Contribution of Agricultural Wastes on Soil Aggregation, Soil Properties and Yield of Maize on Acidic Soil

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Abstract

The stability of soil aggregates against the impact of rainfall has become vital especially in South-eastern Nigeria whose soils are too fragile due to high rainfall distribution in the zone that facilities soil erosion. In trying to finding out ways of improving the aggregate stability of soils, two agricultural wastes (poultry droppings (PD) and saw dust ash (SDA) were applied individually and in combination of both at varying rates to evaluate its effects on soil aggregate stability, soil physicochemical properties and yield of maize. A randomized complete block design was used and the treatments were replicated three times. Pre and post planting soil samples were collected and analysed for physical and chemical soil properties using standard methods. Data collected from soil analyses and growth performances of maize were subjected to analysis of variance and significant treatment means were separated using least significant difference at 0.05 probability level. Results showed that plots amended with 10 t/ha PD + 10 t/ha SDA increased soil organic carbon by 25.4 %, soil total nitrogen by 25.7 %, effective cation exchange capacity by 34.3 % and base saturation by 19.2 %. Plots amended with 10 t/ha PD + 10 t/ha SDA reduced clay ratio (CR), clay dispersion index (CDI) and dispersion ratio (DR) by 75.2 %, 84.9 % and 93.7 % respectively while clay flocculation index (CFI) was increased by 82.3 %. The highest maize yield (74 kg/ha) was recorded from plots amended with 10 t/ha PD + 10 t/ha SDA. Therefore 10 t/ha PD + 10 t/ha SDA was recommended for improvement of soil properties, soil aggregate stability and yield of maize in acid soil.

Key words: Clay flocculation index, Dispersion ratio, Erosion, Soil erodibility, Dispersion index

Introduction

Soil degradation has been an environmental challenge affecting food production in Southern part of Nigeria. Soils of this region have high erodibility and therefore structurally unstable (Idowu and Oluwatosin, 2008; Nwachukwu and Onwuka, 2011). These soils are naturally prone to erosion due to their fragile nature as a result of the parent materials that formed the soils (Oguike and Mbagwu, 2009). Anthropogenic activities like bush burning, continuous cultivation and mining on hill side slopes contribute to high soil degradation in the region (Nwachukwu and Onwuka, 2011). Most arable farm lands have lost their agricultural potential with negative consequences to food security. These activities have reduced the organic matter content of soil thereby making the soil prone to erosion as a result of poor aggregate stability (Nwachukwu and Onwuka, 2011).

One of the methods of measuring the structural status of agricultural soils is by measuring the stability of their aggregates when in contact with water (Mbagwu et al., 1994). Use of organic amendment to increase the aggregate stability of soils susceptible to erosion has been examined in recent studies (Shainberg and Levy, 1994). One of such practice is the incorporation of organic and inorganic amendment on soil (Nutullah et al., 2015). Nutullah et al. (2015) reported significant relationships between total soil carbon and soil aggregation, bulk density, water retention and hydraulic conductivity on soils amended with organic residues. These relationships indicate that amending coarse-textured soils with organic amendments increases organic carbon content and improved saturated hydraulic conductivity, water stable aggregation and water retention (Nutullah et al., 2015). However, little literature is available on the effect of agricultural wastes on soil aggregate stability and how soil aggregation affects the yield of maize in the region. The aim of this work therefore was to evaluate the effect of two agricultural wastes on soil aggregate stability, soil physicochemical properties and yield of maize in an acid soil of Owerri, South-eastern Nigeria.

