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RESIDUAL EFFECTS OF INTEGRATED NUTRIENT MANAGEMENT ON PERFORMANCE OF SWEET POTATO (*IPOMOEA BATATAS* (L.) LAM) VARIETIES IN SOUTHERN GUINEA SANANNAH OF NIGERIA

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ABSTRACT

The Field experiment was carried out in 2020 cropping seasons at the Research Farm of Federal University of Technology Minna to assess the residual effects of integrated nutrient management on the performance of sweet potato varieties as well as their residual effects on soil properties. Treatments consisted of factorial combinations with two varieties of sweet potato (Butter milk and Umuspo1) laid in a Randomized Complete Block Design (RCBD) with three replications. The results showed that there was no statistical difference on the establishment count of two sweet potato varieties at 2 and 4 WAP. However, statistical significant difference was recorded in control with lowest establishment count at 2 and 4 WAP respectively. Also, there was no significant difference in vine length between the treatments at 4, 6,8,10 WAP respectively, except in control which recorded lowest vine length. There was significant difference in number of leaves at 4 and 6 WAP between the treatments and varieties, but no significance difference was observed at 8 and 10 WAP. Significant difference was observed in number of branches at 4, 6, 8, and 10 WAP between the treatments and varieties. The results showed that the application of 200 kg ha^{-1} NPK + 1.5 t ha $^{-1}$ PM recorded highest number of tubers and highest tuber yield. It therefore recommended that farmers in this agro-ecological zone should apply 200 kg ha^{-1} NPK + 1.5 t ha $^{-1}$ PM for high yield of sweet potatoes.

Keywords: Sweet potato, Poultry manure, NPK fertilizer

INTRODUCTION

The potential of sweet potato to guarantee food security is under estimated as its use is often limited to a substitute food in Africa countries. Sweet potato is valued for its roots which are boiled, fried, baked or roasted for human consumption or boiled and fed to livestock as source of energy. The roots can also be processed into flour for bread making; starch for nodules and can be as well used as raw material for industrial starch and alcohol (Ukom *et al.*, 2009). The flour is utilized also in sweetening local beverages like *kunu-zaki*, *burukutu*, and for fortifying baby foods and *fufu* /*pounded yam* in Nigeria (Tewe *et al*., 2003). It is commonly grown by farmers in complex and mixed cropping systems. Several varieties with different characteristics (yield, maturity, palatability, time to maturity, root size and shape, root color, storability in the ground, pest and disease tolerance, drought tolerance and sweetness) are grown in mixtures (Assefa *et al.*, 2007).

Sweet potato is grown in several agro-ecological zones of Nigeria and usually plays a significant role in the farming and food sustainability systems of the country. As a food security crop, it can be harvested in piecemeal as needed, thus offering a flexible source of food and income to rural households that are mostly vulnerable to crop failure and consequently fluctuating cash income. Sweet potato has several advantages within the context of Africa cropping systems. It produces food in a relatively short time, and gives a reliable yield in sub-optimal growth conditions. It requires lower labor inputs (appropriate for vulnerable households) than other staple, and serves as an alternative food source for urban populations facing increasing prices of cereals (Andreas *et al.*, 2009). It ranks fifth as the most important food crop after rice, wheat, maize, cassava, in developing countries (Som, 2007). The leaves are used as vegetables in yam and cocoyam porridge and are rich in proteins, vitamins and various minerals. Sweet potato roots are rich in vitamins A, B and C, and minerals such as K, Na, Cl, P and Ca. (Ikpe and Powel, 2003; Ano and Agwu, 2005)

Organic manure is known to be effective in maintenance of adequate supply of organic matter in soils with attendant improvements in soil physical and chemical conditions and enhanced crop performance (Ikpe and Powel, 2003; Ano and Agwu, 2005). Sweet potato like any other root tuber crop is a heavy feeder exploiting greater volume of soil for nutrients and water (Osundare, 2004). For obvious reasons researchers advocate the use of combined organic and inorganic fertilizers for increased production (Som, 2007). Organic manures and compost discharge their nourishing content only when they break down slowly through the intricate ecology of living organisms in the soil at that time they steadily discharge contents.

