ENHANCING THE YIELD OF CASSAVA (*MANIHOT ESCULENTA*) USING NPK FERTILIZER AND POULTRY MANURE IN SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT
This research was conducted to assess the yield of cassava and the dynamics of nutrient limitations in relation to water availability and nutrient availability to obtain better insight of how crops respond to nutrient availability and application of fertilizer in two different states of Nigeria.. The four treatment combinations used for the two locations were $N_1\,P_1\,K_{1,}\ N_2\,P_2\,K_{2,}\ N_3\,P_3K_{3\,+}\,M_{,}\ N_4P_4K_4$ representing different levels of fertilizers combinations which are; N_1 (0kg/ha), N_2 (80kg/ha), N_3 (70kg/ha), N_4 (90kg/ha), P level. P_1 (0kg/ha), P_2 (26kg/ha), P_3 (26kg/ha), P_4 (20kg/ha), K Level, K_1 (0kg/ha), K_2 (160kg/ha), K_3 (160kg/ha), K_4 (75kg/ha) respectively. The yield parameters of cassava across the two locations was influenced by different fertilizer treatments. In the two locations, the control treatment had the least in all the yield parameters while the treatments with fertilizer inputs had better yield performance. Again, the treatment with 70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha of poultry manure had the best performance in terms of cassava yield parameters such as biomass weight, stem bundle weight and fresh root weight. The growth and yield parameters of cassava were much better in Otobi than Dorowa due to difference in soil properties. Following the result of this trial, the best rate for better cassava performance in both locations is 70 kg/ha N + 26 kg/ha P_2O_5 + 160 kg/ha K_2O + 3 tons/ha poultry manure. This gave significant impacts on growth and yield of cassava in both locations and was recommended for adoption.

Keywords: *Manihot esculentum,* Yield, NPK Fertilizer, Poultry manure, Southern Guinea

INTRODUCTION

Soil is a central component of terrestrial ecosystems, and a fundamental constituent in sustaining life on earth and therefore approaches to soil fertility enhancement are in constant evolution and improvement (Dumanski, 2013). The degradation of soil physical and chemical fertility represents a loss in ecosystem services and a loss of natural capital assets. Sustainable use of natural resources has become an increasingly relevant issue due to the intensification of human activities and the negative impacts they have since the management influences the physical, chemical and biological processes and consequently modifies the soil chemical and physical properties (Costal *et al*., 2008).

Cassava is an important staple crop for the rural population but more and more used as cash and industrial crop, contributing to economic development of sub-Sahara Africa (SSA). Hence, the sustainable intensification of cassava has become necessary, but the crops yield potential is unknown.

There is wider publicity of the impacts of CO_2 release and decrease in biodiversity, resulting from the conversion of grass land or forest to arable lands *(*Haberl*,* 2015*)*. Moreover, it is expected that there will be losses of good quality agricultural lands for urban development and other non-agricultural uses. In addition, the likelihood of expanding irrigated agriculture in Africa is limited (Viala*,* 2008*,* Strezepek and Boehlert*,* 2010*)*. Therefore, 90% of the increase in crop production will have to be from improved crop varieties and management (Hall and Richards, 2013). The ultimate challenge becomes to provide the growing population in SSA with sustainable, secure supply of safe, nutritious and affordable high quality food; using less land, with low in puts, in the context of global climate and environmental changes. Sustainable agricultural intensification especially in SSA, resulting in increased yields per unit of land has been identified as the most promising approach toward food security. Cassava *(Manihot esculenta* Crantzs is a major staple food in SSA and has been vital to food security despite the low productivity in the area (Howeler *et al.,* 2013, Senkoro *et al.,* 2018). There is a large potential to sustainably increase the crops productivity. Subsequently, increasing food availability and provision of other by products for industrial uses.

This research was conducted to find out the yield of cassava and the dynamics of nutrient limitations in relation to water availability and nutrient availability to obtain better insight and theoretical understanding of how crops response to nutrient availability and application of fertilizer in two different state of Nigeria.

Material and Methods

The experiment was conducted in two locations within the southern Guinea Savanna of Nigeria namely Dorowa Kunu, karu LGA of Nasarawa State and National Root Crops Research Institute Otobi Sub-Station experimental field in Otukpo LGA of Benue State.

