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EVALUATION OF ORGANIC AMENDMENTS AND MINERAL FERTILIZER INPUTS ON SOIL CHEMICAL PROPERTIES IN ILORIN, SOUTHERN GUINEA SAVANNA, NIGERIA.

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ABSTRACT

The potential of three (3) organic wastes solely and in combination with NPK (20:10:10) fertilizer was evaluated on soil chemical properties at the University of Ilorin Dam site, Ilorin, Kwara State. Randomized Complete Block design in split plot arrangement was adopted using three treatments at five levels with three replicates. Treatment levels were: 0, 10t/ha, 15t/ha, 10t/ha+NPK and 15t/ha+NPK for Poultry Droppings (PD) and Rice Husk (RH), while Abattoir Effluent (AE) was at 0, 1.3 t/ha, 2.6t/ha, 1.3t/ha+NPK and 2.6t/ha+NPK. Low Nitrogen Tolerant Population White (LNTPw) maize was used as test crop. Results showed that TN, P, Ca, Mg, CEC, ECEC, were significant at $p<0.05$ for all the amended plots but were higher in poultry amended plots. The results also showed that sole application of poultry droppings at 10t/ha and complementary use of poultry droppings and NPK fertilizer at 15t/ha+NPK. Therefore, complimentary use of poultry droppings and NPK could be recommended for improved soil productivity.

Keywords: organic wastes, amended, evaluated, abattoir and productivity.

1. INTRODUCTION

During the past decades, there had been a conscious awareness about soil degradation and its negative effects on productivity. Maintenance of soil fertility is a major concern in the tropics (Okonkwo *et al.*, 2011). Continuous cultivation of soil gradually decreases its productivity due to depletion of organic matter which is known to be a reservoir of plant nutrients (Ogbe, *et al.*, 2015; Uzoukwu, 2012; Ebaid and El-Refaee, 2007).

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Most of the soils in Nigeria are strongly weathered and dominated by low-activity clay minerals with low nutrient status (Economic Commission of Africa, 2001). Therefore, the soils cannot supply the quantities of nutrients required such that the level of crop yield decline rapidly once cropping commences due to soil degradation and nutrient depletion which have become serious threats to agricultural productivity (Olusegun, 2014).

The use of inorganic fertilizer has not been helpful under intensive agriculture, because it is often associated with increased soil acidity, reduced soil organic matter with consequent deterioration of soil physical and chemical properties, soil nutrient imbalance, and reduced crop yield (Ojeniyi, 2000; Adeniyan and Ojeniyi, 2003; Awodun *et al.*, 2007).

In Nigeria, the rising cost of inorganic fertilizers coupled with their inability to recondition the soil, has directed attention to organic manures usage in recent times. Makinde et al. (2001) observed that soil degradation is brought about by loss of organic matter accompanied by continuous cropping. This becomes aggravated when inorganic fertilizers are applied repeatedly because crop response to applied fertilizer depends majorly on soil organic matter.

On the other hand, the use of organic fertilizer had been advocated instead of inorganic fertilizer as a result of its positive influence on soil physicochemical properties. Organic amendments are said to improve soil structure, texture and increase biochemical activities of soil microorganisms aside adding essential nutrients to the soil. But the limitations of organic fertilizers include slow decomposition and mineralization rates, bulkiness, and dirt (Ogundare *et al.*, 2012).

As a result, complementary use of organic and inorganic fertilizers is recently promoted. Integrated use of inorganic and organic fertilizers is therefore required for sustainable soil and crop productivity (Ogundare *et al.*, 2012), reduction of the cost and amount of fertilizer required by crops (Krupnik *et al.*, 2004; Dobermann and Cassmann, 2004) and to effectively combat nutrient depletion and promote sustainable crop productivity (Paul and Mannan, 2006).

Therefore, this research was aimed at evaluating the effect of different organic wastes and their combination with mineral fertilizers on soil chemical properties.

2. MATERIALS AND METHODS

2.1 Site Description

The research was carried out during the dry season of 2015/2016 at the University of Ilorin Dam Site, Ilorin, Kwara State, Nigeria. The site was located in the Southern Guinea Savanna (SGS) belt at longitude N08^{0}28.049’ and latitude E004^{0}39.798’, approximately 344.7m above the sea level. The average temperature is 28^{0}C and an annual rainfall is 1100-1400mm per annum.

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2.2 Experimental Layout

Randomized Complete Block design in split plot arrangement was adopted, using three (3) treatments: Rice Husk (RH), Poultry dropping (PD) and Abattoir Effluent (AE) at five (5) levels i.e control, 10t/ha, 15t/ha, 10t/ha+NPK and 15t/ha+NPK for rice husk and poultry dropping, while abattoir effluent were applied at control, 1.3 t/ha, 2.6 t/ha, 1.3t/ha+NPK and 2.6t/ha+NPK having three (3) replicate. The treatment combination followed a randomized arrangement.