Materials and Methods

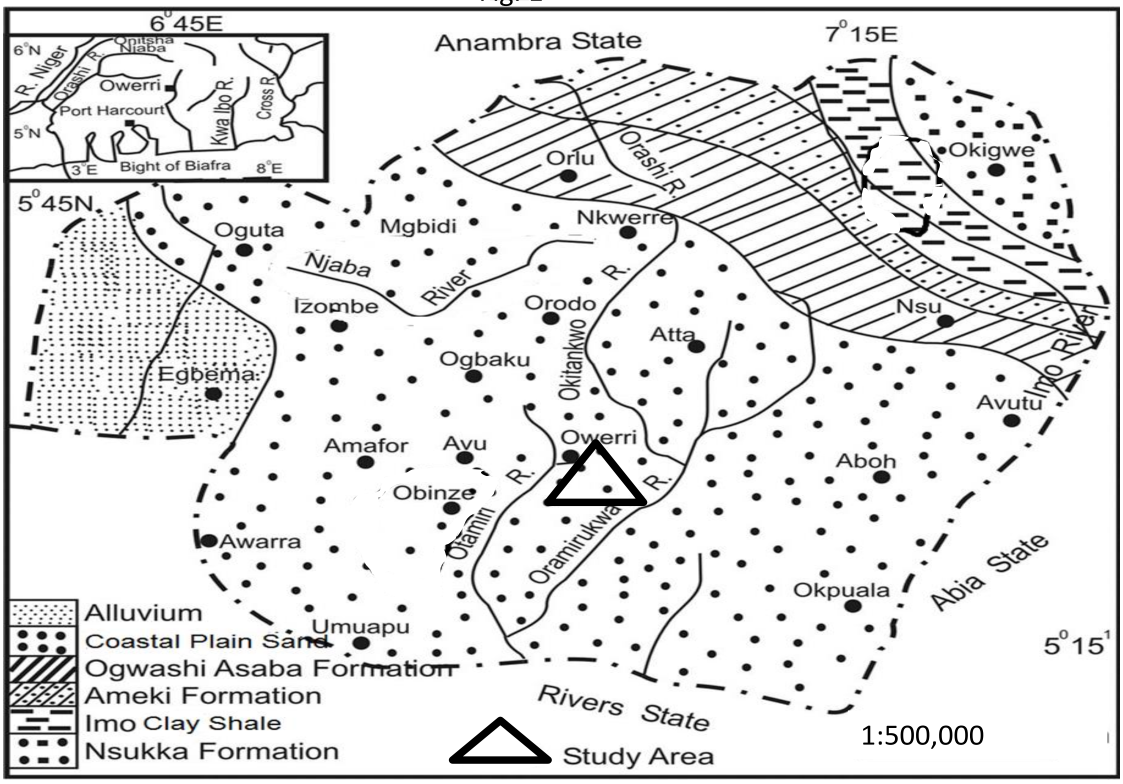
The Study Area

The study was conducted at the Teaching and Research Farm of Federal University of Technology Owerri, Imo State, South-eastern Nigeria during 2016 planting season. The area lies between Latitude 5° 21' N and 5° 28' N and Longitude 7' 02°E and 7° 16' E with an average annual rainfall range of 1950 mm – 2250 mm and annual temperature range of 27°C – 32°C. It has average relative humidity of 80%. The geologic material of soil in the region 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). The region is a tropical rainforest with high anthropogenic activities, especially farming and deforestation and these deplete the vegetation Farming at subsistent level is a major socio economic activity of people in the area and soil fertility restoration is by bush fallow and application of inorganic fertilizers and inorganic manures.

Land Preparation

A two year fallow land, dominated by shrubs and grasses was used for the study. The area was manually cleared using cutlass and hoes and mapped out into 27 experimental plots. Composite soil samples were randomly collected at 0 – 30 cm depth using soil auger and soil core sampler was used to collect soil sample for bulk density determination. The samples were air dried at room temperature and sieved using 2 mm mesh sieve and then subjected to routine laboratory analysis using standard methods.

Fig 1



Geological Map of Imo State showing the Study Area.

Figure 1. *Geological map of Imo State showing the study location*

Field layout, treatments and experimental design

The experimental plots were mapped out into nine treatment plots using ranging pole and measuring tape. Each experimental plot measured 3 x 3 m with inter-plot distance of 1 m and inter-block distance of 2 m. The nine experimental plots were replicated three times given a total of 27 treatment plots. The beds were manually tilled with hoes and spades. Treatments applied consisted of control plot (T1), 5 t/ha PD (T2), 10 t/ha PD (T3), 5 t/ha SDA (T4), 5 t/ha SDA + 5 t/ha PD (T5), 5 t/ha PD + 10 t/ha SDA (T6), 10 t/ha SDA (T7), 5 t/ha SDA + 10 t/ha PD (T8), 10 t/ha SDA + 10 t/ha PD (T9). The treatments were applied on the experimental plots by broadcasting method and later incorporated into the soil using local hoe. The treatments were allowed to incubate for a week and thereafter maize seeds (Oba super II hybrid) were planted on the bed at a distance of 50 x 50 cm given a total of 27 plants per plot and a plant population of 30, 000 plants per hectare. At 13 weeks after planting, the maize cobs were harvested; sun dried and weighed using weighing balance. Soil samples were collected from each experimental plot 12 weeks after planting. The samples were air dried and sieved using 2 mm mesh and subjected to routine analysis. Similarly, some samples of poultry manure and saw dust ash were analysed for nutrient composition before the study.

Laboratory Analysis

Physical properties of the soil

The particle size distribution of the soil (sand, silt and clay fractions) was determined by hydrometer method according to the procedure of Gee and Or (2002). A set of soil sample was dispersed with calgon (DC) while another set was dispersed with water (DW) before the particle size fractions were determined. Bulk density (BD) was determined by core methods according to Grossman and Reinsch (2002). Total porosity of the soil was calculated from the result of bulk density using the formula:

Total porosity (TP) = $1 - \frac{BD}{pd} \times 100$ ....equation 1

where pd = particle density (2.65 g/cm^3) and BD = bulk density

Gravimetric moisture content (GMC) was determined using the formula

GMC = $\frac{Wtmc}{Wtss} \times 100$ ....equation 2

where Wtmc = weight of the moisture contained in soil sample; Wtss = weight of soil sample

Estimation of soil aggregate stability

Soil aggregate stability was estimated using four indices namely Clay Flocculation Index (CFI), Dispersion Ratio (DR), Clay Dispersion (CD) and Clay Ratio (CR) according to Igwe *et al.*, (1995) and Igwe and Obalum (2013).

