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INFLUENCE OF AGRO-WASTES ON SOIL PROPERTIES, GROWTH AND YIELD OF MAIZE (*Zea mays* L.) IN AN ACID ULTISOL OF OWERRI, IMO STATE.

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ABSTRACT
We investigated the effect of selected agro-wastes on soil properties, growth and yield of maize (*Zea mays*) in a Typic Haplusult during 2011 and 2013 planting season at the Teaching and Research Farm of Federal University of Technology, Owerri Imo State Southeastern Nigeria (Latitudes 5° 21' N and 5° 27' N and Longitudes 7° 02'E and 7° 15' E). The experiment was a 3 x 4 factorial fitted in a Randomized Complete Block Design. In 2011 study, treatments consisted of factor A that was made up of 0 t/ha of either Saw dust or rice mill waste, 10 t/ha of Saw dust and 10 t/ha of rice mill wastes and factor B that consisted of 0, 4, 8 and 12 t/ha of poultry manure. In 2013, poultry manure rates were the same while Saw dust and rice mill wastes were reduced from 10 t/ha to 2 t/ha.The treatments were replicated four times. Data collected from soil analyses and growth performances of maize were subjected to analysis of variance while significant means among treatments were separated using least significant difference at 5 % probability level. Results showed that the amendments significantly ($p < 0.05$) increased soil moisture content, soil porosity and reduced soil bulk density in both seasons. Plots amended with 12 t/ha poultry manure + 10 t/ha rice mill waste recorded the highest values in the growth parameters of maize measured in 2011 while in 2013, plots treated with 12 t/ha poultry manure + 2 t/ha rice mill waste performed better than other treatments. Shoot dry matter, weight of cob and maize grain yield were significantly increased by the agro-wastes with application of 12 t/ha poultry manure + 10 t/ha rice mill wastes recording the highest shoot dry matter of 0.96 t/ha, highest cob weight of 1.46t/ha and the highest in grain yield of 1.17 t/ha in 2011. In 2013, admixture of 12 t/ha poultry manure and 2 t/ha rice mill waste recorded the highest values in shoot dry matter (1.19 t/ha), weight of cob (3.75 t/ha) and maize grain yield (1.38 t/ha). We therefore recommend application of 2 t/ha rice mill waste + 12 t/ha poultry manure for soil fertility restoration and maize production in an acid soil.

Keywords: C/N ratio, agro-wastes, maize, haplusult, Owerri

INTRODUCTION

One of the major challenges facing the world at present particularly Africa, is food security. Poor soil fertility status and land degradation has been identified as some of the major constraints militating against food production (Adaikwu *et al.*, 2012; Gichuru *et al.,* 2003; Anikwe and Eze, 2010). These problems have resulted into adoption of many strategies aimed at improving soil productivity and crop yield. Among these strategies was the use of agricultural and domestic solid wastes as soil amendments (Oladipo *et al.,* 2010; Onwuka *et al.*, 2010). Most of these wastes are found in large quantities, deposited either on or along the road sides, unapproved areas, open dump sites in the markets or in water ways and management of these wastes has resulted to environmental pollution and contamination of the atmosphere as well as contamination of underground and surface water bodies (Kalu *et al*., 2009).

Before now, the use of inorganic fertilizers in crop production has been a panacea for nutrient losses with little knowledge on its negative effect on soil condition such as acidification, nutrient imbalance and trace element deficiencies (Ojeniyi *et al.,* 2007, Ajaz *et al.*, 2013). Asadu and Nweke (1999) have reported that in sub –Saharan Africa, soils where inorganic fertilizer are applied for arable crop production have lower nutrient elements when compared to soils where organic fertilizers were used. Therefore, an agricultural practice that is based solely on intensive use of inorganic fertilizers is prone to mismanagement that leads to environmental degradation (Baqual, 2013). To ensure food security, continued crop production is vital for developing countries and this must be accomplished on sustainable bases to avoid jeopardizing the underlying bases of natural resources (Tarang *et al.,* 2013).

Organic wastes contain essential nutrients needed for improvement of soil fertility, plant growth and yield (Oladipo *et al*., 2005). There is need to investigate approaches for the utilization of these agricultural wastes in this ecological zone that has favourable rainfall and temperature distribution for organic matter decomposition. The aim of this study therefore was to evaluate the effect of selected agro-wastes on soil properties and growth performances of maize in Owerri, Southeastern Nigeria.

MATERIALS AND METHODS

The Study Area: The study was conducted at the Teaching and Research Farm of Federal University of Technology Owerri, Imo State, Southeastern Nigeria. The area lies between Latitude 5° 21’ N and 5° 27’ N and Longitude 7’ 02°E and 7° 15’ E. The area has an average annual rainfall range of 1950 mm – 2250 mm and annual temperature range of 27 °C – 29 °C with average relative humidity of 79 %. The geological material of soil in the study area is an ultisol and classified as Typic Haplustult (FDALR, 1985), derived from Coastal Plain Sands (Benin formation) of the Oligocene-Miocene geological era and are characterized by low organic matter, low cation exchange capacity and are highly leached (Onweremadu *et al.,* 2011). Tropical rainforest is the dominant vegetation of the area, though with remarkable ecological diversity caused by anthropogenic activities, especially farming and deforestation resulting into depleted vegetation as a result of demographic pressure. Farming at subsistent level is a major socio economic activity of people in the area and fertility restoration in the area is by bush fallow and application of inorganic fertilizers. The location map of the study area is shown in Figure 1.

Land Preparation: The study area which was under three year fallow, dominated by shrubs and grasses manually cleared using cutlass and hoe and mapped out into experimental plots. Composite soil samples were randomly collected for preplanting soil analysis using soil auger at 0 – 30 cm

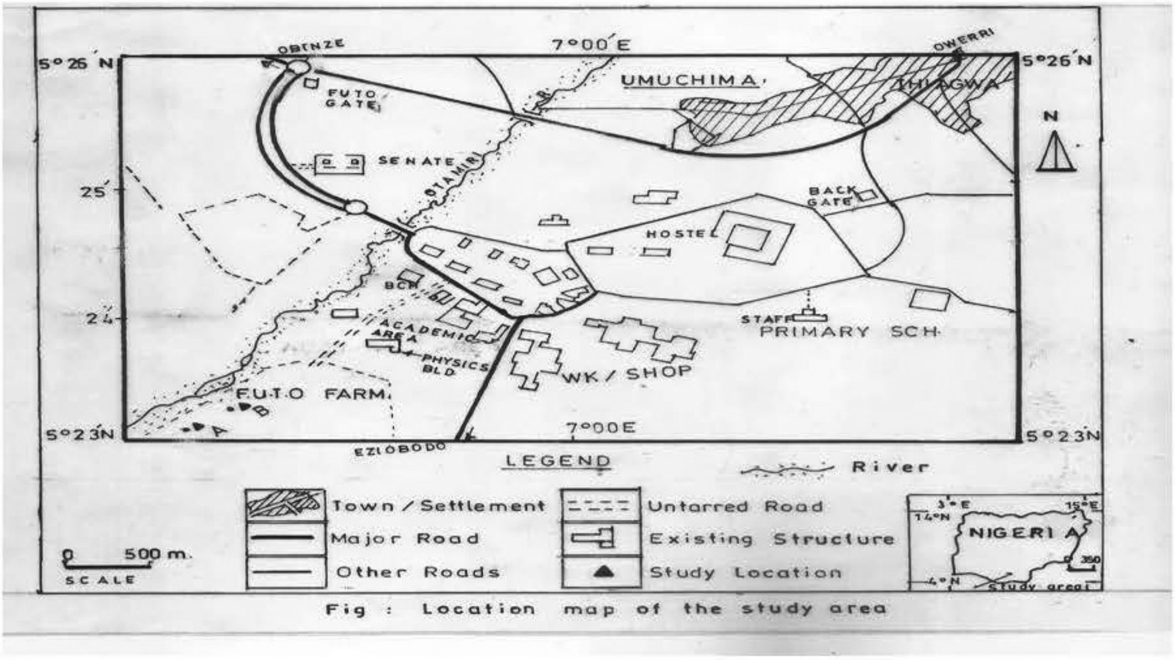

Fig 1: The location map of the study area

depth. The samples were air dried for a period of one week and sieved using 2 mm mesh sieve and then subjected to routine laboratory analysis.