MATERIALS AND METHOD

Experimental site

Field trials were carried out at the Research Farm of Federal University of Technology Minna (Latitude 6° 33°E and Longitude 9° 37° N) during the 2020 rainy season. Minna is located in the Southern Guinea Savanna ecological zone of Nigeria.

Experimental materials and Design

Two varieties of sweet potato (Butter milk and Umuspo 1) were used for the experiment. The treatment consisted of factorial combination of sole and combined inorganic (NPK 15:15:15) and Organic (poultry manure) fertilizer (Control, 400 kg ha^{-1} NPK, 3 tha^{-1} Poultry Manure (PM), 200 kg ha^{-1} NPK + 1.5 tha^{-1} PM, 300 $kgha^{-1}$ NPK + 0.75 tha^{-1} PM, 100 $kgha^{-1}$NPK + 2.25 tha^{-1} PM) and two sweet potato varieties (Butter milk and Umuspo1). Arranged in a Randomized Complete Block Design (RCBD) with three replicates.

Experimental land preparation

The land was cleared manually, then ploughed using a tractor; ridges were constructed with hoe. Each plot size was 2 m x 2 m (4 m^2) having 12 plots in each replication with an inter row spacing of 1m, total experimental land area was 41 m × 8 m (328 m^2).

Planting

The potato vines were planted at a spacing of 30 cm intra row and planting was done without any fertilizer application. Manual weeding was done at intervals of 3 Weeks after Planting (WAP). Weeding was carried out twice

Data collection and analysis

Data were collected on crop established; count, vine length, number of leaves, number of branches, number of tubers, number of damaged tubers and tuber yield. The data collected were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS, 2013) version 9.2. Means were separated using Student-Newman Keuls (SNK) at 5% level of probability.

RESULTS

Selected physical and chemical properties of soils of the study site are shown on Table 1. The result showed that soil was sandy loam in texture with a slightly acidic pH (6.8), organic carbon; total Nitrogen and available phosphorus were low with values of 8.13, 0.78 and 7.31 g kg^{-1} respectively. Exchangeable bases were 0.92, 0.54, 0.58 and 1.55 for Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} respectively. Exchangeable acidity and ECEC were 0.14 and 3.73 cmol kg^{-1} respectively and a base saturation of 96.25 %. The nitrogen, phosphorus and potassium content of the poultry manure used as source of amendment is presented on Table 2. Poultry manure had 27.3, 0.91 and 1.31 % total N, total available P and total K respectively.

Table 1: Physical and Chemical Properties of Soil of the Experimental Site Before planting in 2019

Parameters	**Value**
Textural classification (gkg^{-1})	
Sandy	662
Silt	225
Clay	113
Textural class	Sandy Loam
Chemical properties	
pH (1:2.5) soil water ratio	6.8
$CaCl_2$	6.0
Organic Carbon ($g\ kg^{-1}$)	8.13
Total N ($g\ kg^{-1}$)	0.78
Available P ($mg\ kg^{-1}$)	7.31
Exchangeable bases ($cmol\ kg^{-1}$)	
Ca^{2+}	0.92
Mg^{2+}	0.54
K^+	0.58
Na^+	1.55
Exchangeable acid ($cmol\ kg^{-1}$)	0.14
ECEC ($cmol\ kg^{-1}$)	3.73
Base Saturation (%)	96.25

Table 2: Nutrient Content of the Poultry Manure used in the Experimental Site

Total N ($g\ kg^{-1}$)	27.3
Total Available P ($mg\ kg^{-1}$)	0.91
Total K **($cmol^{(+)}\ kg^{-1}$)**	1.31

Effect of Integrated Nutriets

The residual effect of integrated nutrient management on establishment count of some sweet potato varieties at 2 and 4 WAP in 2020 is shown in Table 3. The application of fertilizer affected establishment count significantly at 2 and 4 WAP respectively. All the plots with sole and integrated nutrient application recorded statistically similar highest establishment count than the control which recorded the lowest establishment count at each sampling time of the study.