DR = $\frac{(\%\ silt + \%\ clay)\ (DW)}{(\%\ silt + \%\ clay)\ (DC)}$ .... equation 3

CFI = $\frac{\%\ clay\ (DC) - \%\ clay\ (DW)}{\%\ clay\ (DC)}$ .... equation 4

CDI = $\frac{\%\ clay\ (DW)}{\%\ clay\ (DC)} x100$ .... equation 5

CR = $\frac{(\%\ sand)}{(\%clay + \%silt)}$ .... equation 6

where DC = dispersed in sodium hexametaphosphate (calgon), DW = dispersed in water

Low values of CR, DR and CDI indicate less erodibility and hence higher stability of soil micro aggregation. CFR is the reverse of the other three indices meaning that the higher the values of CFI the lower the stability of soil aggregate (Igwe and Obalum, 2013).

Soil chemical properties

Soil pH was determined in both 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 acid 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 according to Olsen and Somers (1982). Exchangeable Mg and Ca were extracted 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). Exchangeable Acidity was measured titrimetrically using 1 N KCl against 0.05N 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.

Soil properties before treatment application and selected nutrient composition of agro-wastes used in the study.

The physico-chemical properties of soil used in the study are presented in Table 1. The soil was texturally loamy sand with high sand fraction and silt clay ratio showing advanced stages of weathering. The gravimetric moisture content was low and the soil was strongly acidic, low in organic carbon and exchangeable bases.

Selected nutrient content of the agricultural wastes used in the study are presented in Table 2. The wastes are rich in plant nutrient elements. Poultry droppings contained high values of nitrogen, phosphorus, organic carbon and magnesium than saw dust ash. Saw dust ash contained high value of potassium with high pH.

Table 1. *Physicochemical properties of the soil before the study*

Soil property	Unit	Value
Sand	g/kg	921
Silt	g/kg	15
Clay	g/kg	64
Textural class		Loamy sand
Silt/clay		0.23
Bulk density	g/cm^3	1.35
Total porosity	%	49.1
Gravimetric moisture content	g/kg	117.2
pH (H_2O)		5.11
Organic carbon	g/kg	6.36
Total nitrogen	g/kg	0.56
Available phosphorus	mg/kg	14.3
Exchangeable Ca	cmol/kg	1.40
Exchangeable Mg	cmol/kg	1.01
Exchangeable K	cmol/kg	0.12
Exchangeable Na	cmol/kg	0.04
Exchangeable H	cmol/kg	0.32
Exchangeable Al	cmol/kg	0.59
Effective cation exchange capacity (ECEC)	cmol/kg	3.48
Base saturation	%	73.8

Table 2. *Selected chemical properties of the amendments used in the study*

Chemical property	Unit	Saw dust ash (SDA)	Poultry manure (PD)
pH (H_2O)		9.55	6.83
Nitrogen	g/kg	0.22	4.32
Phosphorus	mg/kg	1.42	7.0
Potassium	g/kg	4.30	3.21
Organic carbon	g/kg	7.31	13.5
C/N		33.2	3.13
Calcium	g/kg	5.90	6.50
Magnesium	g/kg	3.12	5.21

Statistical analysis

Results from laboratory analysis and yield of maize were subjected to Analysis of Variance (ANOVA) while significant means among treatments were separated using Least Significant Difference (LSD) at 5% probability level. Relationship between aggregate stability indices and soil properties was determined using correlation analysis.

Results and Discussion

Effect of the amendments on soil physical properties

The amendments did not significantly (p = 0.05) change the textural class of the soil (Table 3). Soil bulk density was significantly (p = 0.05) reduced in the plots amended with the manure when compared to the control plots. Plots amended with 10 t/ha PD + 10 t/ha SDA recorded the lowest soil density (1.07 g/cm^3). Amended plots significant (p = 0.05) increase in soil total porosity as compared to un-amended plots. Plots amended with 10 t/ha PD + 10 t/ha SDA recorded the highest total porosity of 59.7%. Application of the agro-wastes significantly (p = 0.05) increased soil gravimetric moisture content when compared to un-amended plots. The highest gravimetric moisture content of 369.2 g/kg was recorded in plots treated with 10 t/ha PD + 10 t/ha SDA.

