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Research Article

Comparative effects of some soil amendments on the agronomic performance of maize varieties in a low fertile soil

Rimande AHMADU[1], Kolawole LAW-OGBOMO[2]*, Sunday A. OGEDEGBE[2]

[1]*Federal University, Faculty of Agriculture and Life Science, Department of Crop Production and Protection, Wukari, Nigeria; rimandeahmadu@yahoo.com*
[2]*University of Benin, Faculty of Agriculture, Department of Crop Science, Benin City, Nigeria; edomwonyi.law-ogbomo@uniben.edu (*corresponding author); sundayogedegbe@uniben.edu*

Abstract

A field study was conducted in cropping seasons to determine the comparative effects of some soil amendments on postharvest soil chemical properties and performance of maize (*Zea mays* L.) in humid low fertile soil. The experiment was laid out in 3 x 4 split plot arrangement, fitted into a randomized complete block design with three replications. The main plots were maize varieties ('SUWAN-I-SR', 'Oba 98' and 'Uselu' local maize) and the subplots were soil amendments (control, poultry manure, cattle manure and NPK). Data were collected on growth parameters (plant heights (cm), number of leaves, leaf area index and stem girth) at 50% silking stage. At harvest, data were collected on grain yield components and several soil chemical properties. The results showed that the variety had significant ($p<0.05$) effect on growth and yield performance of maize. Fertilizer application significantly ($p<0.05$) improved maize vegetative characters. The fertilized plants were higher in all the parameters accessed than the unfertilized plants. 'SUWAN-1-SR' had the highest grain yield (2.49 t ha^{-1}). The highest grain yield of 2.22 and 2.11 t ha^{-1} were produced from plants fertilized with NPK and poultry manure, respectively. Variety significantly ($p<0.05$) influenced organic carbon, available P, exchangeable acidity (H^+ and Al^{3+}). Poultry and cattle manures improved soil fertility through increase in soil pH, organic carbon and exchangeable cations. Since NPK and poultry manure had the highest grain yield, poultry manure could be used as viable option for maize production in low fertile soil environment, due to low cost and for environmental cleanliness.

Keywords: fertilizer types; varieties; vegetative growth; yield components

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice (Mohamed and Hassan, 2011). The crop is commonly cultivated worldwide, including in the tropics and warm sub-tropics. It is one of the most important cereals, both for human and animal consumption and is grown for grain and forage. The world production of the crop is of about 785 million tons of grain from about 158 million ha (FAO, 2009). In Nigeria, maize is an important food, fodder and industrial crop grown both commercially

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and at subsistence level. Maize as food is used for the production of indigenous and commercial food products (Agba *et al*., 2012).

The crop productivity is low in Nigeria as compared to other countries due to low nutrient status of most tropical soils and the use of unimproved varieties among other factors. Most soils in humid tropics are intensely weathered, leached and intensively cultivated, leading to impoverished soil (Akanbi and Togun, 2002). Hence, it lacks the capacity to support plant growth to produce optimally. The inherently low fertility status of the soil had resulted in poor crop performance in the field. Most farmers are not aware that new improved varieties exist, which are adapted to their locality. Farmers use the improved varieties without considering the type of location and what they were bred for. Non-use of improved varieties is hindrance to high crop performance.

Efforts aimed at obtaining high yield of maize would necessitate the augmentation of the nutrient status of the soil to meet the crop's requirement for optimum productivity and maintenance of soil fertility. Increasing the nutrient status of the soil may be achieved by boosting the soil nutrient content either with the use of inorganic fertilizers such as NPK or through the use of organic materials such as poultry or cattle manures. The maize crop requires an adequate supply of nutrients, particularly nitrogen, phosphorus and potassium for optimum growth and yield (Agba *et al*., 2012). Inorganic fertilizer exerts a strong influence on plant growth, development and yield (Stefano *et al*., 2004). The availability of sufficient growth nutrients from inorganic fertilizers could lead to improved soil fertility. However, due to high cost and scarcity of inorganic fertilizer, most farmers cannot afford its usage and under intensive cultivation, it is often associated with soil acidity and nutrient imbalance (Ojeniyi, 2000). This had diverted the attention of agronomists towards making use of organic nutrients for improving soil fertility that allow for profitable crop production (Somani and Totawat, 1996). Contradictory results about positive and negative effects of soil amendments (both organic and inorganic) have been found in literature.

There is lack of research work on the evaluation of soil amendments on improved and local varieties of maize in the study area. However, there is need to identify the best variety and the most appropriate soil amendment thereby. Hence, the present study was conducted to evaluate the comparative effects of some soil amendments on performance of several maize varieties in an ultisols of Benin City, Edo State, Nigeria.