Rice husk was obtained from Rice Milling Market at Iyana Oja Gboro, Ilorin, while abattoir effluent was collected from Ilorin Abattoir Center, Ipata market, Ilorin and poultry dropping from Unilorin Poultry Unit at the Teaching and Research Farm, Ilorin, Kwara State. All samples were collected in clean sacs and plastic containers as appropriate prior to analysis and field incorporation.

The area was mechanically ploughed and marking of the experimental plot was done manually.

The treatments were spread uniformly over the plots and incorporated manually into the seedbed. One seed of Low Nitrogen Tolerant population white (LNTPw) maize (Early maturing variety) were planted per hill at a spacing of 25 cm x 75 cm and depth of 2 - 5 cm fourteen days days after incorporation of amendments. The experiment was carried out in dry season and water was supplied through irrigation at an interval of 3days.

2.3 Collection of Soil Sample

Soil samples were collected from six points on the field to form a composite sample and used to determine soil physical and chemical properties of the soil before amendment was applied. Soil samples were also taken from three points on each plot at a depth of 0 – 30 cm after harvest and bulked together to form composite samples. Soil samples were collected using soil auger.

2.4 Soil Chemical Analysis

The samples were taken to the laboratory in well labeled polyethene bags. The soil samples were air dried at room temperature for 7 days and sieved through a 2mm sieve. The samples were then analyzed for the following physicochemical properties; Particle size, Organic Carbon, pH, Total Nitrogen, Available P, C.E.C, and Exchangeable Cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}).

The pH was determined by the method outlined by Bates (1954) using an electronically Jenway 3015 pH meter at ratio of 1:2.5 in soil/water and KCl. Particle size was determined using the hydrometer method as outlined by Bouyoucous, 1962. Exchangeable acidity of the soil was determined by titration method using 1N KCl extract as described by Rhoades (1982). Organic carbon was determined using wet oxidation method of Walkley and Black (1934) as described by

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Jackson (1996). Soil organic matter was obtained by multiplying percentage carbon by 1.724 while available phosphorus was determined using Bray 1 (Bray and Kurtz, 1945) method and Nitrogen was determined using micro-Kjelhdal distillation method by AOAC (1999).

Exchangeable cations of calcium, magnesium, potassium and sodium were extracted with an excess of 1M NH_4OAc (ammonium acetate) as described by Anderson and Ingram, 1993. Effective cation exchangeable capacity (ECEC) was calculated by the summation of exchangeable bases (Ca, Mg, K, Na) and exchangeable acidity as described by Nwite *et al.*, 2013.

3. RESULTS AND DISCUSSION

Table 1: Soil chemical analysis prior to planting

Sand	75.96
Silt	11.28
Clay	12.76
Textural Class	Sand
Organic carbon%	0.5
Organic Matter %	0.87
Nitrogen%	0.07
pH in H_20	9.3
pH in KCl	8.9
Acidity	0.4
Available P	0.05
Exchangeable Ca (Cmol/kg)	2.79
Exchangeable Mg (Cmol/kg)	0.14
Exchangeable K (Cmol/kg)	0.02
Exchangeable Na (Cmol/kg)	0.11
Cation exchange capacity	3.06

Table 1 shows the result of soil chemical properties prior to planting. The soil was sandy, pH of the soil was strongly alkaline (USDA-SCS, 1974). The organic matter, total nitrogen and available phosphorus were very low. Exchangeable cations (Ca, Mg, Na and K) and CEC were all observed to be low as a result of low organic matter content of the soil. The physicochemical analysis of the sediment showed that the soil is low in terms of fertility.

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Table 2: Nutrient composition of organic amendment

Parameters	**Abattoir Effluent (AE)**	**Rice Husk (RH)**	**Poultry Dropping (AE)**
Nitrogen%	1.06	0.27	0.71
Available P (mg/kg)	24.52	26.30	11.92
Calcium (%)	11.58	9.29	33.87
Magnesium (%)	2.61	4.97	17.85
Potassium (%)	4.55	3.27	16.93
Sodium (%)	0.11	0.81	0.14

Table 2 shows nutrient composition of different organic waste used as amendments. The nutrient concentration was observed to be higher in the wastes than in soil. Nutrient composition of abattoir effluent was higher than other organic waste. The order of nutrient composition in the amendments was AE > PD > RH. This could be attributed to the nutrients loads obtained in abattoir.

