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Effects of Poultry Manure and Cropping Systems on Chemical Properties and Productivity of Ultisol in Umudike, Southeastern Nigeria

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Abstract

Problems of maintenance of soil properties and sustainability of crop yield have led to increased use of organic manure. Poultry manure (PM) at 0, 5, 10 and 15t/ha was used for this study as organic amendments on chemical properties and productivity of an Ultisol in Umudike, southeastern Nigeria. Topsoil (0-20cm) samples collected from Michael Okpara University of Agriculture, Umudike farm before planting and after harvesting sole maize (SM), sole okra (SO) and maize-okra intercrop (MO) were used to determine soil properties. The properties determined were organic matter (OM), pH, available phosphorus (AP), total nitrogen (TN), exchange properties (Ca, Mg, K, Na), exchange acidity (EA), micronutrients (Fe, Cu, Zn) and particle size distribution. Fresh maize cob (FMC), weight and fresh okra pod (FOP) weight were measured. The experimental design was a split plot in a randomized complete block design (RCBD) replicated thrice. The PM was the sub-plot treatment while the cropping system (CS) was the main-plot treatment. Data generated were subjected to analysis of variance (ANOVA) and differences between means were detected by Fisher's least significant difference (F-LSD) at 5% probability level ($P \leq 0.05$). Correlation and regression (by the method of Little and Hills) were used to determine relationship among soil properties. The soil texture was loamy sand. Improvements in soil properties and crop performance due to PM application were significant ($P \leq 0.05$) compared to the control. However, at 5t/ha, TN (0.39%), Mg (1.38cmol/kg) and EA (2.08 cmol /kg) were not significantly different from the control (0.31%, 1.36cmol/kg and 2.13cmol/kg). Regression of organic matter and pH showed that organic matter accounted for 25.4% reduction in acidity. The correlation of pH with Ca and Mg indicated a positive significant ($P \leq 0.01$) relationship ($r = 0.585$) and ($r = 0.501$), respectively. Compared to the control, poultry manure application significantly ($P \leq 0.05$) increased fresh maize cob and fresh okra pod weights, as sole or intercrop. At 10t/ha poultry manure, fresh maize cob weight from sole maize plots increased by 63.3% above the control, whereas fresh okra pod from sole okra plots increased by 149.8%. These results suggest that application rate of 10t/ha poultry manure will enhance the chemical properties and production of maize and okra in Ultisols in Umudike.

Key words: poultry manure, cropping system, maize, okra, ultisol, chemical properties

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Introduction

Ability of soils to support crop production and to maintain optimum physico-chemical and biological properties are important in determining the productivity of agricultural systems (Chukwu, 2002). In southeastern Nigeria, shifting cultivation (bush fallow system) was a prevalent practice of regenerating organic matter for recycling plant nutrients. Pressure on land as a result of population increase has reduced availability of land for farming. This phenomenon has led to continuous cultivation of available land (Amujoyegbe *et al.*, 2013). It is therefore no longer feasible to maintain adequate levels of soil essential plant nutrients through bush fallow systems.

The climatic conditions of southeastern Nigeria, exemplified in high temperature and rainfall regimes cause rapid decomposition and mineralization of the already inadequate organic matter. In addition to the poor structure of these soils, they are highly leached. Consequently, the soils will require replenishment to rebuild organic matter for the sustenance of crop yields (Chukwu, 2002; Adeniyan and Ojeniyi, 2005).

To improve crop yield in most tropical soils, organic and inorganic fertilization are needed. These will help to improve the soil condition for crop growth (Onwuka, 2003; Ibrahim and Fadni, 2013). However, due to high cost of inorganic fertilizers, organic manures, especially of animal origin, are used. Organic manure has the additional benefit of improving degraded soil physical properties (Ibrahim and Fadni, 2013). Application of inorganic fertilizer improves yield in the short run but often exacerbates the problems associated with soil acidity. It does little to ameliorate degraded soil physical properties (Oguike, *et al.*, 2006). Hence, the importance of this study which utilized poultry manure as a source of plant nutrients. The objectives of this study were to determine the effects of poultry manure on soil chemical properties and the yield parameters of maize and okra.