Materials and Methods

Description of study location

The study was conducted in 2015 and 2016 at the experimental site of the Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. The site is situated at latitude 6°44 and 7°34 and longitude 6°5 and 6°43 with an altitude of 162 m above the sea level. The temperature at maximum was about 30 °C and minimum of 24 °C. Mean annual rainfall is about 2,300 mm.

Experimental design and cultural practices

The experimental site measuring 23 x 21.5 m was cleared, ploughed and harrowed. Tapes, pegs, mallet and ropes were used to demarcate the area into 3 blocks of 36 subplots. The experiment was laid out in a 3 x 4 split-plot arrangement fitted into randomized complete block design (RCBD) and replicated three times. The main plots were the maize varieties ('SUWAN-1-SR', 'Oba 98' and 'Uselu' which is local) and the sub-plots were the soil amendments (control, poultry manure, cattle manure and NPK 15:15:15 fertilizer). Each of the plots measured 2 x 5 m with a spacing of 0.5 m apart between plots and 1 m space between blocks. Poultry and cattle manures were applied on the subplots in each main plot at 15 t ha^{-1} four weeks prior to sowing for equilibration. Maize seeds of improved varieties ('SUWAN-I-SR' and 'Oba 98') sourced from International Institute of Tropical Agriculture (IITA) was used, while the local variety was bought from Uselu market, Benin-City, Edo State, Nigeria. Two maize seeds were sowed per whole and spaced 75 x 25 cm. Two weeks after germination, they were thinned down to one plant per stand. NPK 15:15:15 at 400 kg ha^{-1}

was applied in two equal splits at 2 weeks after sowing (WAS) and at 50% tasseling. Weeding was done manually with hoe at 2 WAS and subsequently at when due. Harvesting was done when maize ears have fully turned brown and dry at physiological maturity indicated by block layer formation. Harvested ears were air dried to 12% moisture content.

Soil sample collection, organic manure and laboratory analyses

Soil sampling were randomly collected from 36 plots at a depth of 0-15 cm using auger and bulked to form composite sample before fertilizer application and cropping with maize. After harvest, another 36 soil samples were collected separately from all the plots. The soil samples were air-dried and sieved through 2 mm sieve and used for soil physical and chemical properties determination. However, after harvest, soil samples from all plots were analysed for their chemical properties only. All the soil samples were collected in small polythene bags and labeled accordingly. Before the application of organic manure (poultry and cattle manures), they were sampled and air-dried in polythene bags for analysis.

Particle size analysis was determined by hydrometer method (Gee and Or, 2002). Soil pH was estimated potentiometrically in a glass electrode in deionized at a soil/solution 1:1. Organic carbon was determined by wet dichromate acid oxidation method (Page, 1982). Total nitrogen was determined by micro Kjedahl digestion method (Bremner and Mulvancy, 1982). Available phosphorus was extracted using calcium chloride extraction method (Houba *et al*., 2000).

Exchangeable bases (Ca, K, Mg and Na) were extracted using IN ammonium acetate (NH_4OAC) solution at pH 7.0. Calcium and magnesium content were determined by volumetrically ethylene diaminetetra-acetic acid ((EDTA) titration procedure of Black (1965), while potassium and sodium using flame photometer. Exchangeable acidity was determined by titration method (Anderson and Ingram, 1993). For lead determination, 2 g of each sample was digested using 20 ml of concentrated mixture of hydrogen nitrate (HNO_3, $HClO_4$) and H_2SO_4 in 2:1:1 ratio on temperature hot plate. When the volume was reduced with clear digested solution, the content was allowed to cool and transferred to a 50 ml volumetric flask. The volume was made up to the mark then the lead was determined by atomic absorption spectrophotometer (AAS).

Organic fertilizers (cattle and poultry manures) were analyzed for pH, organic carbon, nitrogen, phosphorus, potassium, calcium, magnesium and lead. pH was determined at 1:1 soil to water ratio using manure to water ratio, by using digital glass electrode pH meter. Organic carbon was determined by the wet dichromate acid oxidation method (Page, 1982). Total nitrogen was determined by micro Kjedahl digestion method (Bremner and Mulvancy, 1982). Available phosphorus was extracted using calcium chloride extraction method (Houba *et al*., 2000). Exchangeable base (Ca,K,Mg and Na) were extracted using IN ammonium acetate (NH_4OAC) solution at pH 7.0. Calcium and magnesium content were determined volumetrically with ethylene diaminetetra-acetic acid ((EDTA) titration procedure (Black, 1965), while potassium using flame photometer. The lead, chromium and cadmium were determined by atomic absorption spectrophotometer (AAS).

Data collection

Data were collected on five randomly selected plants from the inner row of each plot on plant height, number of leaves, leaf area and stem girth at 50% silking. Plant height was measured in cm from the ground level to the last leaf before tassel. Stem girth was measured at 5 cm above ground level on each sampled plant with the use of Vernier caliper. Number of leaves refers to the total count of the fully expanded leaves per plant. Leaf area index (LAI) was determined by measuring the length and width of the sampled leaves using a meter rule calibrated in cm and multiplied with a factor of 0.75 and the number of leaves to observed the leaf area of the plant (Remison, 1997). From the leaf area, LAI was computed as: LAI =Leaf area/Land area (Remison, 1997).

