. Source of planting materials

Stems of Obasanjo2, Baba 70, and Game changer were supplied by the cassava unit of IITA during the 2022 demand creation trial exercise, while TME419 and Give Me Chance (GMC) were regarded as locally best cassava varieties by the farming community.

2.1.2. Land preparation, planting and field management

The vegetation in the plots were cleared, trees were fallen, and burnt, while unburnt debris were further carefully packed and re-burnt. The allotted plots measuring 20 m^2 were shallowly dug and cassava stems measuring 20 cm each were planted on the plots at a spacing of 1 m by 1 m. Two months after planting, NPK 15:15:15 fertilizer was applied to allocated plots at the rate of 400 kg/ha, poultry manure was also applied at the of 4.2 t/ha in the allotted plots, while some plots were left un-amended as the land is being cultivated after 5 years of fallow period (control plots). The plots were replanted using the residual nutrients of the 2023 amendment. The farms were weeded bi-monthly to keep the farms weed-free till harvest.

2.1.3. Soil and leaf analysis

Prior to planting, soil samples were collected from each plots using the composite sampling method (soils collected at a depth of 14 cm depth using an auger from 2 meters distance marked parts of the plot, giving a total of 10 samples per plot, and then mixed together as one). The soils were analysed (pre) before the first planting, and samples were collected after harvesting, serving as the post soil analysis for the 2023 planting season and pre soil status for the 2024 planting season. Also, at harvest for the two planting seasons, leaf samples were collected from the plant tips and sent along with the soil samples to the analytical laboratory of the Department of Soil Resources Management, Faculty of Agriculture and Forestry, University of Ibadan for the determination of the soil physico-chemical parameters (pH, organic carbon, exchangeable acidity, sand, silt, clay), macro and micro elements (nitrogen, phosphorus, potassium, calcium, magnessium, sodium, manganese, iron, copper, and zinc).

The soil pH was determined using the potentiometric method, organic carbon was measured using Walkley-Black method (Walkley and Black, 1945), exchangeable acidity was determined using the titration method (Wen and Ke, 2022), sand was determined using sieve method, and silt and clay were determined using the hydrometric method. The macro and micro elements were extracted using the Mehlich-3 extraction method (Mehlich, 1984)

2.1.4. Experimental design

The experiment was a 5 (varieties) x 3 (nutrient sources) x 2 (farming seasons) factorial arranged in a randomized complete block design, and replicated three times (Table 1).

Table 1. Experimental layout

Farming season	Nutrients	Varieties				
		V1	V2	V3	V4	V5
	N1	V2	V3	V4	V5	V1
		V3	V4	V5	V1	V2
		V4	V5	V1	V2	V3
1	N2	V5	V1	V2	V3	V4
		V1	V2	V3	V4	V5
		V2	V3	V4	V5	V1
	N3	V3	V4	V5	V1	V2
		V4	V5	V1	V2	V3
		V5	V1	V2	V3	V4
	N1	V1	V2	V3	V4	V5
		V2	V3	V4	V5	V1
		V3	V4	V5	V1	V2
2	N2	V4	V5	V1	V2	V3
		V5	V1	V2	V3	V4
		V1	V2	V3	V4	V5
	N3	V2	V3	V4	V5	V1
		V3	V4	V5	V1	V2

N1: NPK 15:15:15, N2: Poultry manure, N3: Fallowed soil, V1: Give Me Chance, V2: Game Changer, V3: Obasanjo2, V4: Baba 70, and V5: TME 419.

2.1.5. Data collection and statistical analysis

At harvest, the fresh tuber yield measured in kg per plot and then converted to yield per hectare following the formular below;

1 ha = 10000 m^2,

20 m^2 = 20/10000 m^2 = 0.002 ha,

Hence, yield per 20 m^2 x 500 = 1 ha equivalence.

The collected data were analysed using Analysis of Variance (ANOVA), and treatment means were separated using the least significant differences at 5% level of significance. Also, a correlation analysis was carried out between the leaf micro and macro elements against the yield parameters.