Materials and methods

The study was conducted at Michael Okpara University of Agriculture, Umudike teaching and research farm located within 5^0 29′N and $7^0$33′E with an altitude of 122m above sea level (NRCRI, 2007). Prevailing climate is tropical with wet and dry seasons. Mean annual rainfall ranged from 2100mm to 2300mm. Wet season extends from March to October with peaks in June and September and a short break in August. Dry season starts from November to February. Maximum and minimum monthly mean temperatures are 32^0C and 23^0C, respectively, while monthly relative humidity varies from 51% to 87% (NRCRI, 2007).

The design was a spilt-plot in a randomized complete block (RCBD) with cropping system (sole maize, sole okra and maize-okra intercrop) as the main plot treatment, while different rates of poultry manure (0, 5, 10 and 15t/ha) were the sub-plot treatments. The treatments were replicated thrice.

Plot size was 2.4 x 5m with an inter plant spacing of 0.6m and 1m apart from each block. Maize (Oba Super 2(yellow)) and okra (V-35) used for the experiment were obtained from National Agricultural Seed Council at the National Root Crops Research Institute, Umudike while poultry manure was sourced from the poultry farm of Michael Okapra University of Agriculture, Umudike.

The land was ploughed and harrowed into a fine tilth. The poultry manure was incorporated into each plot 14 days before planting. Two seeds were planted per hole at a spacing of 0.5m and later thinned down to one plant after 10 days of emergence. The study was conducted under rain fed agricultural practice.

Auger samples (0-20cm) were taken randomly from different spots within each plot and bulked to obtain 36 composite samples. The bulk soil samples were air-dried and passed through a 2mm sieve size for laboratory studies. The studies included particle size distribution (Gee and Bauder, 1986), soil pH (H_2O) electrometrically determined with a pH meter using a soil-water ratio of 1:2.5 (Thomas, 1996). Organic matter was determined by the Walkley and Black wet oxidation method as described by Nelson and Sommers (1996). Total nitrogen was by the macro kjadahl method as described by Bremner (1996) while available phosphorus (Bray II) was by the method outlined by Kuo (1996). Ca^{2+}, Mg^{2+}, K^+ and Na^+ were extracted using 1N NH_40Ac (ammonium acetate). The amounts of Ca^{2+} and Mg^{2+} were determined by EDTA titration method whereas K^+ and Na^+ were by flame photometry. Exchangeable acidity (EA) was determined by 1N KCl extraction procedure described by Thomas (1996).

Three plants were sampled per plot for each individual crop. Yield attribute taken for maize was fresh cob weight/plant while fresh pod weight/plant was taken for okra. The percent fresh maize cob and fresh okra pod weights increase above the control was calculated for each treatment thus:

$$PI = (\frac{Ya}{Yc} - 1) \times 100$$

Where Ya is yield due to PM rate while Yc is yield in control (0t/ha PM).

Measured data were analysed according to the procedure for a split-plot in RCBD (Little and Hills, 1978). Analysis of variance (ANOVA) was performed and F-LSD (0.05) was used to detect differences between treatment means (Obi, 1986). Regression and correlation (Little and Hills, 1978) were used to determine relationship amongst soil properties and yield attributes.

Results and discussions

Properties of soil studied are shown in Table 1. The soil is sandy loam in texture with pH value of 4.15 which is extremely acidic (USDA-NRCS, 1998). Values of the exchange properties (Table 1) and organic matter indicate degradation. Therefore, the soil required inputs of organic materials. The poultry manure used for the study improved the chemical properties of the soil.