The farmers' field in Dorowa Kunu is located within Latitude 8^o47'129''N and Longitude 7^o 51'36.6''E at elevation of 299 m above sea level. The area has a tropical climate with two distinct seasons' dry and rainy seasons. The trial site in the National Root Crops Research Institute experimental field, Otobi Sub-Station Otukpo LGA of Benue State is located within Latitude 7^0 6^1 44.34995'' N and Longitude 8^0 $6^1$25.30429'' N at elevation of 167 .00 m above sea level. The area has a tropical climate with two distinct seasons' dry and rainy seasons. The dry season extends from November to June, while the wet season commences from June and terminates in November. The mean annual temperature of the study area is 23°C and 32 °C for minimum and maximum respectively. The mean annual rainfall is 1,747mm. The geological material of the area is basement complex which form the parent material for the soils of the study area (Yusufu, 2017; Audu *et al*., 2018).

A one year trial was conducted in each location. The lands at both locations were slashed, ploughed, harrowed and ridged mechanically in the month of July, 2021. Ridging was done at 1m interval using a disc ridger. An improved cassava variety that was used for experiment was UMUCASS 20 (TME 419), a popular cassava variety in Nigeria, was sourced from National Root Crops Research Institute, Umudike. Umucass has an outstanding characteristics of high yielding, high beta carotene, suitablie for gari and fufu and suitable for high quality cassava flour.

Cassava stakes were planted on the crest of the ridge for the trial and each planting stake was measure about 25 cm length and was planted at 45^0 orientation at 1m x 1m planting distance to give a population density of 10,000 stands /ha. Inorganic N fertilizer was applied as Urea and was blended with single superphosphate (SSP), Muriate of patash (MOP) and poultry manure at the rate of 80 kg ha^{-1} N, 26 kg P_2O_5 ha^{-1}, 160 kg K_2O/ ha^- and three tons of poultry manure. Split application was done immediately after planting and second application was done 8 weeks after planting (8 WAP). The doses were applied by side dressing 5 cm away from the plant and 5cm depth. The field was weeded manually three and eight weeks after planting (WAP), and under brushed 32 weeks after planting (WAP) which kept cassava stands weed free before harvest.

The experimental design was laid in a Randomized Complete Block Design (RCBD), the trial was laid out in plot size of 5 m x 6 m, with four treatment combinations replicated four times.

The treatment combinations used are as follows: Treatment 1: Control, Treatment 2: 80 kg/ha N, 26 kg/ha P_2O_5 plus 160 kg/ha K_2O, Treatment 3; 70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 ton/ha poultry manure, Treatment 4; 90 kg/ha N, 20 kg/ha P_2O_5 plus 75 kg/ha K_2O

Soil samples were obtained from the ploughed layer (0-20) with the aid of soil auger at the beginning of the experiment and bulked. Composite sample were taken and sieved. After harvest soil samples were taken on the basis of treatments. A total of four composite soil samples each were taken from each location and were analyzed in the laboratory.

Crop data was collected to study the treatment effect on the plant growth and yield. This include: plant height (cm) achieved by measuring with meter rule, stem girth (mm) measured with Vernier caliper, number of leaves determined by counting, plant canopy Cover (cm) was calculated by multiplying the length of the canopy cover by the width. Fresh root yield (tones/hectare) was determined by the weight of fresh harvested root using weighing balance.

Collected data were subjected to statistical analysis. Soil data were analysed using descriptive statistics while data on cassava growth and yield parameters were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) 2023 version. Significant means were separated using Duncan multiple range test (DMRT) at 0.05 level of significance.

Results and Discussion

The soils of Dorowa Kunu were loamy sand in texture characterized by very high sand (806 g/kg) content and low silt and clay contents (120 and 74 g/kg respectively). The soil reaction was slightly acidic (6.4), low in organic matter content (4.0 g/kg), low in total nitrogen reserve (0.60 g/kg) and low available phosphorus in the soil (18.50 mg/kg). Soil exchangeable cations were generally low. Calcium, magnesium, exchangeable potassium, exchangeable sodium and exchangeable acidity. The effective cation exchange capacity was low (11.04 cmol/kg). Though the base saturation percentage was seemingly high, (92.75 %), it is based on ECEC.

In Otobi location, soil textural class was sandy loam with moderate sand content of 686 g/kg. Silt and clay contents were also moderate with values of 200 g/kg and 114 g/kg respectively. Soil reaction was moderately acidic having a pH of 5.5. Total nitrogen reserve was very low (0.70 g/kg), as well as available phosphorus in the soil determined as 15.0 mg/kg. Soil organic carbon was moderately low (7.9 g/kg). The soil exchangeable cations were generally low. Calcium was 6.80 cmol/kg followed by magnesium (4.40 cmol/kg). The ECEC was moderately low. Though base saturation percentage appeared to be high, it was based on ECEC not CEC.