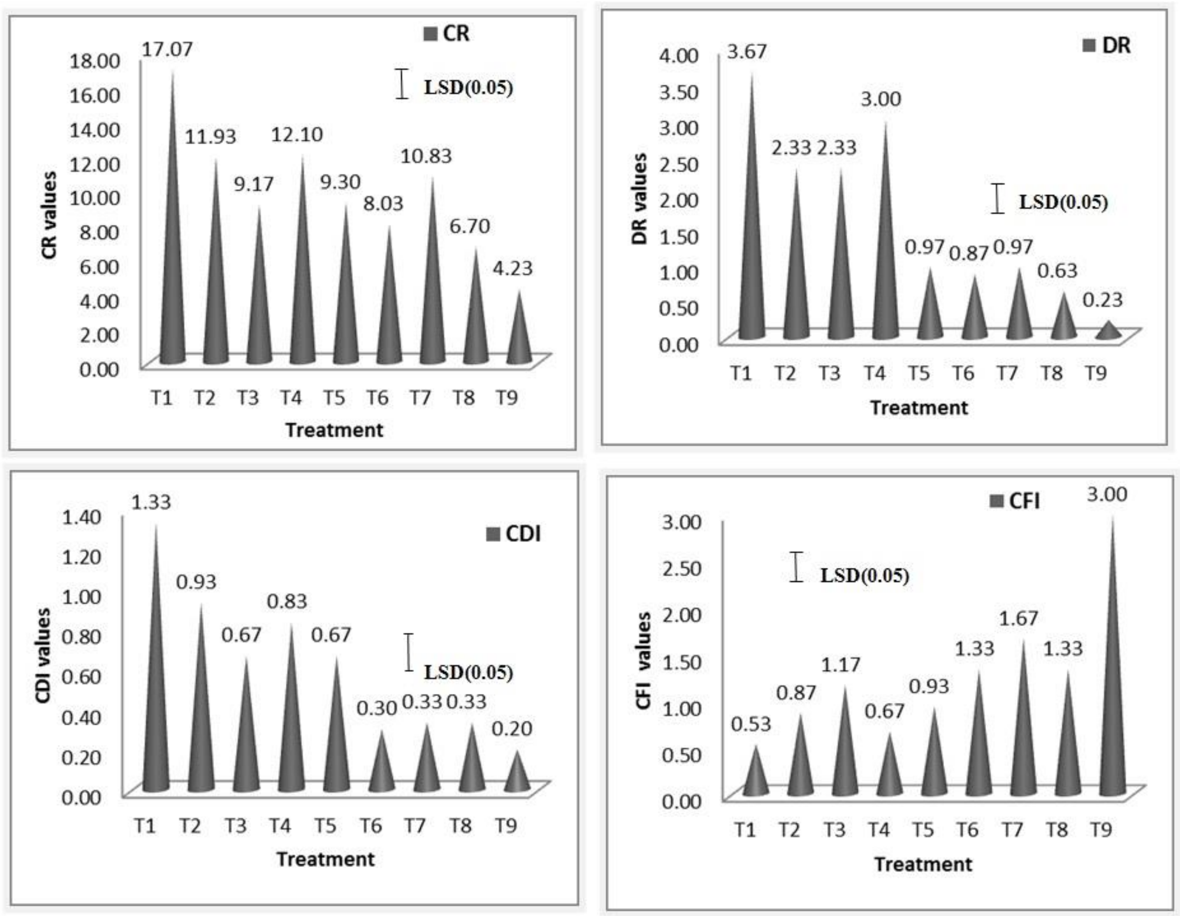
Table 3. *Effect of the amendments on soil physical properties*

Treatment	Sand g/kg	Silt g/kg	Clay g/kg	Textural class	Silt/Clay	BD g/cm^3	TP %	GMC g/kg
Control	922.9	16.2	60.9	Loamy sand	0.19	1.37	48.40	116.8
5 t/ha PM	940.4	19.2	40.4	Loamy sand	1.17	1.30	51.01	144.9
10 t/ha PM	928.9	19.8	49.8	Loamy sand	0.69	1.20	55.36	224.1
5 t/ha SDA	913.9	39.5	44.2	Loamy sand	1.10	1.19	56.63	123.1
5 t/ha PM + 5 t/ha SDA	895.6	22.8	81.2	Loamy sand	0.16	1.27	52.20	243.9
5 t/ha PM + 10 t/ha SDA	902.9	47.8	48.9	Loamy sand	1.0	1.24	55.0	241.3
10 t/ha SDA	895.9	46.1	55.9	Loamy sand	0.48	1.29	52.87	168.2
10 t/ha PM + 5 t/ha SDA	949.2	26.1	26.6	Loamy sand	0.36	1.26	54.1	311.0
10 t/ha PM + 10 t/ha SDA	929.6	29.5	40.9	Loamy sand	1.04	1.07	59.69	369.2
LSD(0.05)	NS	NS	NS		NS	0.076	5.278	27.71

NS = not significant, BD = Bulk density, TP = Total porosity, GMC = Gravimetric moisture content

Effect of the amendments on soil aggregate stability indices.