Table 1: Physico-chemical properties of soil studied

Soil properties	Values
Sand %	65.80
Silt %	19.80
Clay %	14.40
Texture	Sandy loam
OM%	1.80
pH (H_2O)	4.15
AP mg/g	19.39
TN%	0.16
Ca mol/kg	0.99
Mg cmol/kg	1.14
K cmol/kg	0.75
Na cmol/kg	0.17
EA cmol/kg	1.98

OM-Organic matter, TN-Total Nitrogen,
AP-Available phosphorus, EA- Exchangeable acidity

Table 2 shows the organic matter content, pH, available phosphorus and total nitrogen of the soil treated with poultry manure. Increasing rate of the poultry manure resulted to a significant (P ≤0.05) increase in the organic matter content of the soil. Ewulo *et al*. (2008) and Ayeni *et al*. (2008) made similar observations corroborating the findings of Adeniyan and Ojeniyi (2003) and Mbah and Mbagwu (2006). Under sole okra and maize-okra intercrop and with reference to the control, there was significant (P ≤0.05) interaction between poultry manure and cropping system at 10 and 15t/ha poultry manure application. However, under sole maize, there was significant (P ≤0.05) interaction at all levels of poultry manure application when compared to the control. The highest value of 3.10% organic matter obtained under sole maize at 15t/ha poultry manure indicated interaction, suggesting that higher rates of poultry manure may be required to have significant and long lasting improvement on fragile tropical soils (Oguike *et al*., 2006).

Table 2: Organic Matter, pH, Available Phosphorous and Total Nitrogen of Soil Treated with Poultry Manure

Cropping system	PM (t/ha)																			
	0	5	10	15	Mean	0	5	10	15	Mean	0	5	10	15	Mean	0	5	10	15	Mean
	OM (%)					pH					AP (mg/g)					TN(%)				
Intercrop	1.90	2.13	2.52	2.87	2.36	4.32	4.32	4.45	4.50	4.40	19.91	22.79	27.10	30.92	25.18	0.44	0.48	0.74	0.85	0.63
Sole Maize	1.83	2.50	2.69	3.10	2.53	4.17	4.29	4.37	4.42	4.31	19.68	22.66	28.48	32.00	25.70	0.30	0.32	0.55	0.71	0.47
Sole okra	1.88	2.29	2.49	3.01	2.42	4.22	4.32	4.34	4.41	4.32	19.34	23.46	26.60	30.44	24.96	0.19	0.36	0.45	0.95	0.49
Mean	1.87	2.31	2.57	2.99		4.24	4.31	4.39	4.44		19.64	22.97	27.39	31.12		0.31	0.39	0.58	0.84	
$LSD_{(0.05)}$ System	0.46					0.08						1.24				0.19				
$LSD_{(0.05)}$ Manure	0.16					0.07						1.09				0.24				
$LSD_{(0.05)}$ Interaction	0.46					0.12						1.89				0.38				

OM - organic matter, TN-Total nitrogen, AP-Available phosphorus, $LSD_{(0.05)}$ Least significant difference at 5% PM-Poultry manure

There was no significant (P ≤0.05) increase in soil pH at 5t/ha poultry manure when compared to the control. However, up to 15t/ha poultry manures and above may be required to significantly (P ≤0.05) reduce acidity of the Ultisol studied. Poku *et al.* (2014) and Adeleye *et al.* (2010) reported that manure application positively influenced soil pH and that this was because organic matter added basic plant nutrients (Ca^{2+}, Mg^{2+}, etc) to the soil. The increase in soil pH attributed to the presence of basic cations was due to microbial decarboxylation of the poultry manure (Natsher and Schwetnmann, 1991). As reported by Dikinya and Mufwanzala (2010), the mechanism responsible for increase in soil pH was due to ion exchange reactions. This study observed that the increase in pH was due to the addition of poultry manure to the soil thus affirming the findings of Onwu *et al.* (2014). In their earlier studies, Adeniyan and Ojeniyi (2003), Ano and Agwu (2006), Mbah and Mbagwu (2006) and Ayeni *et al.* (2008) had reported that poultry manure increased soil pH as well as organic matter content. The regression model (Table 3) showed that the poultry manure contributed 25.4% to the increase in pH.