Field layout, experimental design and treatments: In both 2011 and 2013, the study area was mapped out into 48 experimental plots using ranging poles and metre rule. Each plot measured 4 m x 4 m with inter plot and inter replicate distances of 1 m. The experiment was a 3 x 4 factorial fitted in a Randomized Complete Block Design. In 2011 study, the treatments consisted of factor A which was made up of 0 t/ha of either of Saw dust or rice mill waste, 10 t/ha Saw dust and 10 t/ha rice mill waste and factor B which was made up of 0, 4, 8 and 12 t/ha poultry manure. In 2013 study, the same rate of poultry manure was applied while 10 t/ha of Saw dust and 10 t/ha of rice mill wastes were reduced to 2 t/ha each. The treatments were replicated four times. The treatments were broadcasted on the tilled plots and were allowed to incubate for one week before planting the test crop.

Planting of test Crops: Maize seeds (Oba super 11 hybrid) were planted three per hole at a planting distance of 25 cm x 75 cm. One week after planting, the germinated seeds were thinned down to one seed per hole, given a plant population of 55, 500 plants/ha. Supply of ungerminated seeds were done a week after planting.The experimental area was weeded two times before harvest using a weeding hoe.

Measurement of growth parameters in experiment 2: Two weeks after planting, 12 out of 36 plants in each experimental plot were labeled specifically for data collection. Number of leaves, maize height and leaf area were measured at weekly intervals. Plant height was measured using a metre rule from the surface of the soil to the tip of the tallest leaf (Nwafor *et al.,* 2010) while number of leaves were manually counted. Leaf area was calculated using the formula adopted by Nwafor *et al.* (2010) Shoot dry matter was determined by oven drying samples of shoots of maize collected from each treatment plot at 60˚ C. The oven dried weight was then used to calculate the total shoots dry matter per treatment plot.

Laboratory Analysis: Particle Size Distribution was determined by hydrometer method according to the procedure of Gee and Or (2002). Bulk Density was determined by core methods according to Grossman and Reinsch (2002). Total Porosity was calculated from the result of bulk density using the formula:

Total Porosity (TP) = [1 - (BD / pd) X 100]; where pd = Particle density (2.65 g/cm3) and BD = bulk density.

Moisture Content was determined using the formula:

Percentage soil moisture content = (weight of the moisture contained in soil sample / weight of soil sample) x 100.

Soil pH was determined in water and in KCl using pH metre in soil / liquid suspension of 1 : 2.5 according to Hendershot *et al.,* (1993). Organic Carbon was determined using chromic wet oxidation method according to Nelson and Somers (1982). Total Nitrogen was determined by kjeldahl digestion method using concentrated H_2S0_4 and Sodium Copper sulphate catalyst mixture according to Bremner and Yeomans (1988). Available Phosphorus was determined using Bray II solution method according to Olsen and Somers (1982). Exchangeable Mg and Ca were determined using ethylene diamine tetra acetic acid (EDTA) (Thomas, 1982) while exchangeable K and Na were extracted using 1 N Neutral ammonium acetate (NH_4OAc) and then determined using flame photometer (Thomas, 1982).

Table 1: Physico-chemical properties of soil in the study locations before planting

Soil Property	2011	2013
Sand (g/kg)	859	816
Silt (g/kg)	64	53
Clay (g/kg)	77	131
Textural Class	Loamy Sand	Loamy Sand
Silt/Clay Ratio	0.83	0.40
Bulk Density (g/cm^3)	1.43	1.41
Total Porosity (%)	46.0	46.8
Moisture Content (g/kg)	125	131.8
pH H_2O (1:2.5)	5.29	5.37
pH KCl (1:2.5)	4.71	4.68
Organic Carbon(g/kg)	10.8	10.2
Total Nitrogen(g/kg)	1.7	1.64
Avail. Phosphorus (mg/kg)	13.9	15.9
Exchangeable Ca (cmol/kg)	3.82	2.89
Exchangeable Mg (cmol/kg)	1.71	1.35
Exchangeable K (cmol/kg)	0.13	0.16
Exchangeable Na (cmol/kg)	0.05	0.03
Exchangeable Acidity (cmol/kg)	1.92	1.86
Effective Cation Exchange Capacity (cmol/kg)	7.63	6.29
Ca / Mg Ratio	2.23	2.14
Base Saturation (%)	74.8	70.4

Table 2: Chemical composition of organic wastes used in the study

Parameter	Saw dust	Rice mill waste	Poultry manure
	2011 Study		
pH H20	6.99	6.84	7.63
pH KCl	6.18	6.16	6.95
Organic Carbon (g/kg)	34.7	24.7	13.6
Organic Matter (g/kg)	59.8	42.6	23.4
Total Nitrogen (g/kg)	0.49	0.98	4.23
C:N	70.8	28.4	3.22
Available Phosphorus (mg/kg)	5.20	6.90	7.20
Exchangeable Calcium (cmol/kg)	4.20	5.30	8.50
Exchangeable Magnesium (cmol/kg)	3.80	5.10	6.90
Exchangeable Potassium (cmol/kg)	2.70	2.90	7.30
	2013 Study		
pH H20	6.43	6.52	7.43
pH KCl	5.79	6.05	6.58
Organic Carbon (g/kg)	36.4	29.0	8.43
Organic Matter (g/kg)	62.8	49.9	14.5
Total Nitrogen (g/kg)	0.52	0.83	3.76
C:N	70.0	34.9	2.24
Available Phosphorus (mg/kg)	3.6	5.11	7.2
Exchangeable Calcium (cmol/kg)	2.7	4.96	8.5
Exchangeable Magnesium (cmol/kg)	2.5	5.03	6.9
Exchangeable Potassium (cmol/kg)	3.1	3.06	7.3

Exchangeable Acidity was measured titrimetrically using 1 N KCl against 0.05 N Sodium hydroxide (Mclean, 1982) while effective cation exchange capacity was calculated from the summation of all exchangeable bases and total exchangeable acidity. Percentage Base Saturation (PBS) was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

Data collected were presented in tables and graphs. Data were subjected to Analysis of Variance (ANOVA). Significant means among treatments were separated using Least Significant Difference (LSD) at 5 % probability level.

RESULTS AND DISCUSSION

Soil of the study location: The properties of the soil used in thestudy are presented in Table 1. The soils were texturally loamy sand for 2011 and 2013 planting seasons respectively. The soils were low in moisture retention, strongly acidic and low in macro nutrients (N, P and K) and exchangeable bases. For better performance of maize plant in these soils, there is need to increase these low plant nutrients and this could be achieved by manure applications.

Chemical properties of the agro-wastes used in the study

Some chemical properties of the organic wastes used in this study are presented in Table 2. The wastes (saw dust and rice mill waste) had higher C/ N ratio than poultry manure. Therefore admixture of the wastes and poultry manure could complement each other. Poultry manure had nutrient elements that could increase maize growth and yield and improve the quality of soil in the study area.

Effect of saw dust, rice mill waste and poultry manure on soil particle size distribution

Results of the effect of agro-wastes on soil particle size distribution are shown in Table 3. Results showed that the amendments did not change the texture of the soil when compared to control. Plots amended with 10 t/ha rice mill waste + 12 t/ha poultry manure recorded sand, silt and clay fractions of 783 g/kg, 103 g/kg and 114 g/kg respectively in 2011 while in 2013, plots amended with 2 t/ha rice mill waste + 12 t/ha poultry manure recorded sand, silt and clay fractions of 763 g/kg, 107.3 g/kg and 129.8 g/kg respectively. This observation was in agreement with Liu *et al.,* (2009) that manure application increases soil aggregation which in turn increases soil aeration, water infiltration and biodiversity. This observation was also in line with previous works of Adaikwu *et al* (2012) who stated that good soil management practices may slightly raise the clay and silt fractions of the soil and improve soil productivity but cannot change the textural class.