Aggregate stability was evaluated using four indices namely Clay Ratio (CR), Dispersion Ratio (DR) Clay Dispersion Index (CDI) and Clay Flocculation Ratio (CFR) as shown in Figure 2. Low values of CR, DR and CDI indicate less erodibility and hence higher stability of soil micro aggregation. CFR is the reverse of the other three indices meaning that the higher the values of CFI the lower the erodibility of the soil (Igwe and Obalum, 2013). Results in Figure 2 showed that plots amended with agro-wastes significantly (p = 0.05) increased the stability of soil aggregates when compared to un-amended plots. Plots treated with 10 t/ha SDA + 10 t/ha PD recorded 4.23 for CR, 0.23 for DR, 0.20 for CDI and 3.0 for CFR. Also, increase in the rate of the amendments resulted to higher micro aggregation of the soil.



CR = Clay ratio, DR = Dispersion ratio, CDI = Clay dispersion index, CFI = Clay flocculation index. The lower the values of CR, DR AND CDI, the more the stability of the soil to resist erosion while the higher the values of CFI, the higher the stability of the soil. T1 = control, T2 = 5 t/ha PM, T3 = 10 t/ha PM, T4 = 5 t/ha SDA, T5 = 5 t/ha PM +5 t/ha SDA, T6 = 5 t/ha PM + 10 t/ha SDA, T7 = 10 t/ha SDA, T8 = 10 t/ha PM + 5 t/ha SDA, T9 = 10 t/ha PM + 10 t/ha SDA

Figure 2. *Effect of poultry manure and saw dust ash on soil aggregate stability.*

Effect of the amendments on soil chemical properties

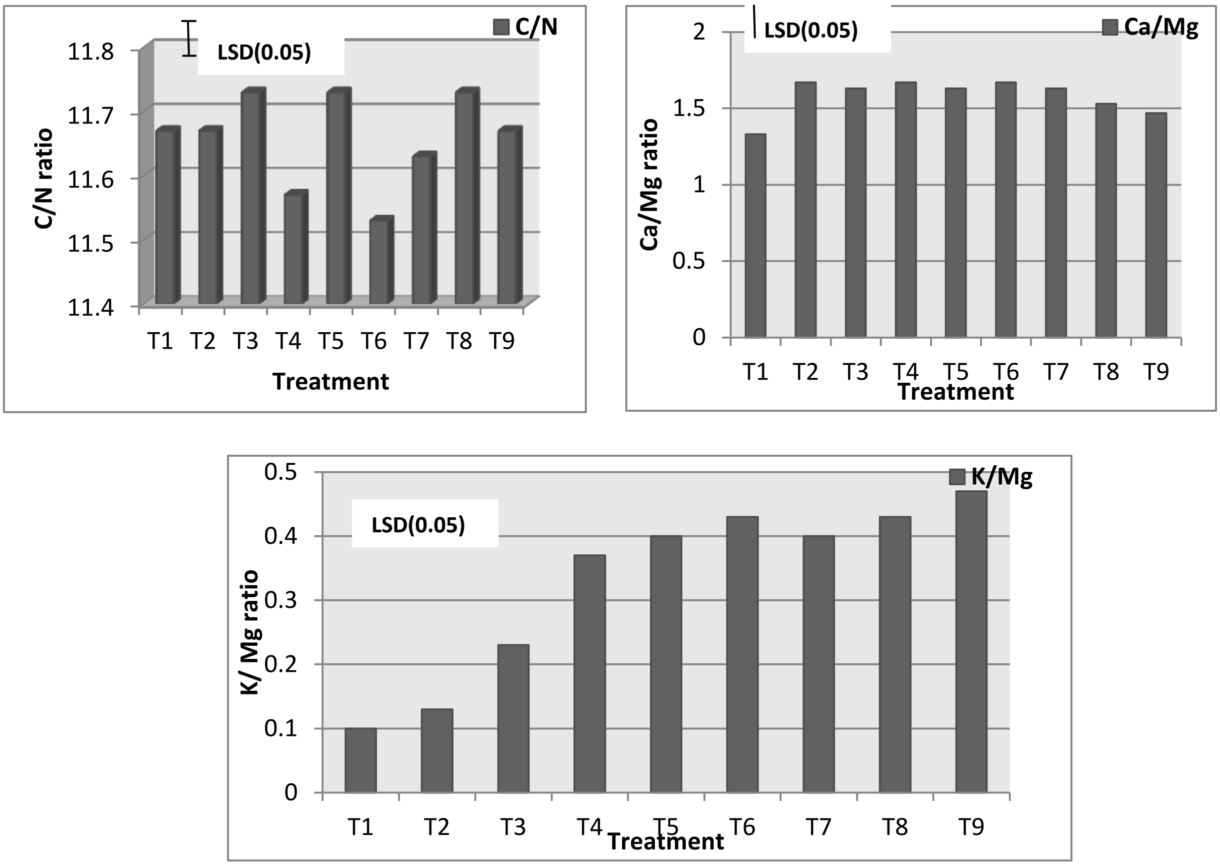
The treatments significantly (p = 0.05) increased soil pH when compared to control plots (Table 4). Plots amended with 10 t/ha PD + 10 t/ha SDA recorded the highest value of soil pH in water (5.29) and in KCl (4.75). The same rate recorded the highest values of soil organic carbon (8.67 g/kg), total nitrogen (0.74 g/kg) and available phosphorus (18.10 mg/kg) when compared to other treatments. Similar trend was observed in exchangeable bases, effective cation exchange capacity and base saturation. Plots amended with 10 t/ha PD + 10 t/ha SDA recorded the lowest total exchangeable acidity of 0.53 cmol/kg.

