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RESEARCH ARTICLE

Agronomic and yield responses of selected improved sweet potato cultivars to different rates of organic fertilizer in the Niger Delta region, Nigeria

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ABSTRACT

The increased demand for sweet potato has led to increased cultivated acreage, with heterogeneous soil nutrient levels, resulting in increased use of inorganic fertilizer with residual effects in the environment. This study thus evaluated the response of selected improved sweet potato varieties to different application rates of organic fertilizer. Seven improved cultivars of sweet potato (UMOSPO 1, UMOSPO 3, UMOSPO 4, KWARA (Local cultivar 1), TIS/087, BUTTER MILK, and NWAOYIRIMA (Local cultivar 2)) were planted in plots fertilized with four rates (0, 15, 30, and 45 ml) per plant of liquid organic fertilizer in the 2020 and 2021 planting seasons. The experiment was a 7 (cultivars) by 4 (nutrient rate (NR)) factorial arranged in a randomized complete block design with three replicates. The vine length (VL), leaf area (LA), and fresh tuber weight (FTW) were collected and analyzed using ANOVA, and means were separated using least significant differences at 5% level of significance. Application of organic fertilizer significantly increased vine length, leaf area, and fresh tuber weight. The highest vegetative growth was recorded at a fertilizer rate of 45 mL. At the same time, cultivar TIS/087 produced the highest tuber yield with VL, LA, and FTW of 143.57±6.07 cm and 82.76±5.23 cm2, and 0.62±0.09, respectively, while cultivar TIS/087 produced the highest tuber yield.

Keywords: *Ipomoea batatas*; improved varieties; organic fertilizer; yield.

INTRODUCTION

Sweet potato (Ipomoea batatas L.) is a horticultural species of the family Convolvulaceae. It is the seventh-most-consumed carbohydrate-rich food source worldwide (Chueyen and Eun, 2013; Bhuyan et al., 2022). In terms of annual production, sweet potato ranks as the fifth most important food crop in the tropics and the seventh globally, after wheat, rice, maize, potato, barley, and cassava (FAO, 2016). In 2022, the annual production of sweet potato stood at 89,487,835 tonnes on a cultivated area of 7,400,472 hectares (FAOSTAT, 2022).

Despite the potential of sweet potato, the crop is constrained by pests and diseases, as well as poor soil fertility (Sofo et al., 2022). In a bid to improve soil nutrient status, many farmers have resorted to using inorganic fertilizers, which could lead to pollution of the surrounding environment (Jote, 2023), while the scarcity of organic inputs contributes to rising production costs (Rós et al., 2014). This constraint has persisted because nutritional imbalances, especially nitrogen excess, can compromise tuberous root formation in the sweet potato crop. In this perspective, it is necessary to seek alternatives that can reduce production costs, increase the yield, and improve the soil chemical attributes. In a bid to maximize the utilization of the limited soil-available nutrients, scientists have developed different varieties of sweet potato to boost its productivity (Ossai et al., 2022).

However, to fully maximize the benefits of these improved sweet potato varieties, one suggested improvement is replacing high-cost mineral fertilizers with organic fertilizers, which are environmentally friendly (Silva et al., 2016a) and have less aggressive environmental effects (Kuzucu, 2019). However, it is important to evaluate further the responses of selected improved sweet potato varieties to different organic manure rates to select higher-producing varieties in the Niger Delta region of Nigeria. Hence, the objective of this study was to evaluate the response of selected improved sweet potato varieties to different rates of organic fertilizer application.

MATERIALS AND METHODS

Area of Study

The experiment was carried out at the Faculty of Agriculture Research Organic Farm, Southern Delta University, Ozoro under rain fed condition within 2020 and 2021 planting seasons. Ozoro is located between Latitudes 5°30N and 5°45N North and longitude 6°50E, east lying immediately North of the coastal swamp region of the West Niger Delta. The climatic condition is humid with a mean annual rainfall of between 2000-3000mm, the mean annual temperature is between 25-31 ^{0}C and a relative humidity ranging between 75-100% respectively with dry and raining season (NIMET, 2019).

Land preparation and maintenance

The field experiment was carried out in two cropping seasons in a well-cleared land, ploughed and harrowed before pegging and lining out on block basis. The field were weeded bi-weekly until the field was covered with sweet potato canopy.