3. Results

3.1. Soil physicochemical properties

Results obtained on the soil physicochemical properties showed that the soil pH of the pre soil samples (6.32±0.11) was significantly higher than the post soil status (5.77±0.11) (Table 2). There were no significant differences between the pre and post soil status on the organic carbon, exchangeable acidity, sand, silt and clay properties. On the source of nutrient, there were no significant differences across the nutrient sources with respect to the soil pH, organic carbon, sand, silt, and clay, however, the exchangeable acidity obtained in the poultry manure system (2.84±0.76) was significantly higher than the rest treatments (nutrient sources). Also, the interaction between soil status and nutrient sources was not significant across the physicochemical properties.

Table 3 showed that there were significant differences between the pre soil status for N (0.30±0.06)%, P (5.60±1.04) mg kg^{-1}, K (0.40±0.03) cmol kg^{-1}, Ca (1.91±0.19) cmol kg^{-1}, Mg (1.08±0.11) cmol kg^{-1}, Na (0.25±0.01) cmol kg^{-1}, Cu (1.35±0.09) mg $kg^{-1}$and Zinc (1.95±0.06) mg kg^{-1} were significantly higher than the post soil status N (0.13±0.06) %, P (2.17±1.04) mg kg^{-1}, K (0.24±0.03) cmol $kg^{-1,}$, Ca (0.76±0.19) cmol kg^{-1}, Mg (0.35±0.11) cmol kg^{-1}, Na (0.14±0.01) cmol kg^{-1}, Cu (0.70±0.09) mg $kg^{-1}$and Zinc (1.51±0.06) mg kg^{-1}, respectively. However, with respect to the nutrient sources, there were no significant differences across the elements checked except the K and Cu. The K content of the NPK source (0.40±0.04) cmol kg^{-1} was significantly higher than the rest two nutrient sources, while the Cu content of the poultry manure source (1.21±0.11) mg kg^{-1} was statistically similar to the NPK nutrient source, but it was significantly higher than the fallowed nutrient source (0.88±0.11) mg kg^{-1}. The interaction between soil status and the nutrient sources was only significant for the K and Na contents.

Table 2. Soil physicochemical properties of the cassava farms cultivated in the 2023 and 2024 farming seasons

Soil status	pH	OC (%)	EA	Sand (%)	Silt (%)	Clay (%)
Pre	6.32a	2.11	2.06	79.74	10.71	9.55
Post	5.77b	1.21	0.51	79.06	10.38	10.23
LSD(0.05)	0.33	1.07	1.84	3.1	2.2	2.09
SE	0.11	0.36	0.62	1.04	0.74	0.7
Nutrient source	pH	OC	EA	Sand	Silt	Clay
Poultry	6.11	1.67	2.84a	79.95	11.65	7.90b
NPK	6.05	1.48	0.51b	78.16	9.96	11.88a
Fallow	5.97	1.83	0.50b	80.08	10.01	9.90ab
LSD(0.05)	0.4	1.32	2.26	3.8	2.69	2.56
SE	0.13	0.44	0.76	1.28	0.91	0.86
SSxNS	0.28ns	0.65ns	14.18ns	4.89ns	2.13ns	12.50ns

pH: acidity, OC: Organic carbon, EA: Exchangeable acidity, LSD: Least significant differences, SE: Standard error, SSxNS: Interaction between soil status and nutrient source. ns: Not significant.

Table 3. Macro and micro elements of the cassava farms cultivated in the 2023 and 2024 farming seasons