Effect of saw dust, rice mill waste and poultry manure on soil bulk density and total porosity

Results of the effect of agro-wastes and poultry manure on soil bulk density and total porosity are presented in Figure 2. Soils amended with agro-wastes significantly ($P < 0.05$) reduced soil bulk density as compared to control in both sea-

Table 3: Effect of saw dust, rice mill waste and poultry manure on soil particle sizes

	2011					2013				
Treatment	Poultry manure (t/ha)					Poultry manure (t/ha)				
Wastes	0	4	8	12	Mean	0	4	8	12	Mean
				Sand (g/kg)						
0 t/ha	872.75	804.25	810.0	796.0	820.75	855.2	814.0	804.2	777.2	812.7
10 t/ha RMW	827.00	791.00	789.0	783.0	797.50	799.8	779.5	779.0	763.0	780.3
10 t/ha SD	846.00	810.00	803.0	782.0	810.25	842.0	798.2	781.2	785.8	801.8
Mean	848.6	801.8	800.7	787		832.3	797.2	788.2	775.3	
	(W)	PM	Wx PM			(W)	(PM)	WxPM		
F – LSD(0.05)	3.33	3.47	5.85			8.78	10.14	17.57		
				Silt (g/kg)						
0 t/ha	73.0	95.0	81.0	97.0	86.50	80.00	92.25	89.75	103.0	91.25
10 t/ha RMW	85.0	108.0	94.0	103.0	97.67	95.50	100.0	104.25	107.3	101.75
10 t/ha SD	82.0	84.0	88.0	103.0	89.25	84.00	89.75	94.00	103.0	92.69
Mean	80.0	95.7	87.7	101		86.50	94.00	96.00	104.4	
	(W)	(PM)	W x PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	NS	3.11	5.93			3.65	4.22	7.31		
				Clay (g/kg)						
0 t/ha	54.3	100.8	109.0	107.0	92.8	64.8	92.8	106.0	119.8	96.1
10 t/ha RMW	88.0	101.0	116.8	114.0	104.9	104.8	120.5	116.8	129.8	117.9
10 t/ha SD	72.0	106.0	109.0	115.3	100.6	74.0	112.0	124.8	111.2	105.5
Mean	71.4	102.6	111.6	112.1		71.4	102.6	111.6	112.1	
	(W)	(PM)	W x PM			(W)	(PM)	WxPM		
F – LSD(0.05)	NS	4.26	8.86			9.55	11.03	19.11		

NS = not significant, W = waste, PM = Poultry manure, SD = saw dust, RMW = rice mill wast

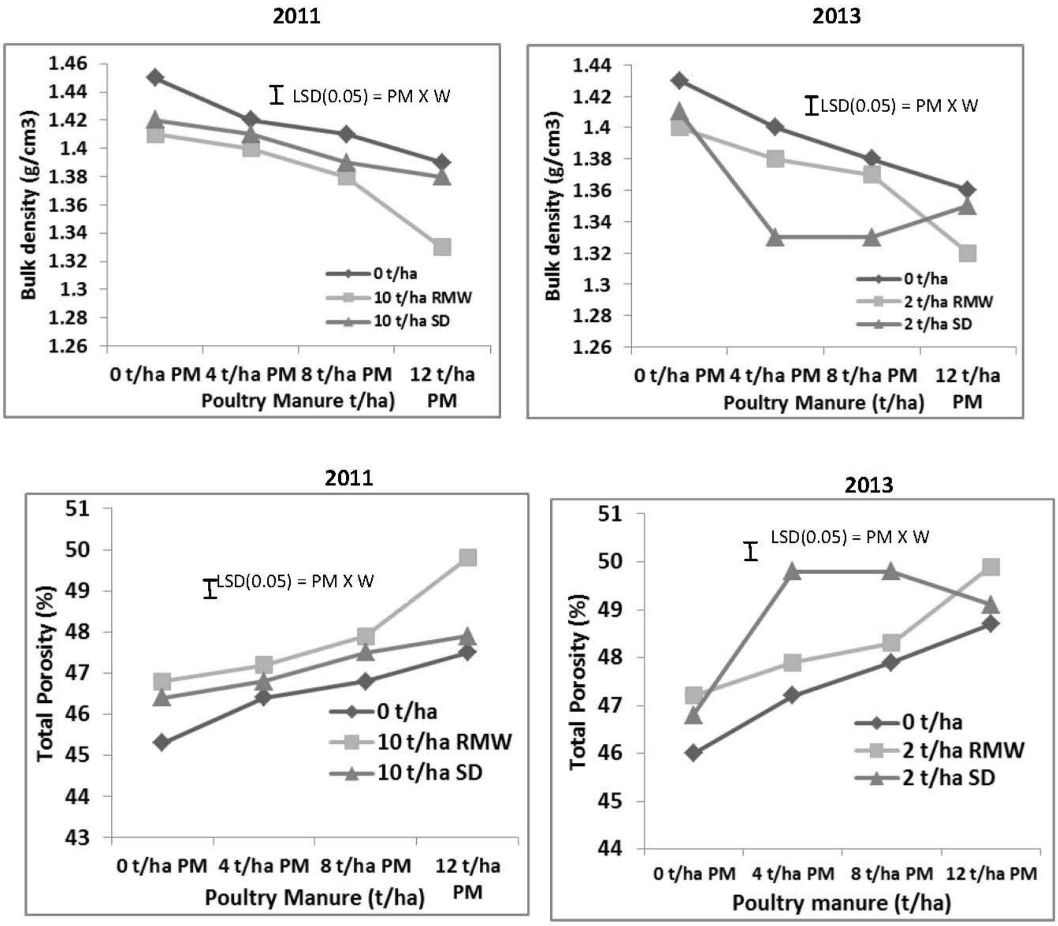

Fig. 2: Effect of poultry manure, saw dust and rice mill waste on soil bulk density and soil total porosity

sons. The lowest bulk density of 1.33 g/cm^3 was attained in soils amended with 10 t/ha rice mill waste + 12 t/ha poultry manure in 2011 and in 2013, soils amended with 2 t/ha rice mill waste + 12 t/ha poultry manure reduced soil bulk density from 1.43 to 1.33 g/cm^3. Increase in the rates of poultry manure application or in combination with either rice mill waste or Saw dust lowered the soil bulk density in both seasons. Decrease in bulk density with these wastes could be as a result of improvement in the aggregate sizes of the soil which reduces compaction and increases aeration, water infiltration and proliferation of soil microbes. Brye *et al.* (2004) in their works noticed that addition of poultry manure as soil amendment decreased soil bulk density. Similar trend was observed in soil total porosity.