Results on the fertility ratios as affected by the amendments are shown in Figure 3. Results showed that application of the organic manure significantly (p = 0.05) influenced carbon to nitrogen ratio (C/N) and potassium to magnesium ratio (K/Mg) while no effect was observed in calcium to magnesium ratio (Ca/Mg). Plots amended with 10 t/ha SDA + 10 t/ha PD recorded the highest K/Mg ratio of 0.47 as compared to 0.1 in the control. There was irregular trend on C/N ratio in all the experimental plots.

Table 4. *Effect of the amendments on soil chemical properties*

Treatment	pH H_2O	pH KCl	OC g/kg	TN g/kg	C/N	Avail. P Mg/kg	Ca (Exch, Cmol/kg)	Mg	K	Na	TEA	ECEC	BS %
Control	5.01	4.14	6.47	0.55	11.67	15.23	1.50	1.09	0.13	0.03	0.99	3.74	73.30
5 t/ha PD	5.13	4.44	7.47	0.64	11.67	16.25	2.25	1.36	0.17	0.04	0.62	4.45	86.03
10 t/ha PD	5.13	4.53	7.61	0.65	11.73	16.37	2.33	1.39	0.37	0.03	0.66	4.79	86.30
5t/ha SDA	5.25	4.53	7.23	0.62	11.57	16.57	2.30	1.34	0.49	0.04	0.62	4.79	87.00
5t/ha PD + 5t/ha SDA	5.26	4.55	7.67	0.65	11.73	16.93	2.44	1.45	0.59	0.03	0.59	5.09	88.43
5t/ha PD + 10t/ha SDA	5.27	4.55	8.18	0.71	11.53	17.40	2.58	1.55	0.68	0.03	0.53	5.38	90.07
10t/ha SDA	5.26	4.57	7.41	0.63	11.63	16.87	2.43	1.49	0.64	0.04	0.49	5.08	90.40
10t/ha PD + 5t/ha SDA	5.27	4.70	8.41	0.72	11.73	17.40	2.54	1.66	0.72	0.06	0.51	5.49	90.60
10t/ha PD+10t/ha SDA	5.29	4.75	8.67	0.74	11.67	18.10	2.56	1.74	0.81	0.06	0.53	5.69	90.77
%CV	0.10	0.70	1.10	1.00	0.60	0.70	5.30	2.60	5.40	42.30	9.20	3.60	1.20
LSD(0.05)	**0.02**	**0.09**	**0.48**	**0.04**	**0.26**	**0.49**	**0.3**	**0.1**	**0.09**	**NS**	**0.15**	**0.42**	**2.83**

NS = Not significant at 0.05 probability, Exch = exchangeable, OC = organic carbon, TN = total N, C/N = carbon to nitrogen ratio, TEA = total exchangeable acidity, ECEC = effective cation exchange capacity, BS = base saturation, PD =poultry dropping, SDA = saw dust ash



T1 = control, T2 = 5 t/ha PM, T3 = 10 t/ha PM, T4 = 5 t/ha SDA, T5 = 5 t/ha PM +5 t/ha SDA, T6 = 5 t/ha PM + 10 t/ha SDA, T7 = 10 t/ha SDA, T8 = 10 t/ha PM + 5 t/ha SDA, T9 = 10 t/ha PM + 10 t/ha SDA

Figure 3. *Fertility ratios as influenced by the amendments*

Relationship between soil aggregate stability indices and soil chemical properties

Relationship between soil aggregate stability indices and soil chemical properties are presented in Table 5. Significant negative correlation existed between CDI and base saturation (r = -0.901), exchangeable Ca (r = -0.988), ECEC (r =.-0.961), exchangeable K (r = -0.925) and with other soil chemical properties. Similar interactions were observed between CR and DR and soil properties such as organic carbon (Table 5).