There were no significant interaction effects between the fertilizer and variety on establishment count at each sampling periods of the study.

Table 3: Residual effect of integrated nutrient management on establishment count of sweet potato at Minna in 2020

	Establishment count (%)	
Treatments	**2 WAP**	**4 WAP**
Fertilizer (F)		
Control	65.47b	28.57b
400 kg ha^{-1} NPK	90.47a	83.33a
3 t ha^{-1} PM	90.47a	85.00a
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	92.85a	77.38a
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	100.00a	75.00a
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	96.43a	83.80a
SE±	5.414	7.475
Variety (V)		
Butter milk	90.08a	73.81a
Umuspol	88.49a	70.55a
SE±	3.126	4.316
Interaction		
F x V	NS	NS

Means with the same letter(s) in a column and under the same factor are not significantly different from each other at 5 % level of probability by SNK.

NS: Not significant, PM = Poultry manure, WAP = Weeks after planting

The residual effect of integrated nutrient management on vine length of some sweet potato varieties at 4, 6, 8 and 10 WAP in 2020 is shown in Table 4. Fertilizer application had a significant effect on vine length throughout the sampling periods in this study. At 4, 6 and 8 WAP, all the plots with sole and integrated application of fertilizer recorded significantly similar longest vines than the control which recorded shorter vines. At 10 WAP, 3 t ha^{-1} PM, 200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM and 100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM recorded significantly similar longest vines than the control, 400 kg ha^{-1} NPK and 300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM which had similar shortest vines.

The sweet potato varieties differed significantly in terms of their production of vine length at each sampling time. Butter milk variety consistently recorded longer vines than Umuspo 1 variety which consistently recorded shorter vines. There were no significant interaction effects between fertilizer and variety on number of leaves.

Table 4: Residual effect of integrated nutrient management on vine length of sweet Potato varieties at Minna in 2020

	Vine length (cm)			
Treatments	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
Fertilizer (F)				
Control	59.50b	105.00b	168.75b	444.08b
400 kg ha^{-1} NPK	145.17a	269.00a	350.50a	516.42b
3 t ha^{-1} PM	137.33a	269.00a	358.83a	752.12a
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	134.00a	263.83a	445.50a	575.92a
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	127.25a	260.92a	328.83a	522.50b
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	138.08a	210.33a	420.08a	565.75a
SE±	26.352	48.115	47.297	70.288
Variety (V)				
Butter milk	169.31a	343.83a	537.36a	905.04a
Umuspol	77.81b	115.53b	153.47b	220.56b
SE±	15.214	27.779	27.307	40.581
Interaction				
F x V	NS	NS	NS	NS

Means with the same letter(s) in a column and under the same factor are not significantly different from each other at 5 % level of probability by SNK.

NS: Not significant, PM = Poultry manure, WAP = Weeks after planting

The residual effect of integrated nutrient management on the number of leaves of sweet potato varieties at 4, 6, 8 and 10 WAP in 2020 is shown in Table 5. Fertilizer application had a significant effect on number of leaves throughout the sampling times. At 4WAP, the application of 400 kg ha^{-1} NPK, 200 kg ha^{-1} NPK+ 1.5 t ha^{-1} PM and 300 kg ha^{-1} NPK+ 0.75 t ha^{-1}PM recorded significantly similar higher number of leaves statistically similar with the application of 3 t ha^{-1}PM and 100kg ha^{-1} NPK + 2.25 t ha^{-1} PM compared with the control which recorded the least number of leaves. At 6WAP, application of 200 kg ha^{-1} NPK+ 1.5 t ha^{-1} PM recorded higher number of leaves similar with all other plots with sole and integrated application of fertilizer than the control which had lower number of leaves. At 8 WAP, the application of sole and integrated fertilizer application recorded significantly similar highest number of leaves than the control which had lower number of leaves. At 10 WAP, application of 400 kg ha^{-1}, 3 t ha^{-1}, 200 kg ha^{-1} NPK+ 1.5 t ha^{-1} and 100kg ha^{-1} NPK + 2.25 t ha^{-1} PM recorded significantly similar highest number of leaves than the control and application of 300 kg ha^{-1} NPK+ 0.75 t ha^{-1}PM which had similar lowest number of leaves.