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Table 3: Effect of organic waste on soil chemical properties

Treat./Levels	pH (water)	pH (KCl)	E.A.	O.M %	TN %	P $mgkg^{-1}$	K	Ca	Mg	Na	CEC $Cmolkg^{-1}$	ECEC $Cmolkg^{-1}$	%PBS
							←	$Cmolkg^{-1}$	→				
Control	7.77	6.90	0.74	2.97	0.09	5.18	0.14	2.26	0.39	0.08	2.87	3.61	80.00
RH10 t/ha	7.27	6.80	0.32	4.45	0.11	6.65	0.19	3.45	1.22	0.09	4.95	5.27	93.86
RH15 t/ha	7.17	6.80	0.66	4.33	0.11	6.77	0.22	3.40	1.53	0.10	5.26	5.91	88.88
RH10 t/ha+NPK	7.80	6.80	0.33	4.51	0.13	6.12	0.18	3.17	1.53	0.09	4.98	5.30	93.84
RH15 t/ha+NPK	7.83	6.77	0.63	3.77	0.12	6.58	0.15	3.19	1.20	0.12	4.67	5.30	88.06
Control	7.77	6.90	0.74	2.97	0.09	6.05	0.14	2.26	0.39	0.08	2.87	3.61	80.00
AE 1.3t/ha	7.33	6.87	0.32	4.47	0.13	6.36	0.31	3.43	1.31	0.11	5.15	5.48	94.07
AE 2.6t/ha	7.40	6.87	0.3	5.07	0.15	11.24	0.18	3.38	1.27	0.09	4.92	5.23	93.95
AE 1.3t/ha+NPK	7.67	6.87	0.32	5.53	0.13	6.30	0.2	3.22	1.43	0.11	4.96	5.28	94.00
AE 2.6t/ha+NPK	7.90	6.77	0.32	4.97	0.13	6.58	0.19	3.21	1.52	0.1	5.02	5.34	94.01
Control	7.77	6.90	0.74	2.97	0.09	6.58	0.14	2.26	0.39	0.08	2.87	3.61	80.00
PD10 t/ha	7.67	6.87	0.31	4.55	0.15	7.31	0.43	4.66	1.38	0.09	6.55	6.86	95.47
PD15 t/ha	7.80	6.85	0.33	5.22	0.13	7.13	0.27	3.48	1.29	0.1	5.14	5.47	94.03
PD10 t/ha+NPK	7.57	6.83	0.31	4.78	0.15	13.01	0.18	3.34	1.46	0.09	5.08	5.38	94.30
PD15 t/ha+NPK	7.90	6.83	0.62	3.94	0.13	12.22	0.18	4.41	1.38	0.10	6.07	6.70	90.65
SED	0.187	0.055	0.116	0.350	0.011	1.771	0.077	0.195	0.076	0.014	0.209	0.224	3.215
LSD(0.05)	ns	ns	ns	ns	***	*	ns	***	*	ns	***	***	ns

Key: E.A.; Exchangeable acidity, O.M; Organic matter, T.N.; Total nitrogen, P.; Phosphorus, K; Potassium, Ca; Calcium, Mg; Magnesium, Na; Sodium, CEC; Cation exchange capacity, ECEC; Effective cation exchange capacity, PBS; Percentage Base Saturation, RH: Rice husk, AE; Abattoir effluent, PD; Poultry dropping, ns; Not significant, * Significant at 0.05%, * * Significant at 0.001%, ***Significant at <0.001%, LSD(0.05); Least significant difference across the column, SED; Standard error of difference.

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Table 3 shows the chemical properties of the soils amended with different organic wastes. pH was not significant at $p<0.05$ between the different levels of the organic amendments applied, but is was observed that there is a significant reduction in pH (KCl) in all the amended plots with control having the highest pH (6.90). The soils were ranked as neutral. The result of this finding confirms findings from Walker et al. (2003), Pattanayak et al. (2001) and Yaduvanshi (2001) that addition of organic materials decreases soil pH.

Exchangeable acidity was not significant at $p<0.05$ with highest percentage observed at control plot while the least percentage was observed at PD10t/ha. The high exchangeable acidity in control plot could be attributed to high presence of Al^{3+} in soil in those plots receiving the treatment relative to other animal wastes amendment. Lavelle et al. (1993) as corroborated by Adeniran (2003) noted that animal wastes decreased exchangeable acidity by removal of Al^{3+} from soil exchange site.

Percent organic matter was not significant at $p<0.05$ between the levels of the different organic wastes applied but there was an increase in the organic matter content in all the amended plots with control having the least, and AE1.3t/ha+NPK followed by PD15t/ha observed to have the highest percent of organic matter. This agrees with the findings of Awodun et al. (2007), Adesodun et al. (2003), Okonko *et al.*, (2011), Ogbe *et al.*, (2015) who observed that the use of organic waste increases soil organic matter content, particularly that the use of animal waste gives higher organic matter percentage.

