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Synergistic effect of sawdust and poultry manure on some soil chemical properties of Ultisol at Umudike Nigeria.

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Abstract

The use of agro-wastes as soil amendments is a sustainable means of improving soil fertility and productivity. This research was conducted on a degraded Ultisol at the Eastern farm of the Michael Okpara University of Agriculture, Umudike during the 2011 and 2012 planting seasons, to study the effect of sawdust and poultry manure combinations on soil chemical properties. The treatments comprised of sawdust (SD) at five levels namely 0, 2, 4, 6, and 8 t/ha, and poultry manure (PM) at five levels namely 0, 5, 10, 15, and 20 t/ha, which were combined to produce 25 treatment combinations. The treatment combinations were laid out in Randomized Complete Block Design (RBCD) and replicated three times in a factorial experiment. The results of the study showed that the treatments improved soil chemical properties. The combinations of poultry manure and sawdust significantly ($p<0.05$) increased soil pH with the highest value obtained with 0t/ha SD + 8t/ha PM in 2011 and 20t/ha SD + 4t/ha PM in 2012; Available phosphorus with the highest value obtained with 20t/ha SD + 8t/ha PM in both 2011 and 2012; total nitrogen with the highest value obtained with 20t/ha SD + 8t/ha PM in both 2011 and 2012; soil organic carbon with the highest value obtained with 0t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 2t/ha PM in 2012. The combinations of poultry manure and sawdust significantly ($p<0.05$) improved soil exchangeable acidity with the highest value obtained with 20t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 6t/ha PM in 2012; total exchangeable bases with the highest value obtained with 20t/ha SD + 8t/ha PM in both 2011 and 2012. The nutrient level of the soil improved as a result of the application of soil amendments like sawdust and poultry manure.

Keywords: Agro waste, poultry manure, Ultisols

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Introduction

Food is a basic necessity of man, and its production is mainly dependent on soil fertility. Consequently, management of soil fertility is a pre-requisite for continuous food production and sustainability of soil resources. Soil fertility depletion is mainly due to intensive and continuous cropping with low application of fertilizer, causing a negative balance between nutrition supply and extraction from the soil. According to Anikwe *et al.* (1999), continuous cropping makes tropical soils highly vulnerable to soil degradation. Hence, they are characterized by low organic matter, low pH, high erodibility, and structurally unstable aggregates with limited capacity for water retention (Oguike *et al.,* 2006). It becomes imperative to incorporate animal manure, recycle secondary crop products and other organic wastes to improve soil fertility and enhanced crop yield (Mbah *et al.,* 2010)

Sawdust, though impacts good structural attributes to the soil, have little or relatively low effects on soil chemical properties due to its low surface area as well as low degradability due to high carbon and low nitrogen content. It could cause nitrogen immobilization, resulting in depressed plant growth and reduced microbial respiration (Eneje and Ukwuoma, 2005). Eneje and Ezeakolam (2009) observed the increase in organic carbon in soil with the application of sawdust as an organic amendment.

Poultry manure has been adjusted to be the most valuable of all organic manures produces by livestock (Okonkwo et al., 2009). Moreover, the nutrient contents of poultry manure are among the highest of all animal manures, and the use of poultry manure as a soil amendment for crops will provide appreciable quantities of all the major plant nutrients. It also improves biological activities, soil tilth, and soil chemical properties (Omisore *et al*., 2009). Poultry manure supplies the essential nutrients, especially nitrogen, phosphorus, and potassium required for maximum crop production (Ibeawuchi, 2009).

Sawdust as an organic amendment is not frequently used because of its high carbon-nitrogen ratio, The supply of nitrogen with poultry manure can help prevent nitrogen immobilization by the high carbon content of sawdust. This will be of great benefit to soils with low organic matter content, resulting in more significant improvement in soil physicochemical properties.

The objective of this study is to determine the effect of sawdust and poultry manure combinations on some soil chemical properties of acid sandy Ultisol.