Table 5: Residual effect of integrated nutrient management on number of leaves of sweet Potato varieties at Minna in 2020

	Number of leaves			
Treatments	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
Fertilizer (F)				
Control	48.0b	120.0b	318.0a	660.0a
400 kg ha^{-1} NPK	157.0a	327.0ab	705.0a	855.0a
3 t ha^{-1} PM	103.0ab	209.0ab	570.0a	958.0a
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	157.0a	355.0a	738.0a	992.0a
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	156.0a	324.0ab	653.0a	749.0a
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	76.0ab	188.0ab	746.0a	1187.0a
SE±	22.914	49.774	108.669	145.485
Variety (V)				
Butter milk	157.0a	342.0a	777.0a	1194.0a
Umuspol	76.0b	166.0b	466.0a	606.0b
SE±	13.229	28.737	62.739	83.996
Interaction				
F x V	NS	NS	*	NS

Means with the same letter(s) in a column and under the same factor are not significantly different from each other at 5 % level of probability by SNK.
NS: Not significant, PM = Poultry manure, WAP = Weeks after planting

The result in Table 6 shows the residual effect of integrated nutrient management in 2020 cropping season on number of branches, control and 100 kg ha^{-1}NPK + 2.25 t ha^{-1} was significantly lower than other treatment combinations, Similarly, at 6WAP plots treated with 400 kg ha^{-1}NPK was not significantly different from plots treated with 3 t ha^{-1}PM and 300 kg ha^{-1}NPK+0.75 t ha^{-1}PM but was significantly higher than others. At 8WAP, plots treated with 400 kg ha^{-1}NPK was significantly higher than control and plots treated with 100 kg ha^{-1}NPK+ 2.25 t ha^{-1}PM but was similar to the others. Results on varietal effects shows that butter milk variety significantly performed better than Umuspo 1 in both years across all the weeks of observation. Similar, to fertilizer effects, the varieties performed better in the 2020 cropping season. There was no significant interaction effect of fertilizer and varieties except at 6 weeks after planting in both years and 8 weeks in 2019 only.

The residual interaction effect of integrated nutrient management on the number of branches of sweet potato varieties at 6 WAP in 2020 is shown in (Table 6). The application of 100 kg ha^{-1}NPK+2.25 t ha^{-1}PM in combination with Butter milk variety produced more branches compared to the control plots with either variety which had the least branches.

Table 6: Residual effect of integrated nutrient management on number of branches of sweet Potato varieties at Minna in 2020

	Number of branches			
Treatments	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
Fertilizer (F)				
Control	5.17b	7.46d	7.62d	9.87c
400 kg ha^{-1} NPK	6.71a	10.51a	11.07a	12.23a
3 t ha^{-1} PM	7.04a	10.24ab	10.57ab	10.82bc
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	6.41a	9.01bc	10.80ab	12.05ab
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	6.67a	9.26abc	9.82abc	11.07abc
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	5.17b	8.56c	9.13c	10. 37c
SE±	0.430	0.560	0.590	0.500
Variety (V)				
Butter milk	6.79a	9.65a	10.21a	11.46a
Umuspol	5.78b	8.56b	9.12b	10. 37b
SE±	0.270	0.390	0.400	0. 370
Interaction				
F x V	NS	*	NS	NS

Means with the same letter(s) in a column and under the same factor are not significantly different from each other at 5 % level of probability by SNK.

NS: Not significant, PM = Poultry manure, WAP = Weeks after planting

Tuber yield (t ha^{-1})

The effect of integrated nutrient management on tuber yield of sweet potato varieties in 2019 and 2020 is shown in Table 7. Fertilizer application had a significant a significant effect on tuber yield in both years. The plots with sole and integrated fertilizer application gave significantly higher tuber yield than the control which recorded lower tuber yield in both years. Tuber yield was not significantly different among the sweet potato varieties in

2019 and 2020 respectively. There was no significant interaction on tuber yield across the year in the study.