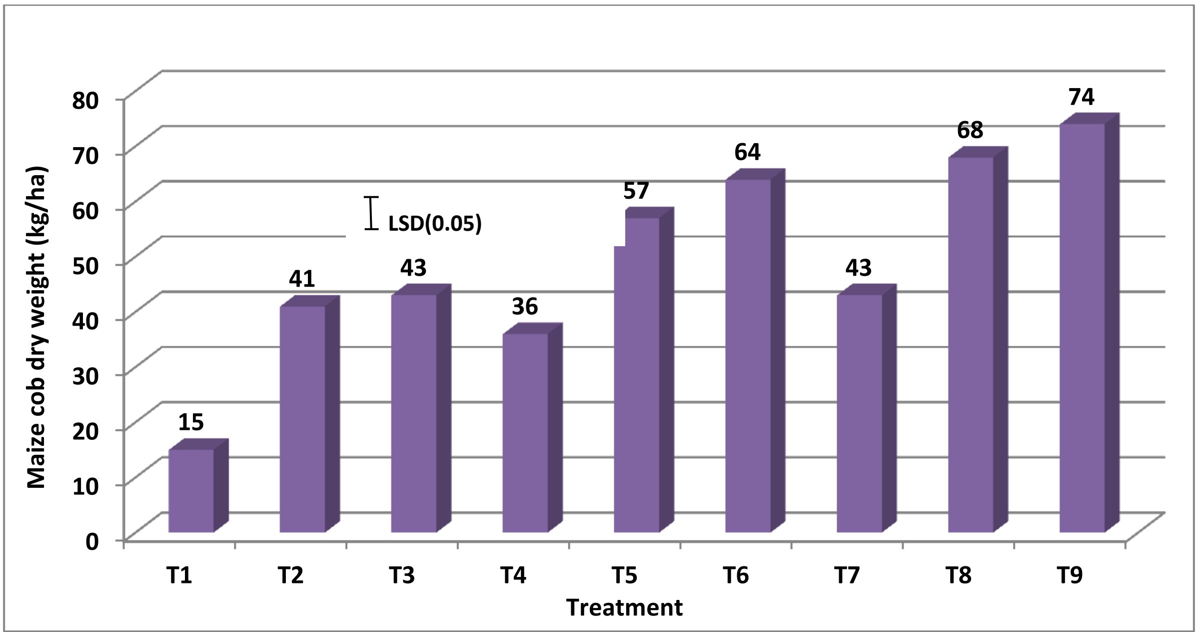
Table 5. *Relationship between soil erodibility indices and soil properties*

Soil property	CDI	CR	DR	CFI
Base saturation	-0.901**	-0.846**	-0.832**	0.570*
C/N ratio	0.114	-0.126	-0.085	0.032
Exchangeable Calcium	-0.899**	-0.883**	-0.837**	0.559*
Ca/Mg ratio	-0.313	-0.238	-0.197	-0.138
ECEC	-0.961**	-0.951**	-0.921**	0.727**
Exchangeable K	-0.925**	-0.842**	-0.883**	0.709**
k/Mg ratio	-0.873**	-0.778**	-0.821**	0.604**
Exchangeable Mg	-0.945**	-0.965**	-0.934**	0.806**
Organic Carbon	-0.878**	-0.979**	-0.878**	0.747**
Soil pH	-0.865**	-0.780**	-0.820**	0.555*
Total exchangeable acidity	0.888**	0.796**	0.823**	-0.544*
Total exchangeable bases	-0.964**	-0.938**	-0.919**	0.706**
Total Nitrogen	-0.874**	-0.967**	-0.860**	0.724**

*and ** = significant at 0.05 and 0.01 probability levels respectively, CR = clay ration, DR = dispersion ratio, CDI = clay dispersion index, CFI clay flocculation index

Effect of amendments on the yield of maize

Application of the amendments significantly (p = 0.05) increased the yield of maize as shown in Figure 4. Plots amended with 10 t/ha PD + 10 t/ha SDA recorded the highest maize yield (74 kg/ha) when compared to other treatments. Combined application of saw dust ash and poultry droppings increased the yield of maize more than when they are applied individually (Figure 4).



T1 = control, T2 = 5 t/ha PM, T3 = 10 t/ha PM, T4 = 5 t/ha SDA, T5 = 5 t/ha PM +5 t/ha SDA, T6 = 5 t/ha PM + 10 t/ha SDA, T7 = 10 t/ha SDA, T8 = 10 t/ha PM + 5 t/ha SDA, T9 = 10 t/ha PM + 10 t/ha SDA

Figure 4. *Effect of amendments on the yield of maize (zea mays)*

The properties of the soil used in the study showed that there is need to improve the fertility status of the soil for better crop performance since the essential nutrients were below the critical levels recommended by FAO (2006) while there was higher plant nutrient elements in the amendments used in the study. Therefore applying these wastes on the degraded soil of the study area is expected to improve soil aggregation and soil fertility status.