2.0 Materials and methods

2.1 Experimental site: the experiment was conducted at Michael Okpara University of Agriculture Research farm in Umudike (Longitude 07° 33'E, Latitude 05° 29'N, Altitude 122m). the climate is essentially a humid tropical climate. The area has a total rainfall of 2177mm per annum, with the annual average temperature of about 26°C. The rainfall pattern is bimodal: a long wet season from April to July is interrupted by a short "August break" followed by another short rainy season from September to October or early November. The dry season stretches from early November to March. (NRCRI Umudike Meteorological station, 2007)

2.2 Experimental layout: The field was mechanically cleared, ploughed, harrowed, and ridged. The ridges were made at 1m apart in a plot size of 4m by 4m with a furrow of 0.5m. the total experimental area was 1496m^2 (68m by 22m). The treatments comprised of sawdust (SD), sourced from Timber shade, Umuahia, was applied at five levels namely 0, 2, 4, 6, and 8 t/ha and poultry manure (PM), which was sourced from National Root Crop Research Institute Umudike, was applied at five levels namely 0, 5, 10, 15 and 20 t/ha, which were combined to produce 25 treatment combinations. The treatment combinations were laid out in Randomized Complete Block Design (RBCD) and replicated three times in a factorial experiment.

2.3 Soil sample and Collection: composite soil sample was collected before treatment application for the characterization of the experimental site. Soil samples were collected with core samplers for physical properties such as Soil Bulk density and Total Porosity. Soil samples were collected using a soil auger at 0 – 15 cm, at the end of the experiment for chemical analysis. The soil samples were air-dried at room temperature and sieved through a 2mm sieve. The soil pH was determined in a 1:2.5 soil to water ratio using a pH meter (Thomas, 1996). The organic carbon was determined using the dichromate wet oxidation method of Walkey – Black as explained by (Nelson and Sommers, 1996). Available phosphorus was determined by Bray 2 method as described by Bray and Kurtz, (1945). Total nitrogen was determined using the Kjeldahl method as described by Bremner (1996). Exchangeable cations such as K^+, Ca^{2+}, Mg^{2+} and Na^+ were determined using the method as explained by Summer and Miller (1996).

2.4 Data analysis: All the data collected were subjected to analysis of variance (ANOVA) for the factorial experiment in RCBD using GEN STAT software and the treatment

Results and Discussion

Soil properties	2011 planting season	2012 planting season
Sand (%)	77.62	78.79
Silt (%)	10.50	7.84
Clay (%)	11.88	13.37
Textural class	Sandy loam	Sandy loam
Soil pH (water)	5.28	5.31
Soil pH (salt)	4.07	4.10
Organic carbon (%)	1.57	1.75
Organic matter (%)	2.71	3.01
Total N (%)	0.14	0.14
Available P (mg/kg)	7.80	8.20
Exchangeable acidity (cmol$^+$/kg)	3.61	3.12
Potassium (cmol$^+$/kg)	0.05	0.06
Calcium (cmol$^+$/kg)	2.10	2.30
Magnesium (cmol$^+$/kg)	1.20	2.00
Sodium (cmol$^+$/kg)	0.13	0.16
Bulk density (g/cm^3)	1.31	1.28
Total porosity (%)	50.68	51.55

Table 2: chemical properties of organic amendment used for the study.

Properties	Poultry manure	Sawdust
Organic carbon (%)	14.47	46.42
Organic matter (%)	24.95	80.03
Total N (%)	1.85	0.30
C: N ratio	7.82	154.73
Available P (mg/kg)	0.80	0.34
Potassium ($cmol^+/kg$)	2.76	0.98
Calcium ($cmol^+/kg$)	13.80	2.60
Magnesium ($cmol^+/kg$)	2.80	2.10
Sodium ($cmol^+/kg$)	1.37	0.90

Table 4: Effect of sawdust and poultry manure on soil pH (0.01$CaCl_3$)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	3.74	4.02	4.04	4.02	4.03	3.97	5.53	6.43	5.98	5.98	6.51	6.09
2	4.04	4.10	4.17	4.04	4,16	4.10	5.87	5.99	6.68	7.16	6.03	6.35
4	4.05	4.10	4.10	4.12	4.11	4.10	5.93	6.03	6.60	6.12	6.25	6.18
6	4.34	4.27	4.33	4.19	4.36	4.30	5.89	6.02	6.14	6.10	6.25	6.08
8	4.53	4.35	4.38	4.37	4.41	4.41	6.05	6.27	6.28	5.92	6.23	6.15
Mean	4.14	4.17	4.20	4.15	4.22		5.85	6.15	6.34	6.26	6.25	
LSD (0.05) for SD = 0.044							LSD (0.05) for SD = 0.043					
LSD (0.05) for PM = 0.044							LSD (0.05) for PM = 0.043					
LSD (0.05) for SD * PM = 0.098							LSD (0.05) for SD * PM = 0.096					

means were separated using the Fisher's Least Significant Different (FLSD) at 5% probability level. The properties of the soil used for the experiment (Table 1) indicate that the soil is Sandy loam, slightly acidic, with low organic carbon, nitrogen, available phosphorus, and exchangeable bases. The organic amendments used in the study (Table 2) showed that poultry manure has higher values in total N, available P, and exchangeable bases (K, Na, Mg, and Ca)while sawdust has higher values in organic carbon, organic matter, and C: N ratio. The result of the effect of the combinations of SD