Effect of Saw dust, rice mill waste and poultry manure on soil gravimetric moisture content

The agro-wastes significantly (P < 0.05) increased the gravimetric moisture content of the amended soils than the control (Figure 3). In plots amended with 10 t/ha rice mill waste + 12 t/ha poultry manure, the moisture content increased from 122.75 g/kg to 152.0 g/kg (23.8 % increase) in 2011 study and this was the highest among the treatments. In 2013 study, application of 2 t/ha rice mill husk + 12 t/ha poultry manure increased soil moisture content from 123.7 – 149.5 g/kg (20.8 % increase) and this was followed by application of 2 t/ha rice mill waste + 8 t/ha poultry manure which increased soil moisture content to 17.6 %. Results also indicated that plots treated with rice mill waste

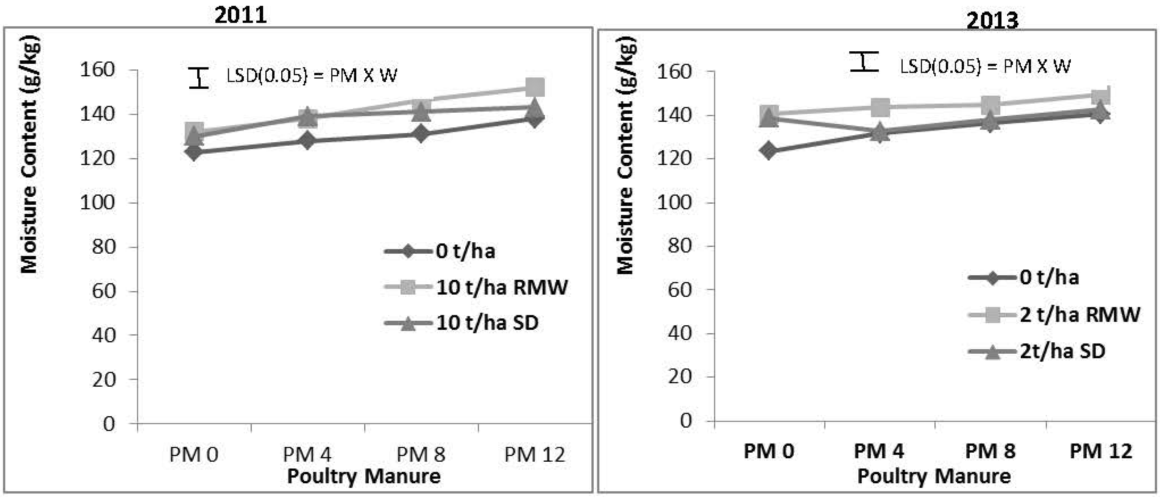

Fig. 3: Effect of poultry manure, saw dust and rice mill waste on moisture content

increased gravimetric moisture content than in plots treated with saw dust (Figure 3). Increase in the moisture content with addition of the agro-wastes could be attributed to increase in the porosity and decrease in the bulk density of the amended soils as well as an increase in the organic matter content of the soil that enhanced water penetration and retention. This was in line with previous works by Mosaddeghi *et al.*, (2000) who observed that application of poultry manure increased soil moisture retention due to an increase in the porosity of the soil and improvement in soil particle size distribution.

Effect of Saw dust, rice mill waste and poultry manure on soil pH

The effects of agro-wastes on soil pH are shown in Figure 4. Results showed significant increase ($P < 0.05$) on soil pH in plots amended with the agro - wastes when compared to control. In 2011, soils amended with 10 t/ha rice mill waste, the pH in water increased from 5.11 to 6.28 while pH in KCl increased from 4.42 - 5.73. In 2013, the pH in water in soils amended with 2 t/ha RMW + 12 t/ha PM was increased from 4.34 to 6.08 and from 3.94 to 5.61 in KCl. Increase in the rate of poultry manure application increased the pH of the soil (Figure 4). Results also showed that plots amended with 10 t/ha of RMW or SD recorded lower soil pH when compared to the results obtained from plots amended with 2 t/ha of either of the wastes (Figure 4). At 10 t/ha application of rice mill waste or Saw dust probably increased CO_2 which reacted with soil water to form carbonic acid that probably reduced the pH of the soil. Increase in the rate of poultry manure application increased the pH of the soil. The results also showed that plots amended with rice mill waste raised soil pH than plot treated with Saw dust in both water and KCl. The reason could also be due to high evolution of CO_2 associated with high C/N ratio in SD than in RMW which when reacted with soil water increased the acidity level of the soil.

Effect of Saw dust, rice mill waste and poultry manure on soil organic carbon, total N and available P

Results of the effects of saw dust, rice mill waste and poultry manure on soil organic carbon are presented in Figure 5. The amendments significantly ($P< 0.05$) increased the organic carbon content of the soil more than the control. Plots amended with 10 t/ha rice mill wastes +

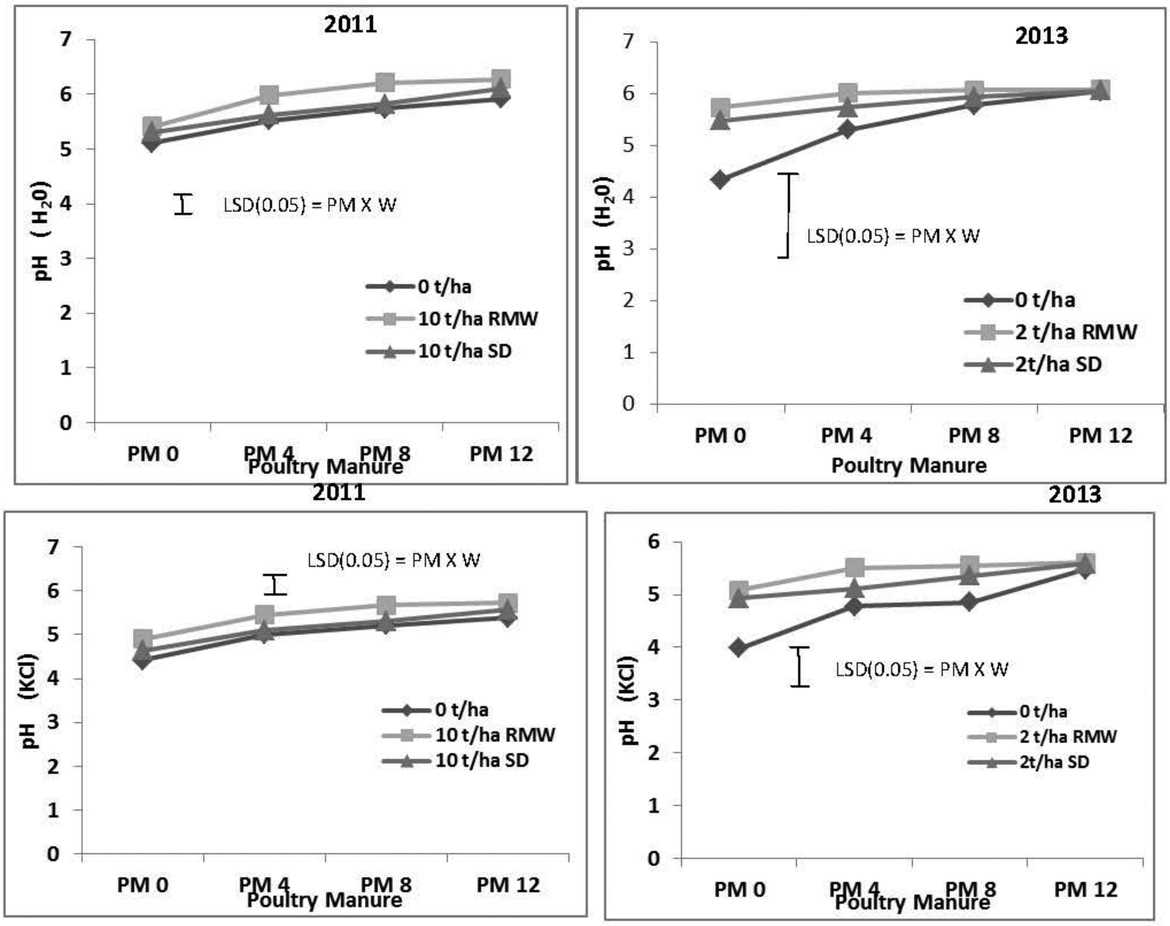

Fig.4: Effect of Poultry manure, saw dust, and rice mill wastes on soil pH

12 t/ha poultry manure recorded the highest organic carbon by increasing the organic carbon content of the soil from 8.91 g/kg (control) to 19.20 g/kg (53.6 % increase) in 2011 while in 2013, plots amended with 2 t/ha RMW + 12 t/ha PM increased soil organic carbon by 52.9 %. Also, rice mill wastes influenced soil carbon content than saw dust and this could be as a result of poor decomposition of the saw dust due to high C/N ratio. This was in accordance with Eneje and Uzoukwu (2012) who made similar observation and noted an increase in soil organic carbon from 8.48 % to 26.49 % when 8 t/ha rice mill wastes + poultry manure was added for maize growth.