Soil status	N (%)	P (mg kg^{-1})	K (cmol kg-^{1})	Ca (cmol kg-^{1})	Mg (cmol kg-^{1})	Na (cmol kg-^{1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
Pre	0.30a	5.60a	0.40a	1.91a	1.08a	0.25a	71.25	119.92	1.35a	1.95a
Post	0.13b	2.17b	0.24b	0.76b	0.35b	0.14b	63.83	114.42	0.70b	1.51b
LSD(0.05)	0.17	3.09	0.09	0.58	0.32	0.04	7.94	10.01	0.26	0.19
SE	0.06	1.04	0.03	0.19	0.11	0.01	2.67	3.37	0.09	0.06
Nutrient source	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn
Poultry	0.22	3.67	0.27b	1.56	0.87	0.20	70.75	118.38	1.21a	1.76
NPK	0.19	5.48	0.40a	1.39	0.71	0.18	68.00	116.38	0.98ab	1.77
Fallow	0.24	2.47	0.29b	1.05	0.56	0.20	63.88	116.75	0.88b	1.65
LSD(0.05)	0.2	3.78	0.11	0.71	0.39	0.05	9.73	12.26	0.32	0.23
SE	0.07	1.27	0.04	0.24	0.13	0.02	3.27	4.13	0.11	0.08
SSxNS	0.01ns	16.25ns	0.10*	1.49ns	0.40ns	0.01*	48.29ns	212.38ns	0.20ns	0.13ns

SSxNS: Interaction between soil status and nutrient source LSD: Least significant differences, SE: Standard error, N: Nitrogen (%), P: Phosphorus (mg/kg), K: Potassium (cmol.kg-^{1}), Ca: Calcium (cmol.kg-^{1}), Mg: Magnesium (cmol.kg-^{1}), Na: Sodium (cmol.kg-^{1}), Mn: Manganese (mg/kg), Fe: Iron (mg/kg), Cu: Copper (mg/kg), Zn: Zinc (mg/kg). ns: Not significant.

3.2. Plant yield, micro and macro element status

Table 4 shows that there were no significant differences among the cassava varieties with respect to the micro elements assessed, however, the yield parameters varied significantly across the varieties. The fresh weight obtained in Obasanjo2 (34.33±0.59) t ha^{-1} was significantly higher than the rest varieties. The number of stem obtained in the GMC variety (3.74±0.13) was significantly higher than the rest varieties. Also, the height of the stem obtained in the GMC variety (2.23±0.04) cm was significantly higher than the rest varieties except TME419 (2.14±0.04) cm. On the years of cultivation, there were no significant differences between year one and year two on the Mn, Fe, and Cu content, but the Zn content of the first year (35.23±0.39) mg kg^{-1} was significantly higher than the second year (25.59±0.39) mg kg^{-1}. Also, the fresh weight obtained from the first year harvest (29.96±0.37) t ha^{-1} was significantly higher than the second year harvest (25.59±0.37) t ha^{-1}, while there were no significant differences between the years in the number of stems produced and the stem height.

There were no significant differences amongst the different sources of nutrient to the cassava plants with respect to the Mn, Fe, Cu, Zn, number of stems and the stem height (Table 5). However, the fresh tuber weight obtained in the NPK fortified cassava plots (29.22±0.46) t ha^{-1} was significantly higher than the poultry manure (27.15±0.46) t ha^{-1} and fallowed farm (26.95±0.46) t ha^{-1}, respectively. The interaction between the varieties and the year of cultivation was significant for the fresh tuber weight and stem height, while the interaction between the varieties cultivated and nutrient source was only significant for the stem height.

There were no significant differences amongst the varieties cultivated with respect to all the macro elements (N, P, K, Ca, Mg, and Na) investigated in the cassava leaf samples (Figure 1). There were no statistical differences between the two years of cultivation (year one and year two) with respect to the macro elements investigated in the cassava leaf samples except the magnesium content obtained in the interaction between the year of cultivation and the nutrient source (Figure 2), while the interaction between the year of cultivation and and the nutrient sources was significant for the magnesium content (Table 6). Also, there were no significant differences existing amongst the nutrient sources (poultry, NPK, and fallowed nutrient source) with respect to the macro elements investigated in the leaf samples (Figure 3). However, the interaction between the year of cultivation and the nutrient sources was significant for the Mg (0.002) cmol kg^{-1} content.