At harvest, data were collected on number of kernel row cob^{-1}, number of kernels in a row, 1,000 grain weight and grain yield. The number of kernel rows cob^{-1} was obtained by counting the number of kernel row of each of the sampled plant and average computed. The number of kernels in each row of the sampled plants was counted and average computed. Grains of five randomly selected plants were randomly collected from each plot; 1,000 grains were counted out, weighed and expressed in grams. Grains of five randomly selected plants were weighed separately, sum up and expressed in t ha^{-1}.

Data analysis

Data collected were subjected to combined analysis of variance by the use of GENSTAT programme, version 8.1 (GENSTAT, 2005). Significant differences among treatment means separated using least significant difference (LSD) at 5% level of significant.

Results

Physical and chemical properties of the experimental site before cropping with maize and the chemical composition of organic fertilizers

The physical and chemical properties of the soil prior to cropping with maize and chemical composition of cattle and poultry manures are presented in Table 1. Soil samples of 2015 and 2016 were textually sandy loam. The soils were highly acidic with moderate organic carbon. However, total nitrogen, available phosphorus. Exchangeable cations (calcium, magnesium, potassium and sodium) were low. Similarly, the exchangeable acidity (H^+ and Al^{3+}) were also present in both soil samples.

The pH of poultry manure was neutral, while that of cattle manure was slightly acidic. Both contained high amount of organic carbon and appreciable quantities of total nitrogen, available P and exchangeable cations. The C:N ratio for both poultry manure and cattle manure were low. Both organic fertilizers also contained lower amount of Pb and exchangeable acidity (H^+ and Al^{3+}).

Growth of maize

The results of the effects of varieties and soil amendments on growth of maize at 50% silking are presented in Table 2. Variety had significant ($p<0.05$) effect on plant height as the shortest plants were observed in 'Uselu' local variety and the tallest plants (128.00 cm) in 'Oba 98'. This trend was also repeated for stem girth and LAI. Higher number of leaves was observed on 'SUWAN-1-SR' and 'Oba 98' than on 'Uselu' local varity.

Soil amendment had significant ($p<0.05$) effect on plant height. All plants treated with soil amendments were significantly ($p<0.05$) taller than control plants. The tallest and thickest plants were observed on plots treated with poultry manure. Poultry manure, cattle manure and NPK had similar values of number of leaves and LAI, but significantly ($p<0.05$) higher than the values unfertilized plants.

Grain yield and its components of maize

The results of the effect of varieties and soil amendments on the grain yield and its components are shown in Table 3. 'SUWAN-1-SR' had the highest number of kernel rows cob^{-1}, number of kernels row^{-1} and grain yield, whereas 1,000 grain weight was significantly higher in 'SUWAN-1-SR' and 'Oba 98' than 'Uselu' local. Soil amendment application had significant effect ($p<0.05$) on grain yield and its components. Number of kernel rows cob^{-1} ranged from 10 for untreated control to 13 for plants treated with cattle manure. All soil amendment treated plants had similar number of kernels in a row and 1,000 grain weight, but significantly ($p<0.05$) higher than untreated plants. The higher grain yields were observed on plants fertilized with poultry manure (2.11 t ha^{-1}) and NPK (2.22 t ha^{-1}), while the least grain yield was observed on control (1.07 t ha^{-1}).

Table 1. Physical and chemical properties of the experimental site before cropping with maize and chemical composition of organic fertilizers

Parameter	Soil		Organic fertilizer	
	2015	2016	Poultry manure	Cattle manure
Particle (g kg^{-1})				
Sand	880.00	876.00	NA	NA
Silt	56.00	58.20	NA	NA
Clay	64.00	65.80	NA	NA
pH	4.40	4.60	7.00	6.90
Organic carbon (g kg^{-1})	20.65	21.40	35.41	32.25
Total nitrogen (g kg^{-1})	0.96	0.88	16.50	10.40
C:N	21.51	24.32	2.15	3.10
Available phosphorus (mg kg^{-1})	8.22	7.96	9.64	5.70
Exchangeable cation (cmol kg^{-1})				
Calcium	0.42	0.46	0.68	0.51
Magnesium	0.21	0.28	2.15	1.80
Potassium	0.30	0.25	1.06	0.83
Sodium	0.18	0.16	0.54	0.51
Exchangeable acidity (cmol kg^{-1})				
H	0.81	0.62	0.03	0.03
Al	0.40	0.10	0.08	0.64
Pb (mg kg^{-1})	0.00	0.00	0.24	0.24