Table 3: Regression of Organic Matter and pH

Model	R	R square	Adjusted R square	Std Error of the Estimate
1	0.504	0.254	0.232	0.11539

In all the cropping systems, there was significant (P ≤0.05) increase in available phosphorus compared to the control. Highest values; 30.92mg/g for maize-okra intercrop, 32.00mg/g for sole maize and 30.44mg/g for sole okra were observed at 15t/ha poultry manure suggesting that higher rates than 15t/ha may further improve the available phosphorus in the soil. Although, among the cropping systems, differences were observed, they were largely statistically similar. At 10t/ha, sole maize (28.48mg/g) was significantly (P ≤0.05) higher than sole okra (26.60mg/g) but similar to maize-okra intercrop (27.10mg/g). In all cases, there were significant (P ≤0.05) interactions of poultry manure and cropping systems. The significant increase in available phosphorus was due to the increase in organic matter (Table 2) as a result of the poultry manure application (Salako, 2008; Ayeni *et al.*, 2008). This observation confirmed earlier reports of Bahl and Toor (2002), Adeniyan and Ojeniyi (2003), Adeniyan and Ojeniyi (2005) and Mbah and Mbagwu (2006).

Total nitrogen increased in all the cropping systems from 0 to 15t/ha. Although, the increase at 5t/ha was not significant (P ≤0.05) relative to the control, there were however, significant differences between means of control (0.31%), 10t/ha (0.58%) and 15t/ha (0.84%). The cropping systems generally did not influence the total nitrogen since there were no significant differences observed among them. The observed improvement in total nitrogen in this study confirmed the reports of Adenawoola and Adejoro (2005), Adeleye *et al.* (2010) and Onwu *et al.* (2014) who also observed increase in total nitrogen due to poultry manure application. At 15t/ha, improvement in total nitrogen in all the cropping systems was due to significant ($P \leq 0.05$) interaction of the cropping systems and the poultry manure. This indicated that application rates higher than 15t/ha may also interact with each of the cropping systems to enhance total nitrogen content of the Ultisol studied. Uwah *et al.* (2014) reported that increase in soil available nitrogen with increasing application rates of poultry manure may be attributed to increased microbial activities resulting to enhanced mineralization of organic forms of nitrogen. This may be the case in the present study. The observation confirmed earlier reports of some researchers (Maerere *et al.*, 2001; Akanni and Ojeniyi, 2008; Dikinya and Mufwanzala, 2010).

Calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}) and exchangeable acidity of the poultry manure-amended soil are shown in Table 4. There was significant ($P \leq 0.05$) increase in Ca^{2+} as the PM application increased from 0t/ha to 15t/ha. Although, under sole okra, Ca^{2+} concentration at 5t/ha poultry manure was higher than the control, they were statistically similar indicating no interaction at this application rate. Comparing the cropping systems, the means indicated significant ($P \leq 0.05$) differences between sole maize and sole okra but not between sole maize and maize-okra intercrop or sole okra and maize-okra intercrop. At 0 to 10t/ha, differences were significant among the cropping systems which followed no particular order.

Table 4: Exchangeable Cations of Soil Treated with Poultry Manure (PM)

Cropping system	PM (t/ha)																								
	0	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
	Ca (cmol/kg)					**Mg (cmol/kg)**					**K (cmol/kg)**					**Na (cmol/kg)**					**EA (cmol/kg)**				
Intercrop	0.92	1.08	1.49	2.00	1.37	1.58	1.59	1.80	1.94	1.73	0.72	1.03	1.91	2.10	1.44	0.14	0.18	0.20	0.23	0.19	1.95	2.01	1.82	0.71	1.62
Sole maize	0.94	1.07	1.53	2.00	1.39	1.38	1.40	1.92	2.21	1.73	0.72	1.06	1.89	2.12	1.45	0.14	0.18	0.18	0.20	0.18	2.17	2.09	2.00	0.84	1.77
Sole okra	0.96	0.98	1.45	2.00	1.35	1.11	1.15	1.83	2.40	1.62	0.72	1.03	1.88	2.06	1.42	0.15	0.16	0.20	0.26	0.19	2.26	2.14	2.00	0.95	1.84
Mean	0.94	1.04	1.49	2.00		1.36	1.38	1.85	2.18		0.72	1.04	1.90	2.09		0.14	0.18	0.19	0.23		2.13	2.08	1.94	0.83	
$LSD_{(0.05)}$																									
System	0.03					0.15					0.02					0.01					0.23				
$LSD_{(0.05)}$																									
Manure	0.03					0.05					0.04					0.01					0.12				
$LSD_{(0.05)}$																									
Interaction	0.05					0.15					0.06					0.02					0.26				