Table 4. Leaf micro-elements of cassava varieties cultivated under different nutrient sources in Ogbagu Ogume farming community farming seasons

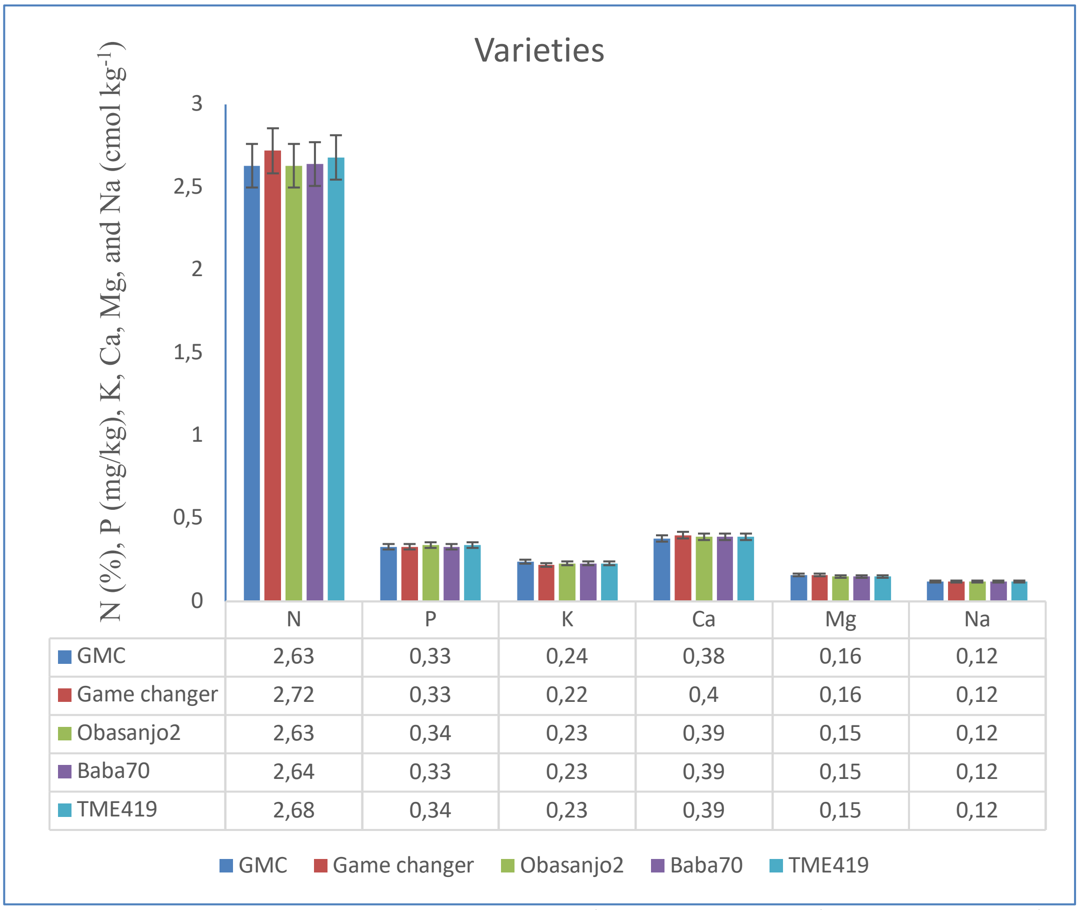
Varieties	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	FW (t/ha)	NOS	SH (cm)
GMC	153.49	140.23	5.27	34.32	28.20b	3.74a	2.23a
Game changer	160.73	138.45	5.10	34.46	27.88b	2.73d	1.99b
Obasanjo2	152.41	138.43	5.23	34.38	34.33a	3.20b	1.58c
Baba70	154.61	140.48	5.25	34.33	27.12b	2.80cd	2.03b
TME419	158.24	138.87	5.10	34.49	21.33c	3.17bc	2.14a
LSD(0.05)	41.07	5.83	0.47	1.77	1.65	0.38	0.1
SE	14.67	2.08	0.17	0.63	0.59	0.13	0.04
Year							
One	157.92	139.76	5.25	35.23a	29.96a	3.12	1.20
Two	153.87	138.82	5.17	33.56b	25.59b	3.15	1.99
LSD(0.05)	25.98	3.69	0.29	1.12	1.04	0.24	0.06
SE	9.28	1.32	0.11	0.39	0.37	0.09	0.02

GMC: Give me chance, FW: Fresh weight, NOS: Number of stems, SH: Stem height, LSD: Least significance differences, SE: Standard error, Mn: Manganese (mg kg^{-1}), Fe: Iron (mg kg^{-1}), Cu: Copper (mg kg^{-1}), Zn: Zinc (mg kg^{-1}).