Table 2. Effects of the studied maize varieties and fertilizer types on the growth of maize

Treatment	Plant height (cm)			Stem girth (cm)			Number of leaves			Leaf area index		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Variety												
'SUWAN-1-SR'	113.80	218.00	165	6.06	6.090	6.09	16	15	15	2.98	3.96	3.45
'Oba 98'	110.20	146.00	128	5.72	6.080	5.90	16	14	15	2.58	3.73	3.16
'Uselu' local	90.40	120.00	105	4.92	6.040	5.48	14	14	14	1.96	3.58	2.77
$LSD_{(0.05)}$	13.450	17.000	15.225	0.293	ns	0.647	0.6	ns	0.7	0.445	ns	0.891
Fertilizer types												
Control	86.60	108.00	43.30	5.04	5.41	5.25	14	14	14	1.92	2.77	2.34
Poultry manure	122.00	281.00	204.20	6.04	6.75	6.40	15	15	15	2.47	4.39	3.43
Cattle manure	109.40	135.00	122.20	5.59	6.01	5.80	15	15	15	2.53	3.68	3.11
NPK	104.60	127.70	123.40	5.61	6.11	5.86	16	15	15	3.11	4.13	3.62
$LSD_{(0.05)}$	13.450	17.000	15.26	0.293	1.00	0.647	0.6	ns	0.7	0.445	1.337	0.574
Interaction	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns-not significant at 5 % level of significant

Table 3. Effects of the studied maize varieties and fertilizer types on the growth of maize

Treatment	No. of kernel row in a cob			No. of kernel in a row			1000 grain weight (g)			Grain yield (t ha^{-1})		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Variety												
'SUWAN-1-SR'	11	13	12	11	18	14	230.3	215.00	222.65	1.75	3.22	2.49
'Oba 98'	11	12	11	10	13	11	225.5	204.00	214.75	1.13	1.70	1.42
'Uselu' local	11	11	11	7	13	10	163.3	197.90	180.60	1.10	1.70	1.40
$LSD_{(0.05)}$	ns	0.6	0.7	ns	3.4	2.3	36.43	19.180	27.805	0.960	0.789	0.524
Fertilizer types												
Control	10	10	10	7	9	8	154.9	175.50	165.20	0.93	1.20	1.07
Poultry manure	11	13	12	9	18	13	2249	221.80	223.35	1.18	3.04	2.11
Cattle manure	14	12	13	9	15	12	213,6	204.80	209.20	1.29	2.07	1.68
NPK	11	12	11	12	16	13	332.2	.223.00	227.60	1.91	2.52	2.22
$LSD_{(0.05)}$	0.700	0.6	0.7	12	3.4	2.3	36.43	19.180	27.805	0.451	0.489	0.524
Interaction	ns	ns	ns	3.9	ns	ns	25.35	ns	ns	0.960	0.787	ns

ns-not significant at 5 % level of significant

Postharvest soil chemical properties as influenced by variety and fertilizer type

The results of the postharvest soil chemical properties as influenced by varieties and soil amendments are presented in Table 4. Variety only had significant effect ($p<0.05$) on organic C, available phosphorus and exchangeable acidity (H^+ and Al^{3+}). Higher organic C was observed on 'SUWAN-1-SR' and 'Oba 98' plots than 'Uselu' local plots. The highest available P was observed on 'SUWAN-1-SR' plots, followed by 'Uselu' local and 'Oba 98' in that order. Exchangeable H^+ ranged between 0.22 and 0.43 cmol kg^{-1} for 'Oba 98' and 'SUWAN-1-SR', respectively. 'SUWAN-1-SR' was not significantly ($p>0.05$) different from 'Uselu' local. Exchangeable Al^{3+} was more abundant on 'SUWAN-1-SR' plots and less on 'Oba 98' and 'Uselu' local.

The soil pH ranged between 4.84 (control) and 5.48 (cattle manure). However, cattle manure and poultry manure had similar pH values. Organic C contents were higher on manures treated plots than cattle manure (20.44 g kg^{-1}). The organic carbon contents of NPK (15.90 g kg^{-1}) and control (14.74 g kg^{-1}) plots were comparable and the least. The highest total N, available P and exchangeable K were observed in NPK treated plots and the least were observed on control plots.

Exchangeable Ca^{2+} and Mg^{2+} were more abundant on poultry and cattle manures treated plots and least on control and NPK plots. Exchangeable Na^+ concentration was highest in poultry manure plots (0.22 cmol kg^{-1}) and least on control plots. NPK plots exhibited the most abundant exchangeable H^+ (0.41 cmol kg^{-1}), which was statistically comparable to control plots and the least were observed on poultry (0.27 cmol kg^{-1}) and cattle (0.23 cmol kg^{-1}) plots. Exchangeable Al^{3+} was most abundant on NPK and poultry manure treated plots and least on control plots. The most contaminated heavy metal (Pb) plot was cattle manure and completely absent in control plots.