Table 1: Pre-planting Physical and Chemical properties of the experimental sites at Dorowa Kunu and Otobi

Parameter	Dorowa Kunu	Otobi
P^H	6.4	5.5
Total N (gkg^{-1})	0.60	0.70
Avail P ($mgkg^{-1}$)	18.50	15.0
Organic C (gkg^{-1})	4.00	7.9
Exch Ca (cmol kg^{-1})	6.40	6.80
Exch Mg (cmol kg^{-1})	3.60	4.40
Exch k (cmol kg^{-1})	0.15	0.16
Exch Na (cmol kg^{-1})	0.09	0.10
EA (cmol kg^{-1})	0.80	0.80
ECEC (cmol kg^{-1})	11.04	12.26
BS (%)	92.75	93.43
Sand (gkg^{-1})	806	686
Silt (gkg^{-1})	120	200
Clay (gkg^{-1})	74	114
Textural classification	Loam sand	Sandy loam

Growth Parameters of Cassava

The growth parameters of cassava in two locations as influenced by different rates of fertilizer combinations are presented in tables 2 and 3 below

Table 2 Growth Parameters of Cassava at Otobi and Dorowa as Influenced by Different Fertilizer Treatments

Treatments	Plant height cm	Stem girth cm	Number of leaves	Plant height cm	Stem girth cm	Number of leaves
Location		Otobi			Dorowa	
Control N1 P1 K1	76.92^{c}	1.6642^{b}	57.2908^{b}	72.8000^{c}	1.6075^{b}	49.6667^{b}
N2 P2 K2	88.8917^{c}	2.1092^{a}	77.0192^{a}	87.1250^{b}	2.0542^{a}	73.2500^{a}
N3 P3 K3	115.4833^{a}	2.2883^{a}	85.0400^{a}	106.1525^{a}	2.2483^{a}	80.2500^{a}
N4 P4 K4	102.3167^{ab}	2.2200^{a}	78.4442^{a}	101.1525^{a}	2.1375^{a}	76.2500^{a}
Sig.	*1.000*	*0.265*	*0.115*	*1.000*	*0.245*	*0.106*

NB: Means followed by the same superscript within a column are statistically the same at p0.05 using DMRT

Table 3 Growth Parameters of Cassava at Otobi and Dorowa Months after Planting (MAP) under Different Fertilizer Treatments

Treatments	Plant height cm	Stem girth cm	Number of leaves	Plant height cm	Stem girth cm	Number of leaves
MAP		Otobi			Dorowa	
3.00	75.1688^{c}	1.5563^{b}	25.8456^{c}	74.2000^{c}	1.5469^{b}	25.1875^{c}
6.00	94.9125^{b}	1.6363^{b}	75.9375^{b}	90.4000^{b}	1.6100^{b}	74.6875^{b}
9.00	117.6250^{a}	3.0188^{a}	121.5625^{a}	111.0081^{a}	2.8788^{a}	109.6875^{a}
Sig.	*1.000*	*0.707*	*1.000*	*1.000*	*0.245*	*0.106*

NB: Means followed by the same superscript within a column are statistically the same at p0.05 using DMRT

Yield Parameters of Cassava

The yield parameters of cassava as influenced by different levels and combination of fertilizers at two different locations are presented Table 4

Table 4 Yield Parameters of Cassava at Otobi and Dorowa as Influenced by Different Fertilizer Treatments

Treatments	Biomass weight kg	Stem bundle weight kg	Fresh Root weight kg	Biomass weight kg	Stem bundle weight kg	Fresh Root weight kg
Location		Otobi			Dorowa	
N1 P1 K1	20.1750^{b}	375.000^{c}	31.1200^{b}	19.9750^{b}	367.000^{c}	26.5250
N2 P2 K2	25.7125^{a}	460.000^{b}	43.1950^{a}	25.3050^{a}	432.750^{b}	41.8750
N3 P3 K3	30.3275^{a}	490.000^{a}	49.6075^{a}	30.0800^{a}	465.5000^{a}	46.4750
N4 P4 K4	29.6375^{a}	484.2500^{a}	49.4125^{a}	29.9025^{a}	463.000^{a}	45.1625
Sig.	*0.059*	*1.000*	*0.250*	*0.058*	*0.910*	*0.556*

NB: Means followed by the same superscript within a column are statistically the same at p0.05 using DMRT