Pre-planting soil analysis

The soil sample was randomly collected from the experimental plots at the depth of 0-20 cm with the aid of a tabular sampling auger. The samples were bulked together and air-dried at room temperature for five days. The air-dried samples were subsequently crushed to pass through a 2mm sieve and analyzed for its initial physical and chemical properties. The analysis was done at the Department of Science and Laboratory Technology of the Southern Delta University, Ozoro and The National Root Crop Research Institute (NRCRI), Umudike Abia State. The parameters analyzed includes; soil particle size, organic carbon, pH, total nitrogen, available phosphorus, exchangeable bases, total exchangeable acidity, effective cation exchange capacity and percentage base saturation following standard procedures.

Seed procurement

Five improved cultivars of sweet potato (UMOSPO 1, UMOSPO 3, UMOSPO 4, TIS/087, BUTTER MILK and two local varieties (NWAOYIRIMA and KWARA) were obtained from the NRCRI, Umudike, Abia State.

Treatment and Experimental Design

There were 28 treatments comprising combination of organic liquid fertilizer (Sweedga) application (0, 15, 30 and 45 ml) and seven sweet potatoes cultivars (UMOSPO 1, UMOSPO 3, UMOSPO 4, KWARA 1(Local cultivar 1), TIS/087, BUTTER MILK and NWAOYIRIMA (Local cultivar 2). The experiment was arranged as a 4 × 7 factorial in a Randomized Complete Block Design (RCBD) with three replications which gave a total of 84 plots in two different seasons.

Land Area and Application rate

The total plot size is 20m x 30m = 600m$^{2.}$ the application rate per plot 15ml is 1.66ml, 30ml is 3.33ml and 45ml is 5ml.

Data collection and Analysis

The growth variables collected includes establishment count at 2 weeks after planting (WAP), girth size, vine length, number of leaves, and leaf area at 2,4,6 and 8 WAP, while the yield parameters was collected at harvest (16 WAP). Data were analysed using analysis of variance (ANOVA) of Statistical Analysis System (SAS version 9.4) and different means were separated by Least Significant Difference (LSD) at $p \leq 0.05$.

RESULTS

Physical and chemical properties of the study site in 2020 and 2021 planting seasons

The result of pre-trial physical and chemical analysis of the soil and compost used for the study is presented in Table 1. The textural class of the soil is sandy loam and is slightly acidic with pH of (5.45). The soil is low in total nitrogen, phosphorus and potassium. The results of the soil analysis showed that the phosphorus, potassium, calcium and magnesium contents were 6.20 mg/kg, 0.15, 4.40 and 2.00 cmol/kg, respectively. However, the total Nitrogen content in the soil was 10.95 g/kg, which was higher than the N concentration in the pre-trial soil analysis used for the experiment (Table 1).

Table 1. Physical and chemical properties of the experimental field in 2020 and 2021 seasons

Parameters	2020 (Pre planting)	2021 (Post planting)
pH (H_2O)	5.45	5.15
Organic matter (g/kg)	10	13.6
Organic carbon (g/kg)	7.5	9.25
Total nitrogen (g/kg)	0.95	1.95
Available P(mg/kg)	2.45	6.2
Exchangeable bases (cmol/kg)		
K	0.25	0.15
Ca	5	4.4
Mg	2.8	2
Na	0.42	0.6
Extractable micronutrients (mg/kg)		
Mn	79	433
Fe	88.7	575
Cu	2.41	14
Zn	1.47	8
Physical properties (%)		
Sand	58.5	59.8
Silt	13.2	13.0
Clay	28.3	27.2
Textural class	Sandy loam	Sandy loam

Effect of Various Application Rate of Liquid Organic Fertilizer on the Vegetative Growth of Sweet Potato

Vine Length (cm)

Generally, application rate of liquid organic fertilizer had no significant ($p \geq 0.05$) effect on the vine length of the plants at 2WAP, 4WAP and 6WAP as shown in Table 2. Although at 8 WAP, the highest vine length was recorded in plants that received 45 ml of liquid organic fertilizer (143.57±6.07) which was not significantly different from 30- and 15-ml application (132.98 and 134.64±6.07) but was significantly higher than plants without organic fertilizer application (0).