EA-Exchangeable acidity, LSD-Least significant difference at 5% (0.05) probability, PM-Poultry manure

There was an increase in Mg^{2+} with increasing rate of poultry manure. Although, in all the cropping systems, the difference in Mg^{2+} between 0t/ha and 5t/ha was not significant ($P \leq 0.05$), there were significant improvements at 10t/ha and 15t/ha with reference to the control. This suggested that more than 5t/ha poultry manure application was required to significantly ($P \leq 0.05$) increase the Mg^{2+} content of the studied soil. Also, significant differences were observed among the cropping systems except at 10t/ha poultry manure.

Significant ($P \leq 0.05$) increase in K^+ was observed in all the cropping systems with the highest increase at 15t/ha when compared to the control. Potassium (K^+) increased by 43% when 5t/ha poultry manure was applied, whereas it increased by about 190% with application of 15t/ha. Comparing the cropping systems, K^+ content was the same at 0t/ha. However, there were significant ($P \leq 0.05$) differences between sole okra and sole maize, and between sole okra and maize-okra intercrop at 15t/ha. There was also significant ($P \leq 0.05$) difference between sole okra and maize-okra intercrop at 10t/ha. Sole okra and maize-okra intercrop were similar at 5t/ha but were significantly ($P \leq 0.05$) different from sole maize.

Irrespective of the cropping system, Na^+ in the poultry manure-treated plots were significantly ($P \leq 0.05$) higher than the control (Table 4). In all cases, highest value of Na^+ was observed at the 15t/ha poultry manure rate. With regards to cropping systems, Na^+ was statistically similar at 0t/ha. At 5t/ha, the same values were obtained for sole maize and maize-okra intercrop but these were significantly ($P \leq 0.05$) different from sole okra. Also, at 10t/ha, the same values were observed for maize-okra intercrop and sole okra, but these were again significantly different from sole maize. At 15t/ha rate, significant differences in Na^+ were observed among the cropping systems.

It is therefore evident that the exchange cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) increased with increase in the application rate of poultry manure (Ano and Agwu, 2006; Dikinya and Mufwanzala, 2010 and Adeleye *et al.*, 2010). Similarly, Grichs (1990) had earlier indicated that the application of organic manure increased exchange cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) more than in soils amended with inorganic fertilizer (NPK) alone. The increase was attributed to high organic carbon content of the poultry manure applied. This increase may also be due to the salts released during microbial decarboxylation of the organic material (poultry manure).

Table 5 revealed a positive significant ($P \leq 0.01$) correlation between Ca^{2+} (r = 0.585) and pH, and between Mg^{2+} (r = 0.501) and pH. These correlations indicated that pH increased as Ca^{2+} and Mg^{2+} increased, corroborating earlier reports by Adeleye *et al.* (2010) and Poku *et al.* (2014) who observed increased pH with addition of basic cations (Ca^{2+} and Mg^{2+}). This observation was also apparent in the regression analysis of organic matter and pH where it was found that organic matter influenced pH by 25% (r^2= 0.254) (Table 3).

Table 5: correlations of pH, Calcium (Ca) and Magnesium (Mg)