Table 5: Paired T-Test for Yield Parameters of Cassava across two Locations (Otobi and Dorowa)

	Parameters across Location	Mean	Standard deviation	Standard error	T	df	Sig.2tailed
Pair 1	Biomass wt Dorowa _Otobi	0.15	0.79	0.21	0.75	15	0.47
Pair 2	Stem Bundle wt Dorowa_Otobi	20.31	10.38	2.59	7.83	15	0.000
Pair 3	Fresh Root wt Dorowa _Otobi	3.32	2.99	0.75	4.45	15	0.000

The Paired T-test that compared the yield parameters of cassava across the two locations of Dorowa Kunu and Otobi are presented in Table 4. The result of the paired t-test showed that for biomass weight across the two locations, the treatment effect is the same. In other words, location effect is not significantly different on biomass weight of cassava. However, for stem bundle weight and fresh root weight, the performance of the treatments was not the same in the two locations. This implied that location effect significantly affects the amount of stem bundle weight and the fresh root weight of cassava. Generally, all the yield parameters in Otobi were higher than in Dorowa Kunu.

Table 6: effect of treatment on soil physical and chemical properties of soils of Dorowa kunu experimental site after harvest

Treatment	Sand	Silt	Clay	Textural class	pH	P	O C	N	Ca	Mg	K	Na	EA	ECEC	BS (%)
	g/kg	g/kg	g/kg		H_2O	mgkg^{-1}	g/kg	g/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg
Control N1 P1 K1	850	74	76	LS	5.6	14.80	2.00	0.24	5.00	2.40	0.12	0.07	0.44	10.69	95.91
N2 P2 K2	850	74	76	LS	5.5	22.00	2.60	1.40	6.20	2.60	0.16	0.14	0.42	9.54	95.57
N3 P3 K3	830	114	56	LS	6.5	32.70	8.90	1.69	6.60	3.80	0.20	0.15	0.56	11.29	94.98
N4 P4 K4	830	114	58	LS	5.5	22.35	2.70	1.53	6.40	3.00	0.18	0.12	0.13	9.47	96.09
Mean	*840*	*94*	*66.50*		*5.78*	*22.96*	*4.05*	*1.22*	*6.05*	*2.95*	*0.17*	*0.12*	*0.39*	*10.25*	*95.64*
C.V. (%)	*1.7*	*24.7*	*16.4*		*8.1*	*32.8*	*80.0*	*548*	*11.89*	*20.99*	*20.70*	*29.66*	*47.09*	*8.71*	*0.51*

Table 7: effect of treatment on soil physical and chemical properties of soils of Otobi experimental site after harvest

	Sand	Silt	Clay	Textural class	pH	P	O C	N	Ca	Mg	K	Na	EA	ECEC	BS (%)
	g/kg	g/kg	g/kg		H_2O	mgkg-^{1}	g/kg	g/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg
N1P1K1	710	191	99	SL	5.4	18.60	4.00	1.20	4.80	2.80	0.19	0.11	0.44	10.69	95.91
N2P2K2	650	251	99	SL	5.84	21.80	5.20	1.20	4.80	2.60	0.18	0.12	0.42	9.54	95.57
N3P3K3	680	211	109	SL	6.2	40.10	15.60	8.80	5.20	3.80	0.22	0.19	0.56	11.29	94.98
N4P4K4	730	131	139	SL	5.5	20.10	3.60	2.50	4.80	3.20	0.17	0.11	0.13	9.47	96.09
Mean	*692.50*	*196*	*18.93*		*5.74*	*25.15*	*7.10*	*3.43*	*4.90*	*3.10*	*0.19*	*0.13*	*0.39*	*10.25*	*95.64*
C.V. %	*5.05*	*25.51*	*16.98*		*6.32*	*39.97*	*80.38*	*106.14*	*4.08*	*17.07*	*11.37*	*29.15*	*47.09*	*8.71*	*0.51*