However, vine length of the different sweet potato cultivars differed significantly (p≤0.05) in response to organic fertilizer application. Among the seven cultivars of sweet potato, TIS/087 had significantly longest vine length at 2 and 4 WAP (28.38±2.42 and 52.00±4.33 while at 6 and 8 WAP KWARA cultivar recorded the longest vine length (83.54±4.62 and 155.13±8.05) compare to other cultivars. All through the period of growth cultivar UMOSP01 had the least vine length (10.25±2.42, 18.71±4.33, 42.17±4.62 and 68.33±8.05). Interaction between organic fertilizer application and different cultivars had no effect on vine length of sweet potato plant at 2, 6 and 8 WAP. However, vine length of the plants was significantly affected by interaction between organic fertilizer application and cultivar types at 4 WAP (Table 2).

Table 2. Mean effect of various application rate of liquid organic fertilizer on vine length (cm) of Sweet Potato in 2020 and 2021 planting seasons

FACTORS	VL2WAP	VL4WAP	VL6WAP	VL8WAP
Application rate (ml)				
0	19.43^{a}	38.88^{a}	72.31^{a}	116.19^{a}
15	19.33^{a}	35.91^{a}	70.17^{a}	134.64^{a}
30	19.29^{a}	36.86^{a}	63.55^{a}	132.98^{ab}
45	22.48^{a}	41.31^{a}	70.21^{a}	143.57^{a}
LSD (0.05)	5.14	9.17	9.79	17.05
SE	1.83	3.27	3.49	6.07
CULTIVARS				
BUTTER MILK	17.58^{b}	35.13^{bc}	74.83^{a}	133.13^{ab}
KWARA	23.21^{ab}	45.96^{ab}	83.54^{a}	155.13^{a}
UMOSP01	10.25^{c}	18.71^{d}	42.17^{c}	68.33^{c}
UMOSP03	17.92^{b}	33.79^{c}	58.13^{b}	122.63^{b}
TIS/087	28.38^{a}	52.00^{a}	73.21^{a}	154.13^{a}
UMOSP04	21.67^{ab}	40.00^{abc}	80.03^{a}	143.25^{ab}
NWAOYIRIMA	21.92^{ab}	42.03^{abc}	71.46^{a}	146.33^{a}
LSD(0.05)	6.79	12.13	12.95	22.58
SE	2.42	4.33	4.62	8.05
INTERACTION				
AR*CUL	103.40^{ns}	3760.28*	409.53^{ns}	1227.71^{ns}

LSD = Least Significant Difference at p≤0.05. SE= Standard Error. Values with similar letters on the same column are not significantly different at p>0.05 of LSD, * Significant, ns= not significant, VL= Vine Length, AR= Application rates, CUL= Cultivars, WAP= Weeks after Planting.

Number of leaves

Liquid organic fertilizer has no significant difference on the various growth stage of number of leaves of sweet potato cultivars produced at 2, 4 and 6 WAP. However, number of leaves reduced significantly at 8 WAP, in plants without liquid organic fertilizer application (67.17±5.23) while plants that received 45 ml rate of liquid fertilizer had the highest number of leaves (82.76± 5.23 (Table 3). The response of the different cultivars to organic fertilizer application deficit was significant all through the growth stages. KWARA had the highest number of leaves (11.25±1.11 and 17.54±22.17±2.02) at 2 and 4 WAP but this was not significantly higher than the number of leaves formed by BUTTER MILK, TIS/087 and NWAOYIRIMA. However, at 6WAP, BUTTER MILK had the highest number of leaves (48.83±2.84) which was significantly higher than other cultivars except

KWARA and TIS/087. While at 8WAP, TIS/087 (102.17±6.92) recorded the highest number of leaves when compared to other cultivars. Number of leaves produced was not significantly influenced by the interaction between liquid organic fertilizer rate and different cultivars at 4, 6 and 12 WAP except at 2 WAP when the interaction influenced number of leaves significantly.