	pH	Ca	Mg
pH	1	0.585**	0.501**
Ca	0.585**	1	0.894**
Mg	0.501**	0.894**	1

** significant at 0.01 probability level (2 tailed).

Generally, there was decrease in exchangeable acidity with increasing rate of poultry manure application as shown in Table 4. This decrease was not significant ($P \leq 0.05$) at 5t/ha poultry manure compared to the control. However, at 10t/ha and 15t/ha rates, there were significant decreases with reference to the control. Except for the control, specifically between sole okra and maize-okra intercrop, there were no significant differences ($P \leq 0.05$) in exchangeable acidity among the cropping systems. The significant decline in each of the cropping systems at 10t/ha and 15t/ha poultry manure suggests that higher rates than 15t/ha may further reduce exchangeable acidity and increase pH of the soil studied. The ability of poultry manure to reduce exchangeable acidity through supply of Ca^{2+} has been reported by Onwu *et al.,* (2014). The reduction in exchangeable acidity could also be a result of neutralization of Al^{3+} by Ca^{2+} and Mg^{2+} released from decomposing organic manure (poultry manure) (Mbagwu *et al.,* 1994). This was corroborated by Oguike *et al.* (2007) who reported that reduction in exchangeable acidity with rice mill waste application could be attributed to the removal of Al^{3+} from the soil exchange site by organic manure from decomposing rice mill waste. Earlier, Akande *et al.* (2003) reported that application of organic material ameliorated slightly acidic tropical soil to improve crop production.

Iron (Fe), copper (Cu) and zinc (Zn) determined in the experiment are shown in Table 6. Under sole maize, and maize-okra intercrop, Fe concentration in the soil was irregular with poultry manure application. For sole okra, with increasing poultry manure rate, there was an increase of Fe concentration in the soil. At 5t/ha poultry manure, when compared to the control, the concentration of Fe in the soil did not significantly ($P \leq 0.05$) increase in the maize-okra intercrop and sole okra. However, under sole okra, Fe concentration was significantly increased at 10t/ha and 15t/ha with reference to the control.

Table 6: Micronutrients (Fe, Cu, Zn) of Soil Treated with Poultry Manure (PM)

Cropping system	PM (t/ha)														
	0	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
	Fe (ppm)					**Cu (ppm)**					**Zn (ppm)**				
Intercrop	0.07	0.05	0.06	0.03	0.05	0.04	0.03	0.06	0.08	0.05	0.02	0.03	0.05	0.07	0.04
Sole maize	0.07	0.20	0.10	0.05	0.11	0.06	0.03	0.03	0.05	0.04	0.03	0.05	0.05	0.08	0.05
Sole okra	0.34	0.36	0.49	0.51	0.42	0.04	0.04	0.04	0.07	0.05	0.04	0.05	0.07	0.14	0.07
Mean	0.16	0.20	0.22	0.19		0.05	0.03	0.05	0.07		0.03	0.04	0.06	0.10	
$LSD_{(0.05)}$															
System	0.03					0.04					0.05				
$LSD_{(0.05)}$															
Manure	0.10					0.03					0.02				
$LSD_{(0.05)}$															
Interaction	0.02					0.05					0.05				

Fe-Iron, Cu-Copper, Zn-Zinc, LSD-Least significant difference at 5% (0.05) probability, PM-Poultry

Except for sole maize, the highest value for Cu was observed at 15t/ha. Although, the increase in Cu was generally not significant (P ≤0.05), however comparing 5t/ha with 15t/ha poultry manure under maize-okra intercrop, there was a significant increase.

In all cropping systems, Zn increased with poultry manure application. With reference to the control, 5t/ha poultry manure was not significantly (P ≤0.05) different. The increase in Zn from 5t/ha to 10t/ha was statistically similar in all the cropping systems whereas under sole maize and sole okra, the increase from 10t/ha to 15t/ha was significantly (P ≤0.05) different. They were also significantly (P ≤0.05) different from the control.

Results for the micronutrients in this study confirmed the observations of Ano and Agwu (2006), Uwah *et al.* (2011) and Uwah *et al.* (2012) who reported that poultry manure increased soil micronutrients (Fe, Cu, Zn). These results could definitely not support the observation of Adeleye *et al.* (2010), who reported that the decrease in Fe content was due to the ability of poultry manure to lower soil Fe concentration.

Table 7 shows the productivity of the soil indicated by fresh maize cob and fresh okra pod weights. Statistically, with reference to the control, there were significant (P ≤0.05) differences in fresh maize cob weight as the rate of poultry manure application increased from 0 t/ha to 15t/ha in the sole maize and maize-okra intercrop plots. The average increase of about 63% peaked at 10t/ha in two cropping systems (sole maize and maize-okra intercrop). This is suggesting that 10t/ha poultry manure treatment is optimum for maize production for the soil studied. Comparing the cropping system, sole maize produced higher weight than maize-okra intercrop in all the poultry manure rates. Under sole maize, a 67% increase over the control was observed at 10t/ha poultry manure while 57% was observed under maize-okra intercrop. This showed that higher weight of fresh maize cob will be obtained from sole maize than from maize-okra intercrop.