The amendments significantly (P< 0.05) increased the total nitrogen of the amended soil when compared to the control (Figure 5). In 2011 season, application of 12 t/ha poultry manure recorded the highest total nitrogen of 7.70 g/kg from 1.15 g/kg in the control plot. This was followed by plot treated with 10 t/ha rice mill wastes + 12 t/ha poultry that recorded 7.20 g/kg total nitrogen while in 2013 planting season, the highest total nitrogen of 8.0 g/kg was obtained on soil treated with 2 t/ha RMW + 12 t/ha PM and this was followed by application of 12 t/ha PM (7.78 g/kg). Reduction of the wastes from 10 t/ha to 2 t/ha resulted to higher soil total nitrogen (Figure 5).

Application of poultry manure at different rates and in combination with either of the wastes significantly (P < 0.05) increased soil available phosphorus than the control plot in

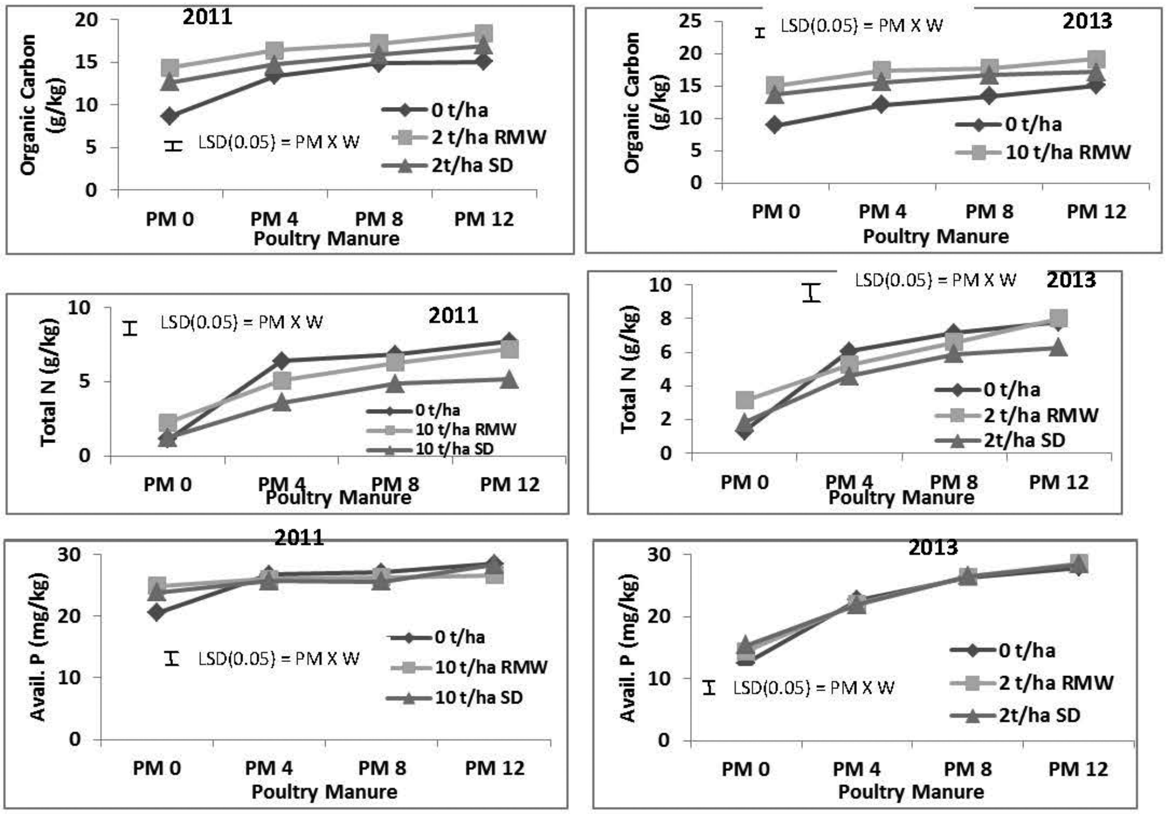

Fig. 5: Effect of poultry manure, saw dust and rice mill waste on organic C, total N and available P

both seasons (Table 5). Due to high C/N ratio in the wastes, marginal increase in the available P was recorded in either of the wastes. In 2011 planting season application of 12 t/ha poultry manure raised soil available P from 20.53 mg/kg (control) to 28.53 mg/kg while in 2013 the highest available P (12.56 mg/kg) was obtained from plots treated with 2 t/ha RMW + 12 t/ha PM. The wastes did not significantly increase available P but with admixture of wastes and poultry manure, there were significant increase.

Effect of saw dust, rice mill waste and poultry manure on the exchangeable cations

Results of the effects of the agro-wastes and poultry manure on the exchangeable cations are presented in Figures 6 and 7. Results revealed a significant increase ($P < 0.05$) in the exchangeable cations with the amendments in both planting seasons. In soils amended with 10 t/ha rice mill waste + 12 t/ha poultry manure, soil exchangeable cations increased in all amended plots relative to control. As the rate of poultry manure application increased, there was increase in the exchangeable cations. Reduction in the rate of application of Saw dust and rice mill waste from 10 to 2 t/ha also increased the exchangeable bases. This could be due to incomplete mineralization of the wastes. The reduction of soil acidity by these amendments assisted in making these exchangeable bases available since soil pH plays significant role in the availability and absorption of plant nutrients by plant roots. This observation was in agreement with Ogbodo and Nnabude (2012).