Discussion

Effect of treatment on soil physical and chemical properties of both locations

The effects of the different fertilizer treatments on the soils at Dorowa Kunu and Otobi where the experiments were carried out are presented in tables 5 and 6 above. At the Doruwa Kunu location, the soil textural classes across the different fertilizer treatments was uniformly loamy sand characterized by very high sand content that ranged from 830 – 850 g/kg with a mean value of 840 g/kg. The very low coefficient of variation indicates that there is very low variation in sand content across the treatments. Silt content of the sand is also very low and ranged from 74 to 114 g/kg with a mean value of 94 g/kg. Clay ranged from 56 – 76 g/kg with a mean value of 66.50 g/kg. The soil textural classification after the harvest of crops did not change from what it was before planting of the crops in the field. Soil reaction at Dorowa Kunu across the different fertilizer treatments ranged from 5.5 (moderately acidic) to 6.5 (slightly acidic). The highest pH value of 6.5 was obtained in the treatment with70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. Soil available phosphorus in the soil ranged from 14.80 – 32.70 mg/kg with a mean value of 22.35 mg/kg. The least concentration of available phosphorus was obtained in the control treatment that had no fertilizer inputs, while the highest concentration was obtained in the treatment that received 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. Organic carbon in the soils was in the range of low to moderate with values ranging from 2.00 – 8.90 g/kg having a mean value of 2.70 g/kg. The highest value of OC was obtained in the treatment with 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure while the least value of OC obtained in the control treatment. The result of exchangeable cations showed that Calcium in the soils across the different treatments ranged from 5.00 – 6.60 cmol/kg with a mean value of 6.05 cmol/kg while magnesium ranged from 2.40 – 3.80 cmo/kg with a mean of 2.95 cmol/kg. Exchangeable potassium ranged from 0.12 – 0.20 cmol/kg with a mean value of 0.17 cmol/kg. Sodium ranged from 0.07 – 0.15 cmol/kg while exchangeable acidity ranged from 0.13 to 0.56 cmol/kg. The result showed that all the exchangeable cations were lowest in the control treatment except for exchangeable acidity (EA) while the higher values were obtained in the treatment that had 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. For effective cation exchange capacity (ECEC), the values across the different treatments ranged from 9.47 – 11.29 cmol/kg with a mean value of 10.25 cmol/kg. The values of ECEC were rated as being low. Base saturation percentage ranged from 94.98 – 96.09 % with a mean of 95.64 %.

At the Otobi location, Soil textural classification was uniformly sandy loam with sand fraction ranging from 650 – 730 g/kg with a mean value of 692.50 g/kg, silt ranged from 131 – 251 g/kg with a mean value of 196 g/kg while clay content across the different treatments ranged from 99 - 139 g/kg. The pH of the soils ranged from 5.4 – 6.2 (moderately acidic). The available phosphorus ranged from 18.60 – 40.10 mg/kg. The least value for available phosphorus was obtained in the soils of the control treatment that had no fertilizer input while the highest available phosphorus value was obtained in the soils of the treatment with 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. Organic carbon ranged from 3.60 – 15.60 g/kg rated as very low to moderate. The low OC was obtained in the treatment that had 90 kg/ha N, 20 kg/ha P_2O_5 plus 75 kg/ha K_2O. Total nitrogen in the experimental soils ranged from 1.20 – 8.80 g/kg rated as low to moderate. The highest nitrogen value was obtained from the treatment with 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure while the control with the other treatments had lower TN values. The distribution of exchangeable cations in the soils was low. Calcium ranged from 4.80 – 5.20 cmol/kg (very low), magnesium ranged from 2.60 – 3.80 cmol/kg and exchangeable K ranged from 0.17 – 0.22 cmol/kg. Also, Sodium (Na) ranged from 0.11 – 0.19 cmol/kg while exchangeable acidity ranged from 0.13 – 0.56 cmol/kg. The ECEC ranged from 9.47 – 11.29 cmol/kg. From the results obtained, the highest values of the exchangeable cations were all obtained from the treatment that had 70 kg/ha N, 26kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. Base saturation percentage ranged from 94.98 – 96.09 %. The base saturation was high but it was determined based on ECEC and not the soil's CEC.

Effect of treatment on Soil Texture

The results of post-treatment soil samples shows the residual effects of different fertilizer combinations on the soil. Soil texture of both Dorowa Kunu and Otobi remained unchanged from the texture before the commencement of the experiments. This implied that the fertilizer treatments did not alter or influence the textural status of the soils. This result agrees with the works of Barnabas and Nwaka (2014) and Barnabas *et al* (2017) when they reported that soil texture is a permanent soil property that does not easily change. Also, Soil Survey Staff (2014) described soil texture as a permanent soil attribute that does not change within a short time. Changes in soil texture are more pronounced when erosion of materials or deposition of same occurs in a soil landscape. Thus soil texture is expected to remain the same or closely the same after the application of the treatments as is seen in the results of the post treatment soil analysis.