Selected soil chemical properties

The effects of integrated nutrient management on sweet potato varieties on selected soil chemical properties is presented on Table 8. Significant differences were observed in the effect of fertilizers on the selected parameters with the exception of exchangeable potassium. Available phosphorus ranged from 8.50 mg ha^{-1} in the control plot to 31.00 mg ha^{-1} in the plot with the application of sole NPK fertilizer. This was followed closely by 25.50 mg ha^{-1} in the plot with 200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM then 3 t ha^{-1} poultry manure gave 18.50 mg ha^{-1}. Available phosphorus, plots treated with 400 kg NPK ha^{-1} was significantly higher than the other treatment combinations. Application of 300 kg ha^{-1}NPK + 0.75 t ha^{-1}PM and 100 kg ha^{-1} NPK + 2.25 t ha^{-1}which had statistically similar lowest phosphorus content. Under Umuspo 1, the application of 400 kg NPK ha^{-1}resulted in higher phosphorus content than the other fertilizer applications compared with the control and application of 300 kg ha^{-1}NPK + 0.75 t ha^{-1}PM which had statistically similar lowest phosphorus content. Generally, the combination of Butter milk and application of 400 kg ha^{-1}NPK resulted in higher phosphorus content than the other fertilizer applications.

Table 7: Effect of integrated nutrient management on number of tubers, number of damaged tubers and tuber yield of sweet Potato varieties at Minna in 2019 and 2020

Treatments	Number of tubers		No. of damaged tubers		Tuber yield (t ha^{-1})	
	2019	2020	2019	2020	2019	2020
Fertilizer (F)						
Control	14.0b	13.0b	3.33a	1.50a	2.05b	2.25b
400 kg ha^{-1} NPK	27.0a	31.0a	2.50a	3.00a	5.42a	8.65a
3 t ha^{-1} PM	34.0a	31.0a	3.33a	3.00a	5.96a	9.67a
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	37.0a	35.0a	3.50a	3.17a	6.52a	11.00a
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	28.0a	35.0a	2.17a	3.83a	5.91a	10.00a
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	33.0a	25.0a	3.00a	1.50a	6.25a	7.00a
SE±	2.993	3.493	0.480	0.720	0.706	1.240
Variety (V)						
Butter milk	30.0a	30.0a	3.22a	3.17a	6.00a	8.23a
Umuspol	29.0a	26.0a	2.72a	2.17a	5.00a	7.86a
SE±	1.728	2.017	0.280	0.420	0.408	0.716
Interaction						
F x V	NS	NS	NS	NS	NS	NS

Means with the same letter(s) in a column and under the same factor are not significantly different from each other at 5 % level of probability by SNK.

NS: Not significant, PM = Poultry manure, WAP = Weeks after planting

Table 8: Residual effect of treatments on selected soil chemical properties after harvest at Minna in 2022

Treatments	Available phosphorous (mg kg^{-1})	Total nitrogen (g kg^{-1})	Organic carbon (g kg^{-1})	Exch. Potassium ($cmol^{(+)}$ kg^{-1})
Fertilizer (F)				
Control	8.50e	0.46c	4.21b	0.13a
400 kg ha^{-1} NPK	31.00a	0.56bc	7.18a	0.20a
3 t ha^{-1}	18.50b	0.96a	4.62ab	0.20a
200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM	25.50b	0.67b	5.77ab	0.18a
300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM	9.00e	0.60bc	4.70ab	0.19a
100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM	12.50d	0.69b	4.70ab	0.24a
SE±	1.32	0.05	0.64	0.042
Variety (V)				
Butter milk	18.17a	0.65a	4.87a	0.19a
Umuspo1	16.50b	0.66a	5.23a	0.18a
SE±	2.16	0.047	0.42	0.024
Interaction				
TxV	*	NS	NS	NS