Effect of poultry manure and agro-wastes on the growth performances of maize

Effects of agro-wastes and poultry manure

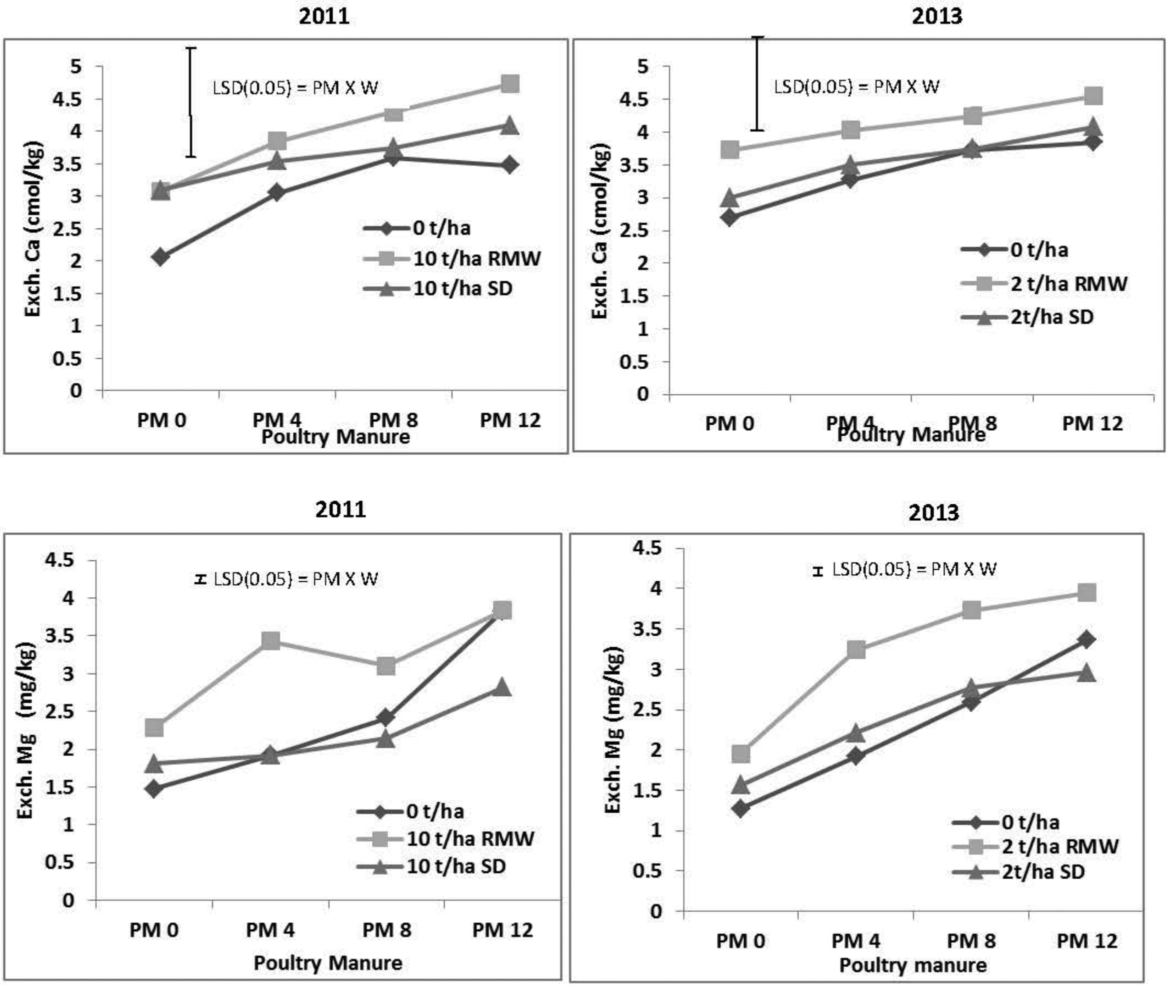

Fig.6: Effect of poultry manure, saw dust and rice mill waste on the exchangeable Ca and Mg

on maize height as presented in Table 4 showed that the amendments significantly ($P < 0.05$) increased maize height relative to the control. The tallest heights of maize plants 17.95, 64.30, 94.70 cm were recorded in plots amended with 10 t/ha rice mill waste + 12 t/ha poultry manure- at 3, 6, and 9 weeks after planting, respectively in 2011 while in 2013, admixture of 2 t/ha RMW +12 t/ha PM recorded the tallest maize plant of 17.43, 69.75 and 93.55 cm at 3, 6 and 9 WAP respectively. Significant differences recorded with application of the wastes, manure and admixture of both could be attributed to increase in the macro nutrients especially nitrogen that helps in cell division and elongation.

The amendments also increased the leaf area of maize more than the control (Table 5). Application of 10 t/ha rice mill waste + 12 t/ha poultry manure recorded the highest leaf area of maize of 28.77, 270.1 and 486.3 cm^2 at 3, 6 and 9 weeks after planting respectively in 2011 while in 2013. Increase in the growth attributes of maize with the application of these amendments could be attributed to higher amount of nutrient elements supplied by these wastes. Earlier works by Sujathan *et al.,* (2008) reported similar observations.

Effect of agro-wastes on the yield of Maize

Results of the effect of agro-wastes on the shoot dry matter, weight of cob and maize grain yield of maize as presented in Table 6 revealed

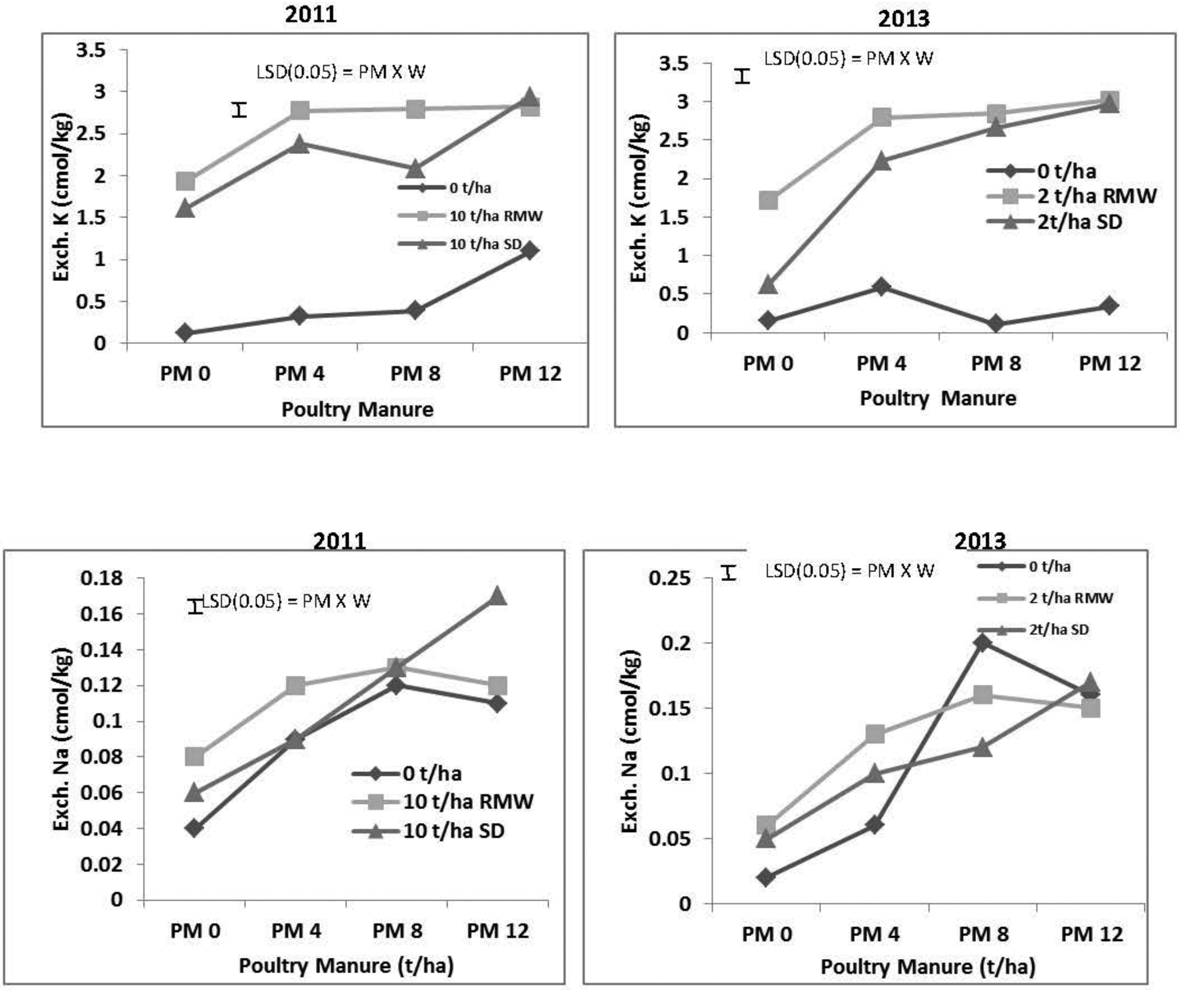

Fig.7: Effect of poultry manure, saw dust and rice mill waste on the exchangeable K and Na

that plots amended with the agro-wastes significant (P < 0.05) increased the shoot dry matter of maize relative to the control in both seasons (Table 6). In 2011, plots amended with 10 t/ha RMW + 12 t/ha PM recorded the highest shoot dry matter of 1.53 kg/plot (0.96 t/ha) while in 2013 plots amended with 2 t/ha RMW + 12 t/ha PM gave the highest shoot dry matter of 1.55 kg/plot (0.97 t/ha). The same trend was observed on the weight of cob. In 2011, plots amended with 10 t/ha rice mill waste + 12 t/ha poultry manure increased weight of cob from 0.48 to 2.33 kg/plot (0.30 t/ha – 1.46 t/ha) while in 2013, plots amended with 2 t/ha RMW + 12 t/ha PM increased weight of cob from 0.47 to 6.0 kg/plot (0.27 – 3.75 t/ha). Soils amended with rice mill waste produced higher weight of cob than saw dust (Table 6).