The interaction of varieties and soil amendments type on soil chemical properties was only significant on pH, available P, exchangeable cations (Mg^{2+} and Na^+) and Pb. The highest soil pH (5.48) was observed from 'Oba 98' plots treated with cattle manure (Figure 1). 'SUWAN-1-SR' plots treated with NPK had the highest available P (16.64 mg kg^{-1}) (Figure 2). The highest Mg content was observed from 'SUWAN-1-SR' and 'Oba 98' plots treated with poultry and cattle manures, respectively (Figure 3). Figure 4 shows the interaction effect of variety and fertilizer type on exchangeable Na plot. Plot cropped with 'SUWAN-1-SR' and 'Uselu' local treated with poultry manure had the highest exchangeable Na^+ concentration (0.23 cmol kg^{-1}). Pb was most abundant in plots cropped with 'Uselu' local fortified with cattle manure (0.22 mg kg^{-1}) (Figure 5).

Table 4. Effects of maize variety and fertilizer type on the postharvest soil chemical properties

Time	Treatment	pH	Organic C	Total N	Available P	Exchangeable cations (cmol kg^{-1})				Exchangeable acidity (cmol kg^{-1})		Heavy metal (mg kg^{-1})
			(g kg^{-1})	(g kg^{-1})	(mg kg^{-1})	Ca	Mg	K	Na	H	Al	Pb
Early season 2015	Variety											
	'SUWAN-I-SR'	5.13	19.63	1.41	10.15	0.55	0.26	1.05	0.16	0.57	0.17	0.11
	'Oba 98'	5.23	18.40	1.45	9.18	0.54	0.27	1.01	0.19	0.28	0.08	0.11
	'Uselu' local	5.10	17.39	1.50	9.96	0.49	0.24	1.12	0.20	0.28	0.07	0.07
	$LSD_{(0.05)}$	ns	0.645	ns	0.636	ns	ns	0.063	ns	0.153	0.041	ns
	Fertilizer types											
	Control	4.77	14.36	0.76	5.16	0.41	0.21	0.26	0.12	0.43	0.13	0.01
	Poultry manure	5.28	22.85	1.20	9.14	0.59	0.28	0.61	0.22	0.37	0.12	0.07
	Cattle manure	5.56	20.66	1.08	7.80	0.65	0.31	0.57	0.20	0.29	0.08	0.23
	NPK	5.01	16.01	2.76	16.68	0.46	0.22	2.80	0.19	0.41	0.11	0.09
	$LSD_{(0.05)}$	0.262	1.075	0.067	0.439	0.040	0.043	0.052	0.027	ns	ns	ns
	$LSD_{(0.05)\ variety\ X\ Fertilizer}$	0.460	ns	0.131	0.814	0.071	0.106	0.091	0.058	ns	ns	ns
Late season 2015	Variety											
	'SUWAN-I-SR'	5.18	18.80	1.46	9.99	0.51	0.23	1.06	0.18	0.30	0.09	0.07
	'Oba 98'	5.32	18.94	1.39	9.10	0.66	0.24	1.03	0.19	0.17	0.05	0.06
	'Uselu' local	5.17	17.26	1.46	9.47	0.56	0.25	1.55	0.17	0.32	0.08	0.05
	$LSD_{(0.05)}$	0.064	ns	ns	ns	ns	ns	ns	ns	ns	0.015	0.005
	Fertilizer type											
	Control	4.92	15.12	0.73	5.12	0.47	0.22	0.26	0.15	0.30	0.08	0.01
	Poultry manure	5.59	22.20	1.16	8.48	0.73	0.25	1.24	0.23	0.17	0.05	0.06

	Cattle manure	5.41	20.22	1.07	7.89	0.62	0.28	0.44	0.18	0.18	0.06	0.16
	NPK	4.97	15.80	2.79	16.60	0.5	0.20	2.92	0.16	0.41	0.10	0.05
	$LSD_{(0.05)}$	0.234	2.927	0.169	1.095	0.132	0.039	1.061	0.035	0.111	0.016	0.009
	$LSD_{(0.05)}$ Variety X Fertilizer	0.354	ns	ns	ns	ns	ns	ns	ns	0.203	0.026	0.015
Combined	Variety											
	'SUWAN-I-SR'	5.15	19.21	1.44	10.70	0.53	0.25	1.06	0.17	0.43	0.13	0.09
	'Oba 98'	5.23	18.67	1.42	9.14	0.6	0.25	1.02	0.19	0.22	0.06	0.08
	'Uselu' local	5.13	17.32	1.48	9.61	0.53	0.24	1.34	0.19	0.30	0.07	0.08
	$LSD_{(0.05)}$	ns	0.847	ns	0.355	ns	ns	ns	ns	0.135	0.037	ns
	Fertilizer type											
	Control	4.84	14.74	0.74	5.14	0.44	0.21	0.26	0.14	0.36	..01	0.01
	Poultry manure	5.43	22.53	1.18	8.81	0.66	0.29	0.92	0.22	0.27	0.08	0.06
	Cattle manure	5.48	20.44	1.08	7.84	0.64	0.28	0.51	0.19	0.23	0.07	0.19
	NPK	4.99	15.90	2.78	16.64	0.48	0.21	2.86	0.18	0.41	0.10	0.07
	$LSD_{(0.05)}$	0.170	1.481	0.097	0.554	0.026	0.030	0.512	0.022	0.096	0.024	0.009
	$LSD_{(0.05)}$ Variety X Fertilizer	0.275	ns	ns	0.886	ns	0.061	ns	0.045	ns	ns	ns