Means with the same letter(s) in a column are not significantly different at 5% level of probability using SNK.
NS: Not significant
*: Significant

DISCUSSION

Soils of the experimental site were low in essential plant nutrients when compared with soil fertility ratings by Esu (1991). This is typical of many tropical soils which are highly weathered with little or no weatherable reserve (Aduayi *et al.*, 2002). The low Phosphorus content could be as a result of high P fixing capacity of most tropical soils (Ibrahim, 2015). Senjobi *et al.* (2013) reported that Nigeria soils are deficient in most nutrients. The low nutrient status of the soil indicates a high probability of getting a response to the application of fertilizers when the soil is cultivated, otherwise partial or total crop failure is probable. The soil texture which is sandy loam is optimum for sweet potato production as they require loose soils through which the roots can penetrate. The soils pH of 6.8 is optimum for sweet potato production. According to Samuel *et al.* (2003), soils with pH of 6.5 -7.0 are considered optimum for crop production.

The chemical composition of poultry manure therefore depends very much on the quality and quantity of the feeds the birds were feed with. This fact agreed with the observation of Oyedeji *et al.* (2014) that the protein constituent in the poultry feeds had a direct relationship with manure nitrogen. Vegetative growth of crops is usually associated with nitrogen, soils amended with fertilizers and poultry manure gave longer vines than the control plots. The 200 kg ha^{-1} NPK + 1.5 t ha^{-1} pm gave longer vine lengths. This might be due to differences in soil fertility occasioned by the application of these amendments. Results of this study is in line with the findings of Abdissa *et al*. (2012) who reported an increase in the vine length of sweet potato with application of organic manure. Also Haliru *et al*. (2015) and El-Hlamy (2011) reported a significant increase in the vine length of sweet potato with application of mineral fertilizer. The varieties significantly differed in the length of vines produced with the buttermilk variety producing longer vines. Mukthar *et al.* (2010) postulates that two cultivars of sweet potato may behave significantly different in their vegetative growth due to differences in their genetic composition. Raemaekers (2001) also asserts that vine length and growth habit of sweet potato depend on cultivar and environment and the plants nutrition. It was observed that longer vines were produced in 2020 perhaps the environmental factors were responsible given the similarities in the weather data of the location at the various times the experiment was carried out. The slow release as well as initial competition of microbes for mineralized nitrogen may be responsible for shorter vines in the 2019 season as more nitrogen is made available in 2020.

The production of more leaves might be attributed to the high nitrogen content obtained from the interactive effect between poultry manure and NPK. The increase in leaves number might be because of better photosynthesis activity in large photosynthesis area. Since, nitrogen is one of the basic minerals associated with synthesis of protoplasm and in primary synthesis of amino acids, components of protoplasm include all elements that are required to synthesize biomass growth. This finding is in agreement with the findings of Cheng-Wei *et al.* (2014), Ouda and Mahadeen (2008) who observed that the combined application of organic and inorganic fertilizers results in the vigorous vegetative growth of. The increase in the number of leaves might be because of mineralization of organic manure leading to release of organic bound nutrients. Similar results were reported by Atayese *et al*. (2013) with application of 10t/ha poultry manure application on sweet potato and Abou-Hussein *et al*. (2003) with organic fertilization in sweet potato influenced leaves growth.