Table 3. Mean effect of Various Application Rate of Liquid Organic Fertilizer on Number of Leaves of Sweet Potato Intercrop in 2020 and 2021 planting seasons

FACTORS	NOL2WAP	NOL4WAP	NOL6WAP	NOL8WAP
Application rates (mL)				
0	9.33^{a}	19.91^{a}	40.79^{a}	67.17^{b}
15	8.43^{a}	16.07^{a}	38.79^{a}	73.64^{ab}
30	8.48^{a}	16.45^{a}	35.64^{a}	78.55^{ab}
45	9.11^{a}	17.50^{a}	36.31^{a}	82.76^{a}
LSD (0.05)	2.37	4.27	6.02	14.66
SE	0.84	1.52	2.15	5.23
CULTIVARS				
BUTTER MILK	10.38^{ab}	20.08^{ab}	48.83^{a}	84.38^{abc}
KWARA	11.25^{a}	22.17^{a}	43.88^{ab}	75.17^{bc}
UMOSP01	4.29^{d}	10.92^{c}	18.46^{d}	34.75^{d}
UMOSP03	5.88^{cd}	12.96^{c}	27.88^{c}	65.21^{d}
TIS/087	10.88^{ab}	20.50^{ab}	45.46^{ab}	102.17^{a}
UMOSP04	8.04^{bc}	16.50^{bc}	40.50^{b}	77.71^{bc}
NWAOYIRIMA	11.17^{ab}	19.25^{ab}	40.17^{b}	89.33^{ab}
LSD (0.05)	3.13	5.65	7.96	19.39
SE	1.11	2.02	2.84	6.92
INTERACTION				
AR*CUL	232.56*	47.93^{ns}	145.67^{ns}	801.86^{ns}

LSD = Least Significant Difference at p≤0.05. Values with similar letters on the same column are not significantly different at p>0.05 of LSD, * Significant, ns = not significant, NOL = Number of Leaves, DOS = Dosage, CUL = Cultivars, WAP = Weeks after Planting.

Number of branches

The application of liquid organic fertilizer had a significant influence on the number of branches of sweet potato cultivars (Table 4). At 2 and 4 WAP, the various rates were not significantly different, but at 6 WAP, plants that had 45 ml dosage had the highest number of branches (8.02±0.24), which was significantly higher than plants that had 30 and 15 ml (7.05±0.24 and 7.64±0.24) organic fertilizer treatment but was not significantly different from those that received 15 ml fertilizer rate. However, at 8 WAP, 30 ml fertilizer application rate had the highest number of branches (13.07±0.34), which was significantly higher than the other rates.

The response of different sweet potato cultivars to organic fertilizer application, as indicated by the number of branches, differed significantly (Table 3). At 2 WAP, KWARA had the highest number of branches (2.25±0.13), which was not significantly higher than the number of branches observed in BUTTER MILK, UMOSP03, TIS/087, and UMOSP04 cultivars but was significantly higher than UMOSP01 and NWAOYIRIMA cultivars (1.79±0.13 and 1.88±0.13). At 4 WAP, TIS/087 recorded the highest number of branches (4.50±0.17) which was significantly higher than UMOSP01 and UMOSP03 cultivars (3.79±0.17 and3.83±0.17), while at 6 WAP cultivar NWAOYIRIMA had the highest number of branches (7.92±0.32) which was significantly higher than UMOSP01 (6.88±0.32) which recorded the lowest number of branches among the cultivars. However, at 8 WAP, KWARA recorded the highest number of branches (12.88±0.44) while UMOSP01 had the lowest

(10.13±0.44) among the cultivars regarding number of branches. The interaction between various rate of liquid organic fertilizer and sweet potato cultivars had no significant influence on number of branches at 2, 4 and 8 WAP but at 6 WAP there was significant effect.

Table 4. Mean effect of various application rate of liquid organic fertilizer on branches of sweet potato in 2020 and 2021 planting seasons