ns = Not significance

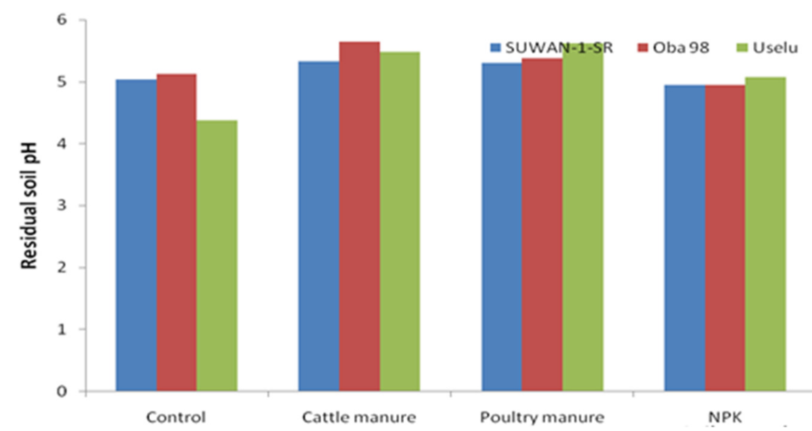

Figure 1. Interaction of maize variety and soil amendment on the residual soil pH

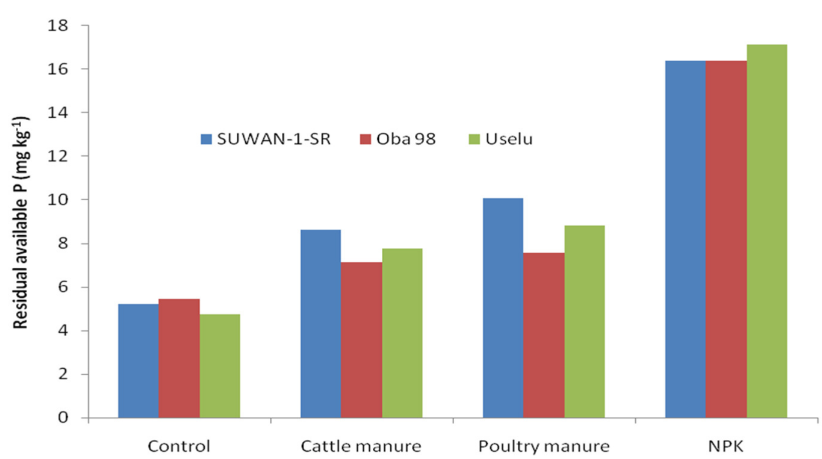

Figure 2. Interaction of maize variety and soil amendment on residual soil available P

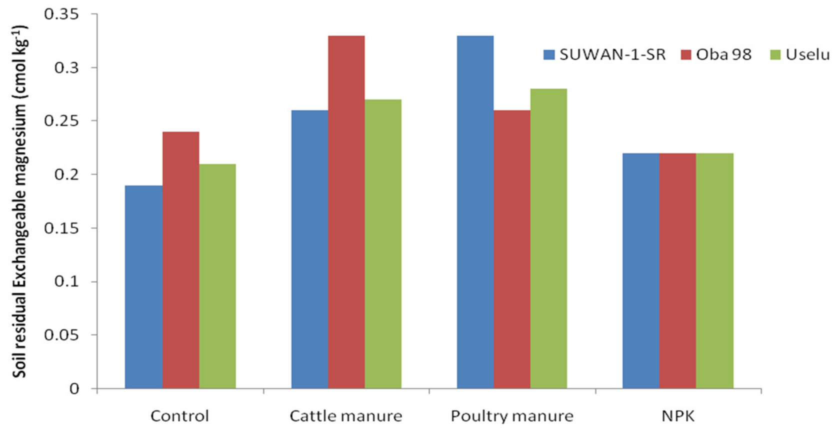

Figure 3. Interaction of maize variety and soil amendment on exchangeable magnesium