Plots amended with 10 t/ha RMW + 12 t/ha PM significantly (P < 0.05) increased the maize grain yield when compared to other plots (Table 6). In 2011 study, the highest grain yield of 1,172 kg/ha or 1.17 t/ha was obtained in plots treated with 10 t/ha rice mill waste + 12 t/ha poultry manure while 1377 kg/ha or 1.38 t/ha was obtained on soils amended with 2t/ha RMW + 12 t/ha PM in 2013. Comparing saw dust and rice mill waste, plots amended with 10 t/ha saw dust recorded 0.234 t/ha maize grain yield while 10 t/ha rice mill waste yielded 0.609 t/ha maize

Table 4: Effect of agro-wastes and poultry manure on maize height (cm)

	2011					2013				
Treatment	**Poultry Manure (t/ha)**					**Poultry Manure (t/ha)**				
Wastes	**0**	**4**	**8**	**12**	**Mean**	**0**	**4**	**8**	**12**	**Mean**
			3 WAP					**3 WAP**		
0 t/ha	12.62	16.15	15.40	15.50	14.92	10.23	13.35	14.25	15.53	13.34
10 t/ha RMW	13.28	17.50	17.60	17.95	16.58	10.83	16.85	17.53	17.43	15.66
10 t/ha SD	11.25	13.25	14.28	15.10	13.60	9.98	13.03	15.25	16.23	13.62
Mean	12.38	15.63	15.76	16.18		10.34	14.41	15.68	16.39	
	(W)	(PM)	Wx PM			(W)	(PM)	WxPM		
F – LSD(0.05)	0.92	0.84	1.46			0.46	0.53	0.92		
			6 WAP				**6 WAP**			
0 t/ha	19.53	52.50	57.75	55.75	46.38	21.28	53.23	58.00	63.00	48.88
10 t/ha RMW	30.05	62.95	63.75	64.30	55.26	30.20	61.75	64.75	69.75	56.61
10 t/ha SD	27.70	35.43	35.03	38.05	34.05	23.83	35.75	36.25	39.73	57.49
Mean	25.76	50.29	52.18	52.7		25.10	50.24	53.00	57.49	
	(W)	(PM)	Wx PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	1.65	1.90	3.15			1.23	1.42	2.46		
			9 WAP					**9 WAP**		
0 t/ha	28.35	73.92	78.58	79.95	65.20	30.20	73.40	80.75	82.17	66.63
10 t/ha RMW	55.25	84.98	86.60	94.70	80.38	57.25	86.50	88.27	93.55	81.39
10 t/ha SD	45.63	59.38	63.53	69.73	59.56	46.25	61.70	66.95	73.75	62.16
Mean	43.08	72.76	76.24	81.46		44.57	73.87	78.66	83.16	
	(W)	(PM)	Wx PM			(W)	(PM)	WxPM		
F – LSD(0.05)	1.60	1.51	2.62			1.82	2.10	3.64		

grain yield in 2011. In 2013, plots amended with 2 t/ha of saw dust and rice mill waste yielded 0.447 t/ha and 0.716 t/ha maize grain yield respectively.

Increase in the cob yield with application of these agro–wastes could be attributed to the plant nutrient elements supplied by these amendments as well as the improvement of soil physical condition such as reduced bulk density, increased total porosity and water retention as well as increased soil organic matter and soil pH. These attributes play significant role in increasing soil aeration and soil biodiversity with an attendant high crop yield. These findings are in concord with previous works by Asawalam and Onyegbule (2009) that organic manures increased maize grain yields. Higher yield recorded in 2013 could be due to reduced quantity of saw dust and rice mill wastes which resulted to faster decomposition, mineralization and absorption of nutrient elements by plants.

CONCLUSION

Combined application of poultry manure with either saw dust of rice mill waste proved more effective in improving soil quality, growth and yield of maize in acidic soils. Application of large quantities of saw dust and rice mill waste should be avoided if not combined with appropriate quantities of organic nitrogen sources. From the findings in the study, we therefore recommend application of 2 t/ha rice mill waste + 12 t/ha poultry manure for soil fertility restoration and maize production in an acid soil of Ow-

Table 5: Effect of agro-wastes and poultry manure on the leaf area of maize (cm^2)

Treatment	2011					2013				
	Poultry Manure (t/ha)					Poultry Manure (t/ha)				
Wastes	0	4	8	12	Mean	0	4	8	12	Mean
			3 WAP					3 WAP		
0 t/ha	20.17	25.22	33.47	27.57	26.61	3.5	4.3	4.3	4.5	4.1
10 t/ha RMW	21.95	31.60	26.27	28.77	27.15	4.5	5.0	4.7	4.5	4.7
10 t/ha SD	15.42	18.65	22.95	22.52	19.89	4.0	4.3	4.5	4.5	4.3
Mean	19.18	25.16	27.56	26.29		4.0	4.5	4.5	4.5	
	(W)	(PM)	Wx PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	2.61	2.54	NS			NS	0.71	NS		
			6 WAP					6 WAP		
0 t/ha	54.3	150.8	158.6	168.6	133.1	53.80	151.7	164.1	174.2	136.0
10 t/ha RMW	115.7	225.7	236.7	270.1	212.1	129.9	216.6	219.7	284.1	212.6
10 t/ha SD	93.0	155.2	157.6	170.9	144.2	98.0	163.4	161.3	182.8	151.4
Mean	87.67	177.23	184.3	203.2		93.9	176.2	181.7	213.7	
	(W)	(PM)	WxPM			(W)	(PM)	Wx PM		
F – LSD(0.05)	12.78	7.65	15.89			10.30	11.89	20.59		
			9 WAP					9 WAP		
0 t/ha	121.3	265.4	315.1	332.5	258.6	129.9	264.5	311.8	333.4	259.9
10 t/ha RMW	307.7	401.0	420.4	486.3	403.8	309.1	391.6	418.8	452.0	392.9
10 t/ha SD	217.9	283.2	258.3	333.5	273.2	220.3	274.4	310.5	344.5	287.4
Mean	215.6	316.5	331.3	384.1		219.8	310.2	347.0	376.6	
	(W)	(PM)	Wx PM			(W)	(PM)	WxPM		
F – LSD(0.05)	41.18	39.02	NS			13.61	15.71	27.22		

WAP = weeks after planting

Table 6: Effect of agro-wastes and poultry manure on the yield of maize

Treatment	2011					2013				
	Poultry Manure (t/ha)					Poultry Manure (t/ha)				
Wastes	0	4	8	12	Mean	0	4	8	12	Mean
			Shoot Dry Matter (kg/plot)							
0 t/ha	0.33	0.83	0.98	1.18	0.83	0.45	0.73	0.80	1.10	0.88
10 t/ha RMW	1.05	1.18	1.28	1.53	1.26	1.06	1.23	1.25	1.55	1.27
10 t/ha SD	0.60	0.98	1.13	1.25	0.99	0.55	1.03	1.05	1.00	0.91
Mean	0.66	0.99	1.13	1.32		0.68	0.99	1.03	1.22	
	(W)	(PM)	Wx PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	0.13	0.14	NS			0.12	0.148	NS		
			Weight of Cob (kg/plot)							
0 t/ha	0.48	1.05	1.20	1.55	1.07	0.47	0.85	1.00	1.62	0.99
10 t/ha RMW	1.38	1.93	1.98	2.33	1.90	1.50	2.37	3.17	6.00	4.39
10 t/ha SD	0.60	1.23	1.38	1.73	1.23	0.72	1.67	2.25	2.52	1.79
Mean	0.82	1.4	1.52	1.87		0.90	1.63	2.14	3.38	
	(W)	(PM)	Wx PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	0.09	0.17	NS			3.20	3.69	NS		
			Grain Yield (kg/ha)							
0 t/ha	203	531	578	766	520	263	620	815	956	663
10 t/ha RMW	609	922	984	1,172	922	716	1144	1226	1377	1116
10 t/ha SD	234	625	688	828	594	447	761	894	928	758
Mean	348.7	692.7	750	922		476	842	978	1087	
	(W)	(PM)	Wx PM			(W)	(PM)	Wx PM		
F – LSD(0.05)	58.2	90.7	NS			77.2	89.1	NS		

NS = Not significant, W = wastes, PM = Poultry manure erri, Imo State Southeastern Nigeria

REFERENCES

Adaikwu, A. O., Obi, M. E and Ali, A. (2012). Assessment of degradation status of soil in selected areas of Benue State Southern Guinea Savanna of Nigeria. *Nigerian Journal of Soil Science.* 22(1): 171 – 180

Ajaz, A., Lone, B., Allai, A. and Nehvi, F. A. (2013). Growth, yield and economics of baby corn (*Zea mays* L.) as influenced by Integrated Nutrient Management (INM) practices. *African Journal of Agric. Research,* Vol. 8(3), pp 4537 – 4540.