The amendments did not change the textural class of the amended soil. This observation was in agreement with Troech and Thompson (1993) and Adikwu *et al*., (2012) who stated that good soil management practices may slightly raise the values of soil particle sizes and improve soil productivity but cannot change the textural class. According to Fit-Patrick (1986), textural class of the soil is a function of weathering in association with parent materials influenced by climate over time. Reduction of soil bulk density in the amended soil agreed with the findings of Tekwa *et al*., (2010) that worked on rice mill husk and found out that application of rice mill husk reduced soil bulk density as compared to un-amended plots. Improvement of soil properties such as soil aeration and moisture content might increase soil biodiversity and soil organic matter that could reduce soil bulk density. Similarly, Li *et al.,* (2011) noted that application of organic wastes increased soil macro and meso-pore volume due to an increase in organic matter content, better aggregation and water transmission rate. Increase in soil gravimetric moisture content could be due to an increase in total porosity, reduction in soil bulk density and better soil aggregation. This finding was in concord with Mbah and Nneji (2010) that water holding capacity depends on soil total porosity and size distribution of its pores.

Plots amended with the organic wastes reduced the vulnerability of soil to erosion as seen in the low values of DR, CDI and CR and increase in the rate of the manure reduced the value of these soil aggregate stability indices. This result was in concord with the findings of Nutullah *et al*., (2015) who noted that increasing dose application of organic wastes in an acidic soil increases soil aggregate stability. Similar results were reported by Li and Zhang (2007) and Hati *et al.,* (2008) when they amended soil with farm yard manure. Improvement of the stability of the soil with application of these wastes could be due to increased organic matter since soil organic matter is a key factor in the formation of soil stable aggregate. Nutullah *et al.,* (2015) recorded significant positive relationship between soil aggregate stability index and soil organic carbon content. Uwanuruocha and Nwachukwu (2012) stated that organic constituents of the soil are very important because of their influence on stability of soil aggregates.

Increase in the organic carbon content in plots amended with the organic wastes could be attributed to increase in moisture retention, improved soil micro-aggregation and reduction in bulk density which created a favourable environment for microbial activity, decomposition and mineralization of organic matter. These conditions result to an increase in soil pH and basic cations. These findings are in agreement with Akanbi *et al.,* (2002), Ewulo *et al.,* (2009) and Ayeni, (2008), who observed that application of organic wastes improved soil organic matter and increased moisture retention. Increase in exchangeable cation could be attributed to an increase in soil pH due to manure application and an increase in organic matter that acts as a sink for exchangeable cations (Onwudike, 2010). Irregular trend on C/N ratio in all the experimental plots indicated different degrees of mineralization of the applied amendments.

Significant positive relationships existed between CFI and soil properties except with total exchangeable acidity. Increase in the organic carbon due to application of these manures as well as higher values of ECEC and exchangeable bases reduced the value of CR, CDI and DR and also increased the value of CFI. This is because soil organic matter plays a vital role in the formation of soil aggregation. Therefore factors that affect soil organic matter will directly or indirectly influence soil aggregate stability. Favourable soil pH which enhances availability of exchangeable cations, microbial population and reduction in soil compaction will improve soil micro aggregation. These findings are in concord with previous works of Nutullah *et al.*, (2015) and Rosool *et al.*, (2008) who recorded significant relationship between soil aggregate stability index and soil organic matter. Uwanuruochi and Nwachukwu (2012) stated that organic constituents of the soil are very important due to their influence on the stability of soil aggregate while Haynes and Naidu (1998) found out that increase in soil organic matter content as a result of organic manure application improves pore structure of the soil.

Increase in the cob yield with application of these agro –wastes could be attributed to the nutrient elements supplied by these amendments (Table 2) as well as the improvement in the soil physical condition such as reduced bulk density, increase in total porosity and water retention as well as increase in soil organic matter. Increase in the aggregate stability of the soil as shown in the values of DR, CR and CDI could contribute to an increase in the yield of maize. These attributes play significant role in increasing soil aeration and soil biodiversity (Jayaprakash et al., 2003) with an attendant high crop yield. These findings are in concord with previous works by Kumar and Puri (2001), Verma et al (2003) and Ajaz et al (2013) who reported that there is a positive effect of organic manure on yield contributing characters of maize.

Conclusion

This study showed that combined application of agricultural wastes like poultry droppings and saw dust ash are effective in improving soil organic carbon, soil total nitrogen and other physicochemical properties of fragile soils. Combined application of 10 t/ha SDA + 10 t/ha PM proved more effective in increasing these soil properties than other treatments evaluated in this work as well as increasing the yield of maize. Since formation of stable soil aggregates is an important soil quality for agricultural sustainability, application of 10 t/ha SDA + 10 t/ha PM is recommended for soil aggregate stability, soil fertility improvement and yield of maize in soils of similar condition.

Acknowledgement

The assistance of soil science laboratory technologists in the Department of Soil Science and Technology, Federal University of Technology Owerri are highly acknowledged. Also we appreciate the Farm Manager of School of Agriculture and Agricultural Technology of the University for providing the experimental site and security.

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