Table 7: Fresh Maize Cob Weight and Fresh Okra Pod Weight of Soil Treated with Poultry Manure

Cropping System	**PM (t/ha)**									
	0	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
			FMC (t/ha)					**FOP (t/ha)**		
MO	1.52	2.13 (40%)	2.39 (57%)	1.85 (22%)	1.97	2.12	3.65 (72%)	5.35 (152%)	3.81 (80%)	3.73
SM	1.87	2.85 (52%)	3.13 (67%)	2.42 (29%)	2.57	-	-	-	-	-
SO	-	-	-	-	-	3.01	3.97 (32%)	7.48 (149%)	6.46 (115%)	5.23
Mean	1.69	2.49 (47%)	2.76 (63%)	2.13 (26%)		2.57	3.81 (48%)	6.42 (150%)	5.14 (100%)	
$LSD_{(0.05)}$ System	0.34					1.02				
$LSD_{(0.05)}$ Manure	0.14					0.64				
$LSD_{(0.05)}$ Interaction	0.26					0.94				

MO= Maize-okra intercrop; SM= Sole maize; SO= Sole okra; FMC = Fresh maize cob weight; FOP= Fresh okra pod weight; PM= Poultry manure; Figures in parenthesis are percentage increases over the control.

There were significant (P ≤0.05) increases in fresh okra pod weight with poultry manure application in sole okra and maize-okra intercrop. At 10t/ha, the increase in fresh okra pod weight peaked, revealing a 150% increase over the control. This implies that 10t/ha poultry manure is optimum for okra production for the soil studied. Comparing the cropping systems, sole okra had a higher fresh okra pod weight than maize-okra intercrop. At 10t/ha poultry manure, sole okra produced 7.48t/ha fresh okra pod while maize-okra intercrop produced 5.35t/ha.

Generally, it was evident that fresh maize cob and fresh okra pod weights were affected by the application of poultry manure. These results corroborated the findings of earlier researchers (Sanwal *et al.*, 2007; Premsekhar and Rajashree, 2009). The observed increase in fresh maize cob and fresh okra pod weights in the poultry manure treated plots compared to the control, may be as a result of improvements on the soil's properties. Since the highest fresh maize cob and fresh okra pod weights were observed at 10t/ha poultry manure, it therefore indicated that this rate improved the nutrient status of the soil (Onwu *et al.,* 2014). The weight decline beyond 10t/ha poultry manure could be due to excess manure which may have become toxic to the crops as a result of high ammonia production (Silva *et al.,* 2003). Odeleye *et al.* (2005) reported that poultry manure application beyond 12t/ha was in excess for okra growth and development because it promoted structural development at the expense of reproduction.

Since fresh maize cob and fresh okra pod weights obtained from sole maize and sole okra plots, respectively, were higher than that from maize-okra intercrop, it follows that the intercropping caused a reduction in the productivity of the Ultisol probably due to competition that existed between maize and okra for the available resources (nutrients, air, sunlight and water) (Okpara and Omaliko, 1995; Iremiren *et al.*, 2013). Also reduction in fresh okra pod weight may be due to aerial competition for space and light resources to the crops for optimum expression of their yield (Famaye and Adeyemi, 2011).

Conclusion

The result of this study showed that poultry manure application enhanced chemical properties of the soil. The results also revealed that maize and okra responded well to the application of poultry manure at 10t/ha rate. The use of poultry manure for production of maize and okra on the Ultisol located in southeastern Nigeria was considered desirable because, it ensured improved soil organic matter status, nutrient availability and high crop performance.

On the basis of these findings, 10t/ha poultry manure appears optimal for ameliorating degraded chemical conditions of Ultisol in southeastern Nigeria as it was better than the other rates (0, 5 and 15t/ha) in the present study regarding the fresh maize cob and fresh okra pod weights.

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