The greatest number of branches, which is also a vegetative attribute of sweet potato, were obtained from plots where sole mineral fertilizer was applied and where mineral fertilizer was combined with poultry manure. The reasons for this is not quite different from reasons responsible for differences in the other vegetative traits. Mukthar *et al.* (2010) explained that a difference in number of branches of sweet potato cultivars largely depends on differences in genetic composition. However, Djilani and Senoussi (2013) states that fertilizers either organic or inorganic provide adequate plant nutrient for optimum growth and development. Also Havlin *et al.* (2005) reported that an adequate supply of nutrient to plant release nitrogen which is associated with vigorous seedling emergence, vegetative growth and yield. The higher number of branches obtained in 2020 was as a result of the residual effect of the fertilizers. Adenawoola and Adejoro (2005) reported that the cumulative agronomic value of some organic manure applied to agricultural soils could be more than five times greater in the post-application period than the value realized during the year of application. Crop yield is a measurement of the amount of a crop that can be harvested per unit of land usually measured in tons per hectare or kilogram per hectare, and this in most cases is the major interest of the farmer. In both years' yield obtained with other treated plots were higher than what was obtained in the control plots, this might be due to differences in soil fertility as a result of the amendments added in the other plots (Mukthar *et al.,* 2010). These amendments have the ability to correct adverse soil conditions both physical and chemical. Both organic and inorganic fertilizers have been reported to be of great importance in increasing the productivity of crops (Ali *et al.,* 2009). Leytem and Westermann (2005) reported the important effects of fertilizer on the yield of potatoes. Also that potato is highly responsive to nitrogen fertilization and that it is usually the most limiting essential nutrient for potatoes growth and development (Sincik *et al.,* 2008). Inorganic fertilizers when applied are readily available for crop uptake and use. This advantage coupled with the fact that organic fertilizer is environmentally friendly and supply both macro and micro nutrients to the soil (Negassa *et al.*, 2001; Tirol-padre *et al.*, 2007) and also improve the physio-chemical properties of the soil, may be responsible for this combination giving the best yield.

The yields in 2020 were generally better than that of 2019. Chen (2006) reported that decomposition of manure and mineralization of the nutrients contained in it is fairly slow and may take a few months to several years depending on environmental factors. These released nutrients are stored for a longer period in the soil ensuring longer residual effects, improved root development and higher crop yields Rosen and Bierman (2005) reported that organic fertilizers applied to preceding crops had a remarkable residual effect on yield and yield contributing components of succeeding crop because time was needed for the processes of mineralization to take place.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The results of this study revealed that the applications of 200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM and 300 kg ha^{-1} NPK + 0.75 t ha^{-1} PM in 2019 and all the treatments with sole and integrated nutrient management in 2020 had highest establishment count than the control which had the lowest in both years. The application of 200 kg ha^{-1} NPK + 1.5 t ha^{-1} PM consistently gave higher number of leaves and longer vines similar with all other fertilizer applications than the control which had the lowest in 2019 and 2020 respectively. The application of 100 kg ha^{-1} NPK + 2.25 t ha^{-1} PM consistently produced higher number of branches in 2019 and application of 3.0 t ha^{-1} PM produced higher number of branches in 2020 than the control which consistently recorded lower number of branches in both years. The treatments with sole and integration of inorganic (NPK) and organic manure (PM) recorded statistically similar highest number of tubers and tuber yield than the control which had the lowest in 2019 and 2020 respectively. Number of damaged tubers was significantly different among the fertilizer applications in both years. The application of 400 kg ha^{-1} NPK recorded higher residual phosphorus and organic carbon content than the control which had the lowest. The application of 3.0 t ha^{-1} PM recorded higher residual total nitrogen content in the soil than the control which had the lowest nitrogen content in the soil. Exchangeable potassium was not significantly different among the fertilizer applications in this study.

Establishment count was not significantly different among the sweet potato varieties in both years. The variety Butter milk consistently recorded higher number of leaves in 2020 than Umuspo 1 which had the lowest number of leaves. Longer vines were produced by Butter milk sweet potato variety than Umuspo l which produced shorter vines in 2019 and 2020 respectively. Number of tubers, number of damaged tubers and tuber yield were not significantly different among the fertilizer applications in both years. The variety Butter milk supported higher residual available phosphorus in the soil. Total nitrogen, organic carbon and exchangeable potassium were not significantly different among the sweet potato varieties in 2019 and 2020 respectively.

Recommendations

Based on the results of this study, it is recommended that farmers should plant Butter milk sweet potato variety with the application of 200 kg ha^{-1}NPK 15:15:15 + 1.5 t ha^{-1} poultry manure for higher growth and tuber yield. The application of 400 kg ha^{-1}NPK 15:15:15 and 3.0 t ha^{-1} poultry manure is recommended for improved soil fertility in the study area.

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