Nitrogen was significant at <0.05 with highest nitrogen percentage observed at AE2.6t/ha, PD10t/ha and PD10t/ha+NPK which ranked as medium, with control showing the least nitrogen percentage ranked as low. Nwite *et al.*, 2013, Macrere and Kumbi, 2001 asserted that animal waste have high total N that increased soil productivity than other animal wastes. Furthermore, Nwite *et al*. (2011a) and Okonkwo *et al*. (2011) agreed that the use of rice husk results in lower N compared to animal wastes amended plots.

Table 3 also shows that phosphorus was significant at $p<0.05$, with plots amended with poultry droppings at PD10t/ha+NPK and PD15t/ha+NPK observed to have the highest phosphorus content which ranked as moderate and control showed the least percentage phosphorus which ranked as low. Although there was an elevated increase in P level in all the amended plots. This agrees with the findings of Mbah and Onweremadu, 2009 and Adesodun et al. (2003) who also found elevated increase in P in all amended plots especially in poultry droppings amended plots.

Exchangeable bases (Ca, Mg, K and Na) were observed to be significant at $p<0.05$ except K and Na. K was not significant but there was an increase in K in all amended plots with the highest percentage observed at PD10t/ha and lowest at control plots. Ca was observed to be significant at

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$p<0.05$ in all the amended plots with highest percentage observed at poultry amended plots at PD10t/ha and PD15t/ha+NPK. Mg was also significant at $p<0.05$ with the highest percentage observed at rice husk amended plots at RH15t/ha and RH10t/ha+NPK. Na was not significant at $p<0.05$ but there was an increase in all amended plots with the least percentage observed at control plots. Increase in exchangeable bases in poultry amended plots might be because animal manure contain substantial amount of calcium, magnesium and potassium (Moyin and Atoyosoye, 2002; Hue and Licudine, 1999). This also agrees with Adeleye *et al*., (2010) also showed that application of organic amendment increased soil exchangeable Mg, Ca, K, and Na.

cation exchange capacity (CEC) was significant at $p<0.05$ in which the highest CEC value was observed was at poultry amended plots at PD10t/ha and PD15t/ha+NPK with the least CEC obtained at the control plot in which all ranked as very low. This is in line with the findings of Mbagwu *et al*. (1991), Owolabi *et al*. (2003) and Mba, 2006 who all agreed that organic matter tends to buffer soils and cause the release of exchangeable cations during mineralization of organic matter.

Effective cation exchange capacity was significant at $p<0.05$ in all amended plots with the highest increase observed at plots amended with poultry droppings at PD10t/ha and the least ECEC observed at control plots. Similarly, Percentage Base Saturation was not significant at $p<0.05$ but there was an increase in %PBS in all amended plots with the highest obtained at PD10t/ha and the least at control plots. This result agrees with Nonga (2001) who reported that application of poultry droppings significantly increased effective cation exchange and percentage PBS.

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Table 6: Grain yield of maize as influenced by different organic amendment singly and in combination with NPK

Variety	Treatments	Yield ($^{th-1}$)
LNTPw		
	Control	1.9
	RH 10t/ha	2.2
	RH 15t/ha	2.6
	RH 10t/haNPK120	2.8
	RH 15t/haNPK120	3.9
	AE 1.3 t/ha	1.4
	AE 2.6 t/ha	2.3
	AE 1.3 t/haNPK120	2.7
	AE 2.6 t/haNPK120	3.7
	PD 10t/ha	6.3
	PD 15t/ha	5.1
	PD 10t/haNPK120	3.5
	PD 15t/haNPK120	6.3
	SED	294.5
	LSD(0.05)	***

Table 6 shows that grain yield of maize was significant at $p<0.05$ as affected by different organic waste and at different level of application. The result obtained shows that poultry droppings especially at 10t/ha and 15t/ha+NPK of poultry droppings gave the highest yield in LNTPw maize plot. This result shows that poultry droppings has a higher nutrient released to the soil to increase its productivity. This agrees with the findings of Nwite *et al.*, (2013), Moyin, (2002) who reported increase in grain yield of maize in poultry droppings when compared to other organic waste.

CONCLUSION

Results from the study have shown that application of different organic waste increases soil productivity because of their positive effect on soil chemical properties. But more importantly, the result of the study shows that poultry droppings at sole application at 10t/ha and combined application at 15t/ha+NPK had a better influence on soil productivity and grain yield relative to other organic waste.

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