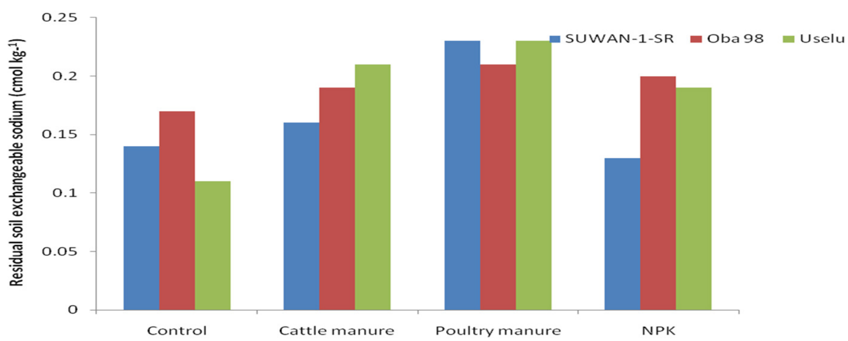

Figure 4. Interaction of maize variety and soil amendment on residual soil exchangeable sodium

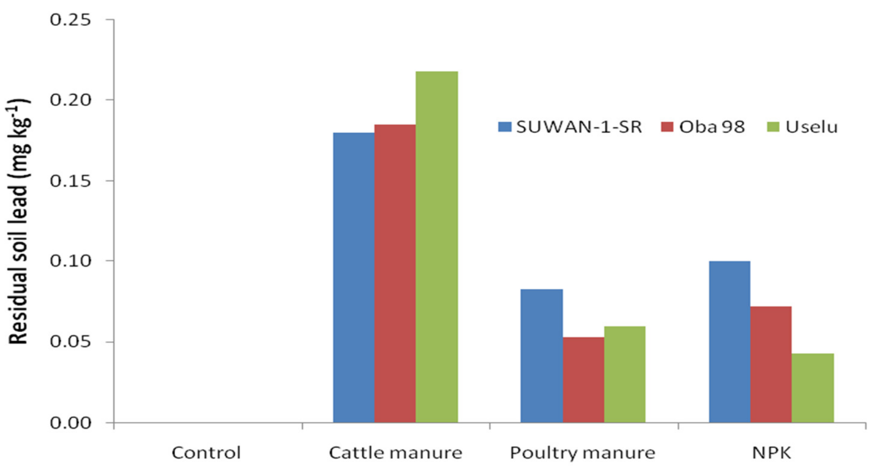

Figure 5. Interaction of maize variety and soil amendment on residual soil lead

Discussion

The soils of the study sites were of low fertility status evidenced through the exhibition of deficiencies of some essential nutrients (total N, available P and exchangeable bases (Ca^{2+} and Mg^{2+}). The soil type was a typical ultisols. The effective cation exchange capacity was less than 10 and is acidic sand. The low fertility status of the soil of the experimental site has resulted in low yield per hectare for maize plant without soil amendment application. This observation is in agreement with Akanbi and Togun (2002) who reported that most of agricultural soils of southern and northern Nigeria are of low fertility status owing to weathering, leaching and intensive cultivation. This implied that reasonable yield could only be achievable through the use of soil amendment and justified the need for augmenting the soil with external fertilizer input in the form of organic (cattle and poultry manures) and inorganic (NPK). An assessment by Stewart *et al*. (2005) found out that 40-60% of crop yields are attributed to fertilizer (commercial fertilizer) use. This increase in crop yield could be attributable to the supplementation of nutrients in the soil by nutrient content of the applied fertilizer.

The chemical composition of cattle and poultry manures indicated that they contained essential plant nutrients in appreciable quantity. The high organic carbon content of the organic fertilizer is an indication of abundant organic matter which plays an important role as reservoir of soil nutrients, buffer the soil reaction, binding the soil particles to form good soil and stimulating the activities of soil organisms. Adekayode and Ogunkoya (2010) reported that manures help to improve the soil physical condition and is an indication of being a major contributor of plant nutrients.

In the hereby study, fertilizer application showed a promising result in improving crop productivity. Soil amendment application promote vegetative growth through the enhancement of plant height, stem girth, number of leaves, leaf area index and total dry matter. The high values of plant height and other parameters with organic (poultry and cattle manures) and inorganic (NPK) fertilizers might be due to their synergistic effect of increasing nutrient use efficiencies and special effects of the fertilizers which acted as the store house of plant nutrients. This coincided with the findings of Adekayode and Ogunkoya (2010) who reported that there was a very high significant difference in maize plant height in plots treated with fertilizers compared with no fertilizer application. The observed significant performance in growth parameters with the application of poultry manure, cattle manure and NPK fertilizer could also be attributed to the essential nutrient elements contained in them that are associated with increased photosynthetic efficiency (Agba *et al*., 2012). Enhancement of plant height implied more avenue for emergent of leaves. Leaf is an organ of photosynthesis. Any increase in the number of leaves will increase the plant photosynthetic ability and thus enhanced plant growth and vigour. Higher LAI signify greater leaf production rate (Law-Ogbomo *et al*., 2012). LAI of any plant is a measure of the capacity of the photosynthetic system of translocation. Increase in LAI is an indication of greater light interception. This implied efficient production of assimilates (photosynthate) leading to higher dry matter and economic yield production (Law-Ogbomo *et al*., 2012).