FACTORS	NOB2WAP	NOB4WAP	NOB6WAP	NOB8WAP
Application rates (mL)				
0	1.90[a]	3.95[a]	8.00[a]	10.71[c]
15	2.07[a]	4.21[a]	7.64[b]	11.62[bc]
30	1.95[a]	4.26[a]	7.05[b]	13.07[a]
45	2.14[a]	4.31[a]	8.02[a]	11.98[b]
LSD (0.05)	0.27	0.36	0.68	0.94
SE	0.1	0.13	0.24	0.34
CULTIVARS				
BUTTER MILK	2.08[ab]	4.29[ab]	7.25[ab]	11.63[bc]
KWARA	2.25[a]	4.29[ab]	7.79[a]	12.88[a]
UMOSP01	1.79[b]	3.79[c]	6.88[b]	10.13[d]
UMOSP03	2.00[a]	3.83[bc]	7.33[ab]	10.92[cd]
TIS/087	2.08[ab]	4.50[a]	7.71[ab]	12.75[ab]
UMOSP04	2.04[ab]	4.13[abc]	7.29[ab]	12.21[ab]
NWAOYIRIMA	1.88[b]	4.46[a]	7.92[a]	12.42[ab]
LSD (0.05)	0.35	0.48	0.9	1.25
SE	0.13	0.17	0.32	0.44
INTERACTION				
AR*CUL	0.43[ns]	0.17[ns]	4.37*	5.05[ns]

LSD = Least Significant Difference at $p \leq 0.05$. SE= Standard Error. Values with similar letters on the same column are not significantly different at $p > 0.05$ of LSD, * Significant, ns = not significant, NOB = Number of Branches, AR = Application Rate, CUL = Cultivars, WAP= Weeks after Planting.

Leaf Area (cm²)

The application of liquid organic fertilizer had a significant effect on the leaf area of sweet potato cultivars. Plants that were given 45 ml fertilizer dosage had the highest leaf area throughout the period of growth, while plants without fertilizer application (0) recorded the lowest leaf area as presented in Table 5. At 8 WAP, sweet potato plants fed with 45 mL of organic nutrients produced the largest leaf area (10.29±0.11) was significantly higher than the 0 mL rate (9.57±0.11) and 15 mL (9.71±0.11). The interaction between application of liquid organic fertilizer and different cultivars had no significant effects on leaf area at 2, 4 and 6 WAP, but at 8 WAP there was significant effect as (Table 5). Organic fertilizer had no significant effect on plant girth thickness produced at 2 and 4 WAP. However, plant girth thickness was influenced significantly at 6 WAP in plants that received 30 ml fertilizer rate (0.89±0.04) when compared to other rates. Then at 8 WAP, plants that had the highest fertilizer treatment that is 45 ml, recorded the highest plant girth thickness of (39.91±1.69) which was significantly higher than plots with no fertilizer application (32.03±1.69) but statistically similar to other fertilizer application rates.

The interaction between organic manure rate and sweet potato cultivars on the leaf area was significant at 8 WAP. Different sweet potato cultivars responded differently to the treatment imposed on them. Leaf area of TIS/087 was significantly higher than other cultivars at 2 and 4 WAP (4.96±0.19 and 7.37±0.14), while at 6 WAP it also recorded the highest leaf area (8.86±0.19) but statistically similar to KWARA, BUTTERMILK, UMOSP03 and NWAOYIRIMA. Also, at 8 WAP, BUTTER MILK had highest leaf area (10.83±0.14) which was significantly higher than the leaf area of other cultivars

Table 5. Mean effect of Various Application Rate of Liquid Organic Fertilizer on Leaf Area of Sweet Potato Intercrop in 2020 and 2021 planting seasons

FACTORS	LA2WAP	LA4WAP	LA6WAP	LA8WAP
Application rates (ml)				
0	3.93^{b}	6.64^{a}	7.96^{c}	9.57^{b}
15	4.03^{ab}	6.72^{a}	8.54^{b}	9.71^{b}
30	4.09^{ab}	6.65^{a}	8.62^{ab}	10.05^{a}
45	4.33^{a}	6.71^{a}	9.02^{a}	10.29^{a}
LSD (0.05)	0.4	0.29	0.4	0.3
SE	0.14	0.1	0.14	0.11
CULTIVARS				
BUTTER MILK	3.61^{a}	6.48^{b}	8.82^{a}	10.83^{a}
KWARA	3.71^{c}	6.50^{b}	8.64^{ab}	9.83^{bc}
UMOSP01	3.83^{c}	6.50^{b}	8.10^{c}	9.83^{bc}
UMOSP03	4.43^{b}	6.77^{b}	8.58^{abc}	9.12^{d}
TIS/087	4.96^{a}	7.37^{a}	8.86^{a}	10.20^{b}
UMOSP04	4.06^{bc}	6.59^{b}	8.24^{bc}	9.47^{cd}
NWAOYIRIMA	4.07^{bc}	6.57^{b}	8.53^{abc}	10.07^{b}
LSD (0.05)	0.53	0.39	0.53	0.4
SE	0.19	0.14	0.19	0.14
INTERACTION				
AR*CUL	0.97^{ns}	0.17^{ns}	0.40^{ns}	0.88*

LSD = Least Significant Difference at p≤0.05. SE= Standard Error. Values with similar letters on the same column are not significantly different at p>0.05 of LSD, * Significant, ns= not significant, LA= Leaf Area, AR= Application Rate, CUL= Cultivars, WAP= Weeks after Planting.