Table 5. Leaf microelements and yield of cassava varieties cultivated in Ogbagu Ogume farming community over two farming seasons

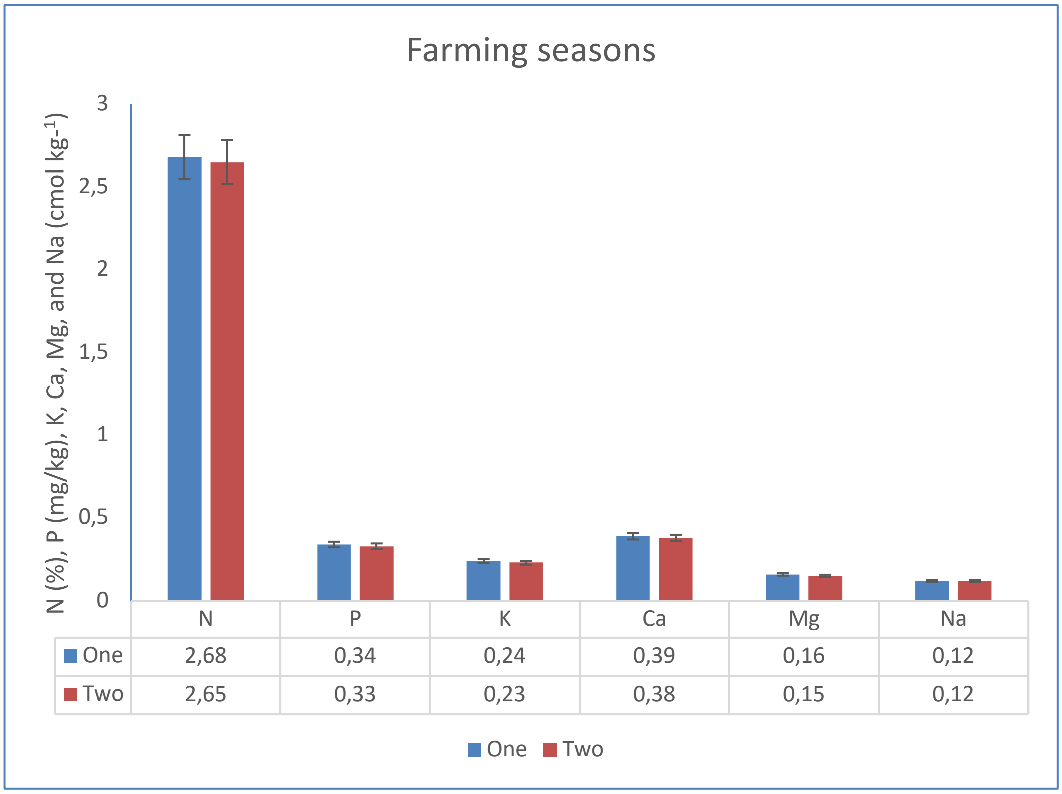
Nutrient source	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	FW (t/ha)	NOS	SH (cm)
Poultry	159.58	140.44	5.22	34.29	27.15b	3.24	1.96
NPK	152.43	138.64	5.15	33.92	29.22a	3.04	2.01
Fallow	155.68	138.81	5.25	34.98	26.95b	3.24	2.01
LSD(0.05)	31.81	4.51	0.36	1.37	1.27	0.29	0.08
SE	11.36	1.61	0.13	0.46	0.46	0.1	0.03
VxY	NS	NS	NS	NS	125.37*	NS	0.22*
VxNS	NS	NS	NS	NS	NS	NS	0.14*
YxNS	NS	NS	NS	NS	NS	NS	NS
VxYxNS	NS	NS	NS	NS	NS	NS	NS

FW: Fresh weight, NOS: Number of stems, SH: Stem height, LSD: Least significance differences, SE: Standard error, VxY: Variety by Year interaction, VxNS: Variety by nutrient source interaction, YxNS: Year by Nutrient source interaction, VxYxNS: Variety by year by nutrient source interaction. Mn: Manganese (mg/kg), Fe: Iron (mg/kg), Cu: Copper (mg/kg), Zn: Zinc (mg/kg). NPK: Nittrogen:Phosphorus:Potassium. Ns: Not significant. *: Significant at 5% level of significance.