The study showed higher number of kernels per cob and other parameters of the maize plant on plots treated with soil amendments. This might be due to effects of these fertilizers that improved the nutrient efficiencies and normal development of the maize cob with higher number of kernel rows cob^{-1}, number of kernels row^{-1}, 1,000-grain weight and grain yield. Number of kernels cob^{-1} had direct effect on grain yield of maize per unit area (Haseeb-ur-Rehman *et al*., 2010). These findings were supported by the observation of N'Dayegamiye *et al*. (2010) who reported that application of fertilizer led to high maize yields. Rasheed *et al*. (2004) also found that maximum grain yield of maize was obtained from plots treated with fertilizer. Law-Ogbomo and Law-Ogbomo (2009) reported that the increased yield associated with fertilized plants was an indication that these soil amendments provided adequate nutrients for optimum plant growth and consequent yield of maize. Increase in stem girth is a reflection of retention of appreciable amount of assimilates in the stem for leaf production (Law-Ogbomo and Law-Ogbomo, 2009).

The reduction in the yield of maize plant observed in samples without fertilizer treatment may be related to insufficient nutrient uptake as the plants had to rely on native fertility of the soil which has been shown to be deficient in total nitrogen, available P exchangeable cations (calcium and magnesium). The significant grain yield increase obtained by application of fertilizers clearly demonstrated the benefit of the application of fertilizer to the maize plant. Fertilizer application enhanced plant height and LAI. This confirmed the role of soil amendment in promoting vigorous vegetative growth and yield (Ekesiobi *et al*., 2015).

'SUWAN-1-SR' variety exhibited highest plant height, thickest stem, highest LAI, thus indicating superiority of 'SUWAN-1-SR' over 'Oba 98' and 'Uselu' local in terms of growth. This was reflected in the highest number of kernel row cob^{-1}, number of kernels row^{-1} and grain yield. The superiority of 'SUWAN-1-SR' variety over 'Oba 98' and 'Uselu' local could be attributed to its genetic potential to excel in that environment. Sanginga *et al*. (2003) have reported yield differences among crop varieties. They observed that some crop genotypes tend to have greater need for nutrients and are often more responsive to nutrient input.

After cropping, the fertilized plots contained more nutrient reserve than unfertilized plot. This could probably due to enrichment of the soil with added nutrients from applied fertilizers. This is a reflection of plant nutrient availability in organic (cattle and poultry manures) and inorganic (NPK) fertilizers. However, the soil organic carbon was lower in unfertilized plots and NPK treated plots than organic fertilizer treated plots. The organic carbon contents in unfertilized plots and NPK were less than 20 g kg^{-1}. An ideal soil should contain 20 g kg^{-1} organic carbon. This emphasized that crop production can be sustained continuously in organic fertilizer treated plots. The exhibition of higher exchangeable acidity by the unfertilized plots is as a reflection of the exhaustion of the soil nutrient and low organic carbon content. The higher soil pH in plots treated with poultry and cattle manures showed in the present study agreed with Ano and Agwu (2005). The higher pH associated with organic fertilizer application was probably due to ionic exchange reaction which occurred when terminal OH^- of K or Al were replaced by organic anions such as tartrate, malate and citrate (Bell and Besho, 1993). The ability of organic fertilizer to increase soil pH could be attributed to the enrichment of the soil through mineralization of cations particularly calcium.

The content of lead (Pb) in the soil after harvest might have resulted from the inclusion of the soil amendment which led to the Pb content in the soil. The Pb concentration in the soil amendment treated plots was within this permissible limit of 2-60 mg kg^{-1} (Alloway, 1990). Lead was significantly most concentrated in plots treated with cattle manure. This could probably be due to the nomadic rearing of cattle thereby giving them the opportunity to feed and drink water anywhere they are available. This will make them have access to lead (Pb) from contaminated food material.

Conclusions

The present study has showed that the yield of maize can be increased with soil amendment application and the selection for use of the most promising variety. It was observed that increases in growth and yield parameters were more effective in plants treated with NPK and poultry manure. Also, the effects of varieties on maize growth and yield parameters showed that 'SUWAN-1-SR' variety performed better than 'Oba 98' and 'Uselu' local varieties in the area of study. Higher nutrient residual effect was associated with organic fertilizers, with higher organic carbon control. Based on the hereby findings, 'SUWAN-1-SR' and poultry manure could be adopted by maize growing farmers in the low fertile soil environment.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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