Plant girth (cm)

Organic fertilizer had no significant effect on plant girth thickness produced at 2 and 4 WAP. However, plant girth thickness was influenced significantly at 6 WAP in plants that received 30 ml fertilizer dosage (0.89±0.04) when compared to other dosages (Table 6). Then at 8 WAP, plants that had the highest fertilizer treatment, that is 45 ml, recorded the highest plant girth thickness of (39.91±1.69), which was significantly higher than plots with no fertilizer application (32.03±1.69) but statistically similar to other fertilizer application rates.

The response of the different cultivars to liquid fertilizer application was significant (Table 6). KWARA and NWAOYIRIMA cultivars had the highest plant girth thickness at 2 WAP (0.15±0.01 and 0.15±0.01), respectively, while the least among the cultivars was UMOSP03 (0.11±0.01). At 4 WAP, TIS/087 cultivar had the highest plant girth thickness (0.26±0.01), which was significantly higher than UMOSP01 (0.22±0.01) but statistically similar to other cultivars, while at 6 WAP, the highest plant girth thickness was produced in NWAOYIRIMA cultivar (0.98±0.05), while KWARA cultivar had the lowest (0.56±0.05). However, at 8 WAP TIS/087 cultivar had the highest plant girth thickness (44.30±2.23), but this was not significantly higher than plant girth thickness produced by BUTTER MILK, KWARA and UMOSP04. Plant girth thickness produced was not significantly influenced by the interaction between liquid organic fertilizer application and different cultivars at 2, 4, 6 and 8 WAP.

Table 6. Mean effect of various application rate of liquid organic fertilizer on plant girth thickness of sweet potato intercrop in 2020 and 2021 planting seasons

FACTORS	PGT2WAP	PGT4WAP	PGT6WAP	PGT8WAP
DOSAGE (ml)				
0	0.13^{a}	0.25^{a}	0.60^{c}	32.03^{b}
15	0.14^{a}	0.23^{a}	0.71^{b}	35.94^{ab}
30	0.13^{a}	0.23^{a}	0.89^{a}	38.07^{a}
45	0.14^{a}	0.23^{a}	0.79^{b}	39.91^{a}
LSD (0.05)	0.02	0.02	0.11	0.73
SE	0.01	0.09	0.04	1.69
CULTIVARS				
BUTTER MILK	0.13^{a}	0.25^{ab}	0.80^{bc}	39.04^{ab}
KWARA	0.15^{a}	0.23^{ab}	0.56^{d}	39.54^{ab}
UMOSP01	0.14^{a}	0.22^{b}	0.73^{c}	21.36^{c}
UMOSP03	0.11^{b}	0.23^{ab}	0.73^{c}	34.87^{b}
TIS/087	0.14^{a}	0.26^{a}	0.90^{ab}	44.30^{a}
UMOSP04	0.13^{ab}	0.23^{ab}	0.53^{d}	39.24^{ab}
NWAOYIRIMA	0.15^{a}	0.23^{ab}	0.98^{a}	37.05^{b}
LSD (0.05)	0.03	0.03	0.14	6.25
SE	0.01	0.01	0.05	2.23
INTERACTION				
AR*CUL	0.003^{ns}	0.002^{ns}	0.04^{ns}	27.74^{ns}

LSD = Least Significant Difference at p≤0.05. SE= Standard Error. Values with similar letters on the same column are not significantly different at p>0.05 of LSD, * Significant, ns= not significant, PGT= Plant Girth Thickness, AR= Application Rates, CUL= Cultivars, WAP= Weeks after Planting.