Keys: GMC: Give me chance, N: Nitrogen (%), P: Phosphorus (mg kg^{-1}), K: Potassium (cmol kg^{-1}), Ca: Calcium (cmol kg^{-1}), Mg: Magnesium (cmol kg^{-1}), Na: Sodium (cmol kg^{-1})

Figure 1. Leaf macro-elements of cassava varieties cultivated in Ogbagu Ogume farming community over two farming seasons.



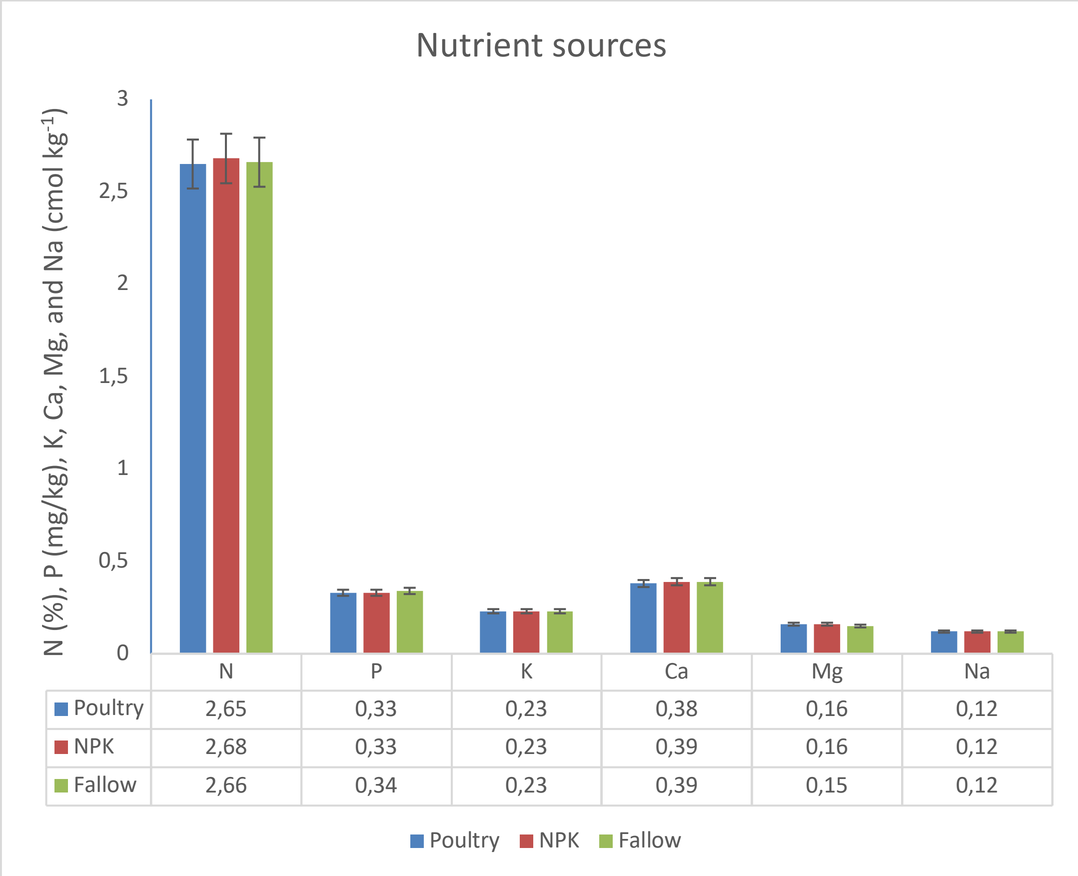
Keys: N: Nitrogen (%), P: Phosphorus (mg kg^{-1}), K: Potassium (cmol kg^{-1}), Ca: Calcium (cmol kg^{-1}), Mg: Magnesium (cmol kg^{-1}), Na: Sodium (cmol kg^{-1}), One: First farming season, Two: Second farming season.