Soil texture controls many other properties of the soils especially the ease with which erosion washes the soil, water movement within the soil, nutrient and moisture retention in the soil. The soils of DorowaKunu and Otobi are high in sand content and this implies that the soil structure will be relatively weak. This type of soils would require a large input of organic manures to improve the structure and productive potential of the soils, thus enhancing its capacity to favourably sustain crop performance

Effect of treatment on Soil pH

There was no visible changes in the soil pH after the different fertilizer treatments were administered. The soil pH after the treatments remained moderately to slightly acidic. These range of pH favours the availability many plant nutrients especially phosphorus, sulphur and potassium as well as a vast range of other micronutrients that are essential for good plants performance as reported by Adepetu *et al*., (2014). Also, Barnabas *et al*, (2017) and Wapa *et al*, (2020) all observed that soil pH is a master property that controls many other chemical properties of the soils and is important in determining the solubility, mobility and availability of nutrients to crops.

Effect Treatment on Soil Organic carbon, Total Nitrogen and Available Phosphorus

The organic carbon of the soils was initially low especially at the Dorowa location prior to the commencement of the experiment. This was attributed to the porous nature of the soils that are sandy in texture and prone to loses due to leaching. The post treatment analysis of the soils showed that soil organic carbon became much lower especially in the composite samples from the control treatment as well as in other treatments that had fertilizer inputs such as the treatment with 80 kg/ha N, 26 kg/ha P_2O_5 plus 160 kg/ha K_2O; and the treatment with 90 kg/ha, 20 kg/ha P_2O_5 plus 75 kg/ha K_2O. However, the treatment with 70kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure had a much higher soil organic carbon content. This is probably due to the addition of 3 tons/ha of poultry manure and that has boosted the organic carbon reserve of the soil. The reduction in organic carbon content of the soil could be attributed to plant roots absorption and removal from the soil. This agrees with Wapa *et al*, (2017), Chude *et al*, (2011) and Agbede (2009). At the Otobi location, the same trend was observed for organic carbon.

There was a significant increase in the available phosphorus content of the soils in both locations in the post treatment soil samples. The increase in available phosphorus content could be attributed to the application of P_2O_5 in the soils as fertilizer. Also, the poultry manure added in one of the treatments is responsible for the significant rise in the available phosphorus concentration of the soils. Also, P is known to be less mobile in soils and can last a long time even up to another cropping season. Ogbodo (2011) worked on the availability of flood plain soils of south eastern Nigeria and reported that soil moisture content and application of phosphorus as fertilizer to crops are factors that enhances its availability in the soils. At both Otobi and Dorowa locations, the significant rise in phosphorus content of the soils is attributed to the application of the nutrient as part of the fertilizer components of the treatment. This is important for cassava crop being a root crop as reported also by Onyekwere *et al*, (2020).

Nitrogen is one of the most limiting factor in crop production. The pre-treatment samples showed that N in the soils of both Otobi and DorowaKunu was very low. The post treatment samples showed that there was an increase in the N content of the soils especially in the soils treated with 70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha poultry manure. The addition of the poultry manure has significantly boosted the N reserve of the soil in spite of plant roots absorption. Nitrogen is very mobile in soils and is prone to losses due to leaching, extremes of temperature and rainfall (Chude *et al*., 2011 and Adepetu *et al*., 2014).

Effect Treatment on Exchangeable Cations of the soil

The soils exchangeable cations were low before and after the treatment administration. All the basic cations such as calcium, magnesium, potassium and sodium were all low in the soils. Most tropical soils are known to be very low in basic cations probably due to excessive leaching, nutrient mining and extremes of climate. Effective cation exchange capacity is also low.

Conclusion

The different fertilizer combinations influenced the growth parameters of cassava plant. All the growth parameters such as plant height stem girth and numbers of leaves were better in all the treatments except the control treatment. However, the treatment with 70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha of poultry manure had the best performance in terms of growth parameters of cassava in the two locations – Otobi and DorowaKunu.

The yield parameter of cassava across the two locations was influenced by different fertilizer treatments. In the two locations, the control treatment had the least in all the yield parameters while the treatments with fertilizer inputs had better yield performance. Again, the treatment with 70 kg/ha N, 26 kg/ha P_2O_5, 160 kg/ha K_2O plus 3 tons/ha of poultry manure had the best performance in terms of cassava yield parameters such as biomass weight, stem bundle weight and fresh root weight. The growth and yiel

parameters of cassava were much better in Otobi than Dorowa due to difference in soil properties.

Considering soil properties before and after application of treatments, it is concluded that the different fertilizer treatments influenced some soil properties.

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