Tuber yield (kg/plant)

The different rates of organic liquid fertilizer had no significant effect on fresh tuber weight and weight of dry fodder of sweet potato (FTW and WODF). However, organic fertilizer had significant effect on weight of fresh fodder after harvest (WOFFH), as the highest plots without organic fertilization had the highest WOFFH (1.69±0.14) which was not significantly different from plots that received 30 ml organic fertilizer rate (1.35±0.14) but was significantly higher than 15- and 45-ml fertilizer rate treatment (Table 7).

Application of liquid organic fertilizer had significant effect on yield components of sweet potato cultivars. TIS/087 produced the highest fresh tuber weight (1.34±0.12) which was significantly similar to fresh tuber weight recorded in BUTTER MILK but statistically higher than fresh tuber weight obtained in the other cultivars. Likewise, TIS/087 had highest weight of dry fodder (0.98±0.13) that was significantly similar to weight of weight of dry fodder in BUTTER MILK, KWARA and NWAOYIRIMA but significantly higher than other cultivars. Similarly, TIS/087 had highest weight of fresh fodder harvest (2.72±0.18) and the lowest (0.37±1.50) was recorded in UMOSP01 cultivar. Fresh tuber weight (FTW) and weight of fresh fodder (WOFF) were significantly influenced by the interaction between application of liquid organic fertilizer and sweet potato cultivars. However, the interaction did not cause significant effect on weight of dry fodder (WODF) of sweet potato cultivars.

Table 7. Mean effect of Various Application Rate of Liquid Organic Fertilizer on yield of Sweet Potato Intercrop in 2020 and 2021 planting seasons

FACTORS	FTW kg/plant	WOFFH kg/plant	WODF kg/plant
Application rates (ml)			
0	0.67[a]	1.69[a]	0.58[a]
15	0.51[a]	1.03[b]	0.50[a]
30	0.73[a]	1.35[ab]	0.57[a]
45	0.62[a]	1.09[b]	0.62[a]
LSD (0.05)	0.25	0.39	0.27
SE	0.09	0.14	0.1
CULTIVARS			
BUTTER MILK	1.19[a]	1.60[b]	0.73[ab]
KWARA	0.18[cd]	1.05[c]	0.72[ab]
UMOSP01	0.15[d]	0.37[d]	0.12[c]
UMOSP03	0.84[b]	0.62[cd]	0.29[c]
TIS/087	1.34[a]	2.72[a]	0.98[a]
UMOSP04	0.24[cd]	0.83[cd]	0.40[bc]
NWAOYIRIMA	0.50[c]	1.86[b]	0.72[ab]
LSD (0.05)	0.33	0.52	0.36
SE	0.12	0.18	0.13
INTERACTION			
AR*TRANS	0.57*	1.50*	0.44[ns]

LSD = Least Significant Difference at $p \leq 0.05$. SE= Standard Error. Values with similar letters on the same column are not significantly different at $p > 0.05$ of LSD, * Significant, ns= not significant, FTW= Fresh Tuber Weight, WODF= Weight of Dry Fodder, WOFFH= Weight of Fresh Fodder after Harvest, AR= Application Rates, CUL= Cultivars, WAP= Weeks after Planting.

DISCUSION

Sweet potato (*Ipomea batatas*) is an important arable crop cultivated and consumed worldwide, and it is currently ranked the second most cultivated tuberous crop worldwide as the consumed tuber part serves as a rich source of carbohydrate, proteins and vitamins (Nedunchezhiyan et al., 2012; Ossai et al., 2022). It is an important food source to both rich and poor thereby serving as an income source to farmers and retailers (Essilfie et al., 2016). However, for improved productivity, the cultivating soil, varieties best suited to the environment, the planting method and nutrient enrichment strategy need to be considered.

In this study, the pre and post soil pH was slightly below the acceptable range for optimal growth and development of sweet potato plant at the optimum pH range for sweet potato production is from 5.8 to 6.2, a value the pH of the soil falls slightly below, which makes the plot slightly acidic, however, with little change in the post status (Hopkins et al., 2018; Hopkins and Hansen, 2019). Brandenberger et al. (2014) had earlier reported the optimum range of pH for sweet potato production to be 5.8 to 6.0, and further stated that sweet potato has the ability to withstand variations in soil pH. This could be attributed to the soil buffering capacity due to its high soil organic matter content and clay (Inheong et al., 2023). It has also been reported that sweet potato releases exudates which interacts with soil microorganisms to stabilize soil pH (Inheong et al., 2023). Also, sweet potato is regarded as low nutrient utilizer which ultimately limits the amount of fertilizer need, thereby reducing an alteration in the soil pH that primarily comes from high input of acidic fertilizers like Ammonium (Mwanga et al., 2017). Also, the debris released by the sweet potato plant used in this study can decompose and add to the stability of the soil (Uwamahoro et al., 2023).