Figure 2. Leaf macro-elements of cassava varieties cultivated under different nutrient sources in Ogbagu Ogume farming community for 2023 and 2024 farming seasons.

Table 6. Interactions between varieties, nutrient sources and year of cultivation on the leaf macro-elements of cassava varieties cultivated in Ogbagu Ogume farming community

Year	**N (%)**	**P (mg kg^{-1})**	**K (cmol kg^{-1})**	**Ca (cmol kg^{-1})**	**Mg (cmol kg^{-1})**	**Na (cmol kg^{-1})**
VxY	NS	NS	NS	NS	NS	NS
VxNS	NS	NS	NS	NS	NS	NS
YxNS	NS	NS	NS	NS	0.002*	NS
VxYxNS	NS	NS	NS	NS	NS	NS

VxY: Variety by Year interaction, VxNS: Variety by nutrient source interaction, YxNS: Year by Nutrient source interaction, VxYxNS: Variety by year by nutrient source interaction. N: Nitrogen (%), P: Phosphorus (mg kg^{-1}), K: Potassium (cmol kg^{-1}), Ca: Calcium (cmol kg^{-1}), Mg: Magnesium (cmol kg^{-1}), Na: Sodium (cmol kg^{-1}). ns: Not significant. *: Significant at 5% level of significance.



Keys: .N: Nitrogen (%), P: Phosphorus (mg kg^{-1}), K: Potassium (cmol kg^{-1}), Ca: Calcium (cmol kg^{-1}), Mg: Magnesium (cmol kg^{-1}), Na: Sodium (cmol kg^{-1})

Figure 3. Effect of nutrient sources on the leaf macro-elements of cassava varieties cultivated in Ogbagu Ogume farming community over two farming seasons.

4. Discussion

Cassava is one of the food crop placed under the deep feeders due to its tuber formation, (Howeler, 2017) hence the need for some farmers to help dig and loosen the soil before planting for the ease penetration of the bulked tubers. Loose soil texture has been reported to enhance the root penetration of cassava (Abass et al., 2014). In this study, the soil structure falls under the loamy-clay which is characterized with optimum organic matter content and exchangeable acidity that accommodated the cultivation of cassava for both the first and second production seasons. However, there was a decline in alkaline status of the soil, and it could be due to the gradual uptake of the nutrient contents of the soil by the cassava varieties in the first planting season (Sri et al., 2021). There was no significant changes in the soil physicochemical properties of the soil relative to the different nutrient sources used in the cassava cultivation, except the exchangeable acidity and clay contents of the soil. The exchangeable acidity of the poultry manure farm was higher than the rest farms, and this could be traced to the high acidic content of the poultry manure used in this study, meaning it could have been left for more time to cure before use (Manogaran et al., 2022). Also, the clay content of the soil increased in the NPK fertilizer amended soil, which could be the lack of organic matter contents in NPK as found in the poultry manure and fallowed soil which relied mostly in the organic matter debris. This finding supports the work of Loss et al. (2019) who stated that the use of animal manure for soil ammendment over time improves the soil physical and biological structures.

All the macro and micro elements investigated decreased from the pre soil status to the post soil status, and from the first year of cultivation to the second year. This is as expected as the first planting operation led to a feeding habit where the plants will take up some portion of the available nutrient in the soil. Igbozuruike (2022) had earlier reported that the cultivation of cassava in a farmland leads to the gradual reduction in the soil macro and micro elements with major reduction of K content of the soil. The K content of the NPK farm was higher than the poultry manure and fallowed farms, and this could be directly linked to the K component of NPK which was directly released to the soil. However, the Cu content of the poultry manure farm was high, and it could also be linked to the presence of Cu in the poultry manure nutrient source relative to other nutrient sources. This supports the findings of Verma et al. (2020) who reported that poultry manure contains different macro and micro elements of which Cu is one of them.