Anikwe, M. A. N and Eze, D. C. (2010). Effect of indigenous legumes on soil properties and yield of maize on an ultisol in Southeastern Nigeria. *Nigerian Journal of Soil Science*. Vol. 20 (2), 47 -53.

Asawalam, D. O. and Onyegbule, U. (2009). Effects of some local mining materials and organic manure on some soil chemical properties and growth of maize. *Nigerian Journal of Soil Science,* 19 (2): 71 – 76

Bremner, J.M and Yeomans, J.C. (1988). Laboratory Techniques for determination of different forms of nitrogen. In: J, R. Wilson (ed.). *Advances in Nitrogen Cycling in Agricultural Ecosystem*, pp 339 – 414.

Brye, K. R., Slaton, N. A. Norman, R. J. and Savin, M. C. (2004). Short-term effects of poultry litter form and rate on soil bulk density and water content. *Communication in Soil Science and Plant Analysis.* 35: 2311 – 2325.

Eneje, R. C and Uzoukwu, I. (2012). Effect of Rice mill waste and poultry manure on some chemical properties and growth and yield of maize. *Nigerian Journal of Soil Science*. 22(1): 59 – 64.

Federal Department of Agriculture and Land Resources FDALR (1985). Reconnaissance Soil Survey of Anambra State of Nig. Soil Reports 1985. Federal Dept. of Agric. Land Resources, Lagos- Nigeria.

Gee, G.W. and Or. D. (2002). Particle size analysis. In: *Methods of Soil Analysis.* Dan. D. J and Topps G.C (Ed.). Part 4, *Physical Methods. Soil Sci. Soc. of America Book Series.* No. 5, ASA and SSSA Madison, WI, PP 225 – 293.

Gichuru, M. P., Bationo, A., Bekunda, M. A., Goma, H. C., Mafongonya, P. I., Mugendi, D. N., Murwir, J. M., Nnadwa, S. M., Nyathii, P. and Swift, M. J. (2003). *Soil fertility management in Africa: A Regional Perspective.* Published by Academy Science Publishers in Association with the Tropical Soil Biology and Fertility of CIAT.

Grossmans, R.B. and Reinch, T.G. (2002). Bulk density and linear extensibility. In: *Methods of Soil Analysis. Part 4 Physical Methods*. Dane, J.H and G.C Topp (eds.). *Soil Science Society of Am. Book Series*, No 5 ASA and SSA Madison, W. I, pp 201 – 228.

Hendershot; Lalande, H and Duquette, M. (1993). Soil reaction and exchangeable acidity. In: *Soil Sampling and Methods of Soil Analysis.* Carter, M.R. (Ed.), Canadian Soc. Soil Sci. Lewis Pub., London. PP 141 – 145

Kalu, C., Modugu, W. W. and Ubochi, I. (2009). Evaluation of soil waste management policy in Benin Metropolis, Edo State, Nigeria. *African Sci.,* 10: 1 – 7.

Liu M., Hu F., Chen X., Huang Q., Jiao J., Zhang B. and Li H. (2009). Organic amendments with reduced chemical fertilizer promote soil microbial development and nutrient availability in a subtropical paddy field: The influence of quantity, type and application time of organic amendments. *Applied Soil Ecology,* 42: 166 –175.

Mclean, E.D., (1982). Soil pH and lime requirements in Page, A.L. (Ed). *Methods of Soil Analysis part*

2. Chemical and Microbiological Properties (2nd Ed.). Agronomy series No. SSSA. Maidison, Wis. USA., pp: 199-234.

Mosaddeghi, M. R., Hajabbasi, M. A., Hemmat, A. and Afyuni, M. (2000). Soil compactibilty as affected by soil moisture content and farmyard manure in central Iran. *Soil & Tillage Research* 55(1-2):87-97.

Nelson, D.W. and Sommers, L.E. (1982). Total organic carbon and matter. In: Page, A. L. (ed.). *Methods of Soil Analysis. Part 2 Chemical and Microbiological Properties* (2nd ed.). Agronomy series No.9, ASA, SSA, Maidison, Wis.USA., pp: 570.

Nwafor, O.E., Adepoju, S.O., Mba, A.A., Okonkwo, M.C; Emefiene, M and Aminu, K. (2010). The effect of manual weeding intervals on the yield of water melon (*Citrullus lanatus*) in Jos Metropolis, Nigeria. In: *Proceedings of the 24th Annual National Conference of Farm Management Association of Nigeria.* Pp 35 – 38

Ogbodo, E. N. and Nnabude, P. A. (2012). Effect of tillage and crop residues on soil chemical properties and rice yields on an acid ultisol at Abakaliki Southeastern Nigeria. *Nigerian Journal of Soil Science,* Vol. 22 (1): 73 - 85.

Ojeniyi, S. O., Faleye, B. T., Taiwo, L. B., Akande, M. O. and Adediran, J. A. (2007). Effect of some manure on Soil plant nutrient status, growth and yield of maize in Southwest Nigeria. *The 4th African Soil Science Society Conference, GIMPA*, Accra Ghana, 7th – 8th January, 2007.

Oladipo, O. G, Olayinka, A, Aladesanmi, O. T, Sanni, M, Famurewa, A. J. and Siyanbola, W. O. (2010). Risk mitigation strategies and policy implications for carbon dioxide emission in organically amended soils in Nigeria. *African Journal of Environmental Sci. and Technology.* Vol. 4 (11): 801 – 806.

Olsen, S.R. and Sommers, I.E. (1982). Soil available phosphorus. In: D. L. Sparks, A. L. Page, P.A. Hennke, K. H Loppez, E.N. Solanpour and M.E Summers (2nd ed.). *Methods of Soil Analysi*s, Part 2. Agron., Mono. ASA and SSSA Madison, USA.

Onweremadu, E.U., Ihem, E.E., Onwudike, S.U., Ndukwu, B.N., Idigbor, C.M and Asiabaka, C.C. (2011). Evaluation of selected physical properties of soils as influenced by legumes and prominol-P fertilization. *Journal of Emerging Trendsin Engineering and Applied Science* (JETEAS), 2(2): 198 – 202.

Onwuka, M.I., Osodeke, V. E. and Ano, A.O. (2010). Assessment of the effect of some liming materials on some soil chemical properties in a degraded ultisol of Southeastern Nigeria. *Nigerian Journal of Soil Science.* Vol. 20 (2): 54 – 62.

Sujathan, M. G, Lingaraju, B. S, Palled, Y. B, and Ashalatha, K. V. (2008). Importance of integrated nutrient management practices in maize under rainfed conditions. *Karnatake J. Agric. Sci.* 67(1):13-15.

Tariq, H. K,. Kamal, Sh. Q. and Salahaddin, A. A (2013). Rate of soil aggregates disintegration as affected by type and rate of manure application and water quality. International Journ. of Plant, Animal and Environmental Sciences. Pp 94 - 102

Thomas, G.W. (1982). Exchangeable Cations. In: A. L. Page, A. Miller and D.R. Keeney (2nd Ed.). *Methods of Soil Analysis*. Part 2, ASA and SSSA, Madison, WI, PP 159 – 166.