There were negligible changes in the soil physical properties with the sand content increasing in the post soil status with corresponding reduction in the clay content. This is as a result of the tuberous nature of sweet potato which the harvesting method is characterized with the upturning of the soil, and this process could have led to deposition of more sand and part of the clay content sticking to the body of the harvested tubers (Monostori et al., 2017). The increase in sand content could also be due to the disturbances during the harvesting process of the sweet potato tubers. Another factor that can contribute to an increased sand and reduced clay content is the soil tillage activity prior to planting (Sushil et al., 2018).

However, there were considerable increment in the soil organic matters, organic carbon, exchangeable bases and extractable micronutrients from the pre to post status. This could be attributed to the farm management system by the nutrient enhancement practice in this study where mineral fertilizer at different rates were applied, since the post soil analysed was in a composite form, so it combined the amended and un-amended plots. Another contributing factor was the deposition of debris or drop off leaves from the plant which eventually decomposed and added to the soil physic-chemical enrichment. Also, sweet potato has been reported to trap atmospheric nitrogen and fixes it to the environment (Risako and Katsuya, 2022).

Despite the nitrification ability of sweet potato to the soil, its optimum growth and development largely depend on a well-balanced soil with the optimum nutrients. This is evident in the superior performance of the sweet potato plants in the 30 ml and 45 ml liquid fertilizer amended soil relative to the non-amended and less amendment rate. This shows that the fertilizer amendment compensated for the depreciation in the initial soil nutrient status as a result of the direct feeding activity by the sweet potato plants. Despite the superior agronomic performances of the higher rate mineral fertilizer supplicated plots, the effect was not significant in the yield parameters. This could be as a result of the good nutrient status of the soil which was enough to support the tuber yield, while the excess nutrient in the applied plots got converted to the vegetative part of the plants. This could also be that the timing of application of the liquid fertilizer did not correspond to the bulking period of the sweet potato plants. This agrees with the findings of Egbe (2012) on the root bulking of sweet potato.

In terms of the varietal performances, TIS/087 produced a higher agronomic performance relative to other varieties. This shows that the TIS/087 adapted to the soil type and environmental condition better than the rest varieties with better photosynthetic efficiency, partitioning of its carbohydrate and to the roots, making it the variety with the best nutrient use efficiency. The TIS/087 also produced the highest tuber yield and tuber weight. This could be as a result of the source-sink relation of the vegetative phase and the tuber production, where the higher leaf surface area produces higher photosynthetic assimilates that eventually got converted to the higher bulking of the root part into the tubers. This finding is in agreement with the findings of Alfred and Adoyi (2024) who identified TIS/087 as a superior improved variety of sweet potato in Southern Guinea savanna region of Nigeria.

The insignificant interaction between the rates of mineral fertilizer and the varieties implies that the differences existing between the varieties planted is solely due to the inherent genetic makeup of the varieties, and their adaptability rate in terms of nutrient assimilation from the environment. Rosero et al. (2023) has stressed that varietal adaptation is an important attribute to consider in selecting a sweet potato variety to be grown in an area due to differences in inherent genetic makeup.

CONCLUSION

To avert the spill-over effect of synthetic fertilizer on the environment emanating from the cultivation of sweet potato, this study had shown that the application of organic fertilizer at the rate of 45 mL per 4 meter square plot is optimal for improved productivity, and the cultivation of an improved variety TIS/087 produces higher yield to other varieties evaluated and thus recommended for cultivation in the coastal swamp region of Nigeria as it showed high adaptation rate.

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AUTHORS CONTRIBUTION

All the authors contributed equally to this research work.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not Applicable

CONSENT FOR PUBLICATION

Not Applicable

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AVAILABILITY OF DATA AND MATERIALS

All datasets analyzed and described during the present study are available from the corresponding author upon reasonable request.

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