In terms of plant micro and macro elements, the rate of nutrient uptake from the soil was similar irrespective of the fertilization method in the cultivation environment. This explains why the nutrient sources had negligible influence in the yield parameters of the cassava plant except the fresh weight where the application of NPK produced the highest, and it could be related to the optimized amount of N, P, and K which cassava plants needed in large quantity and the K is highly assimilated during cassava bulking (Howeler, 2017; Munyahali et al., 2024). Temegne et al. (2019) has earlier reported an improvement in the fresh yield of TME419 due to the application of NPK fertilizer at the rate of 400 kg/ha as used in this study, although they used NPK 11-12-18 in their study. This shows that despite cassava producing considerably good yield in marginal soil as widely reported (Sri et al., 2021), there is need to improve the soil nutrient structure to attain higher yield in such environment. Although, NPK fertilizer gave higher yield in this study, Biratu et al. (2018) has suggested that the combination of synthetic fertilizer and organic manure gives a higher cassava yield. Also, Wahyuninsih and Sutrisno (2019) suggested that to attain a yield of 33 t/ha, the farmer needs to amend his/her soil with synthetic fertilizer. The use of poultry manure gave less fresh tuber yield compared to the synthetic fertilizer (NPK 15:15:15) with the fallowed farmland producing the least yield. This could be linked to the more time required by the organic manure source to mineralize and release the inherent nutrient to the soil for plants uptake as reported by Emami (2015).

The yield obtained in the first year of cultivation was higher than the second year, and this is directly linked to the reduced nutrient content of the soil in the residual production (Howeler, 2017). In relation to the varieties, the rate of nutrient uptake was similar and not significant, however, Obasanjo2 produced the heaviest yield, while GMC gave the highest number of stem and stem height. This shows that the height of cassava stem is not a direct determinant of yield, although it is important when considering the sale of cassava stem which can also generate fund to the farmer in the seed system. This is an important finding as the GMC variety also produced good tuber yield as two other newly released cassava varieties (game changer and Baba70), while the previously released cassava variety TME419 gave the least fresh weight. The better improved yield observed in the newly released varieties relative to the old released variety (TME419) speaks to the genetic gain in the cassava breeding program over time as the breeding program further improves the yield parameter of the hitherto low yielding varieties through crosses and selection (Dimkpa et al., 2021).

Despite the findings of this study in identifying the best nutrient source and rate of application to improve cassava output for rural cassava producers, it is important to note that climatic conditions is variable and constantly changing. Hence the optimum growth of the plants will depend on availablility of rainfall to facilitate the mineralization of the nutrient sources. This could be a challenge for the farmers when rainfall is low in a given year without alternate means of irrigation. Also, it is recommended that the study be carried out in areas with different climatic conditions to develop a robust nutrient schemes for the management of the newly released cassava varieties relative to the micro-climates.

Conclusion

Cassava can give appreciable yield in a marginal soil, but cultivating either old or newly improved cassava varieties in a nutrient rich soil enhances the productivity. This study has shown that the application of NPK 15:15:15 fertilizer at the rate of 400 Kg/ha allows for optimum fresh tuber production relative to the application of poultry manure and fallowed farming. However, it does not translate to higher number of stem or stem sizes which can also generate money in the seed system. The soil nutrient contents depreciates in the second season, which tells that to re-cultivate same farm land the farmer still needs to augment the soil each year due to nutrient uptake by cassava from the soil.

Ethical Statement

Ethical approval is not required for this study because the study does not involve humans or animal data sets, or endangered plant species protected by international laws.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Author Contributions

Ossai, C. O. (Conceptualization, design, implementation, data curation, writing original draft, manuscript review)
Ojobor, S. A. (Conceptualization, design, implementation, manuscript review)
Ogwuche, T. O. (Conceptualization, design, implementation, manuscript review)
Akpeji, S.C. (Conceptualization, design, implementation, data curation, manuscript review)
Odeh, O. H. (Conceptualization, design, implementation, manuscript review)
Diebiru-Ojo, E. M. (Conceptualization, design, supervision, manuscript review)

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