Table 4: Effect of Sawdust and Poultry Manure on Soil Available Phosphorus (mg/kg)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	1.34	1.94	2.26	2.45	2.31		4.22	10.37	16.37	15.75	14.07	
2	2.36	2.18	3.21	3.329	3.644		14.11	10.42	10.46	9.43	8.43	
4	3.31	7.53	7.63	8.448	12.42		9.18	10.38	25.52	9.35	14.17	
6	5.29	7.45	7.72	11.70	13.50		29.18	27.27	17.23	10.60	25.12	
8	6.46	8.24	13.41	21.60	23.21		14.05	14.23	18.07	25.93	28.72	
Mean												

LSD (0.05) for SD = 0.18 — LSD (0.05) for SD = 0.31

LSD (0.05) for PM = 0.18 — LSD (0.05) for PM = 0.31

LSD (0.05) for SD * PM = 0.22 — LSD (0.05) for SD * PM = 0.65

and PM on soil pH in 2011 and 2012 planting seasons as shown in Table 3 indicates that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 0t/ha SD + 8t/ha PM in 2011 and 20t/ha SD + 4t/ha PM in 2012. The increased soil pH could be attributed to the release of calcium and magnesium from the decomposition of the organic wastes, thus precipitating $Al(OH)^3$. The increased soil pH observed agrees with the reports of Chigbundu et al., (2010), Adeleyeet al., (2010), and Magagula et al., (2010) with the application of organic wastes.

The result of the effect of the combinations of SD and PM on soil Available P in 2011 and 2012 planting seasons as shown in Table 4 indicates that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 20t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 6t/ha PM in 2012. The increased soil Available P may be attributed to the release of liming effects of organic wastes, through the release of calcium and magnesium from the decomposition of the organic wastes, thus precipitating $Al(OH)^3$ and increasing soil pH, thereby releasing the adsorbed P, which enhanced the availability of soil available P, and as well as the high P available in the organic wastes. Similar results were reported by Onwuka (2008), Mbah and

Table 5: Effect of Sawdust and Poultry Manure on Soil Nitrogen (%)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	0.108	0.146	0.165	0.173	0.177	0.154	0.089	0.146	0.145	0.141	0.128	0.130
2	0.163	0.166	0.181	0.186	0.204	0.180	0.185	0.165	0.148	0.137	0.168	0.161
4	0.175	0.189	0.182	0.198	0.209	0.191	0.174	0.159	0.167	0.138	0.153	0.158
6	0.180	0.195	0.200	0.204	0.208	0.198	0.188	0.181	0.172	0.170	0.166	0.175
8	0.216	0.237	0.243	0.255	0.275	0.245	0.197	0.169	0.195	0.180	0.193	0.187
Mean	0.168	0.187	0.194	0.203	0.245		0.167	0.164	0.165	0.153	0.162	

LSD (0.05) for SD = 0.003 — LSD (0.05) for SD = 0.005

LSD (0.05) for PM = 0.003 — LSD (0.05) for PM = 0.005

LSD (0.05) for SD * PM = 0.007 — LSD (0.05) for SD * PM = 0.010

Table 6: Effect of Sawdust and Poultry Manure on Soil Organic Matter (%)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	3.054	4.937	4.194	6.287	6.401		0.177	1.896	0.844	0.798	0.568	
2	4.890	4.994	4.956	5.992	6.066		1.684	1.287	0.908	0.632	1.329	
4	4.280	4.753	4.363	5.596	5.837		1.436	1.155	1.327	0.667	1.034	
6	4.292	4.597	5.166	5151	6.273		1.741	0.660	0.724	0.706	1.332	
8	5.570	4.856	4.754	5.034	6.546		1.982	1.322	0.431	0.977	1.172	
Mean												
LSD (0.05) for SD = 0.035							LSD (0.05) for SD = 0.029					
LSD (0.05) for PM = 0.035							LSD (0.05) for PM = 0.029					
LSD (0.05) for SD * PM = 0.077							LSD (0.05) for SD * PM = 0.065					

Mbagwu (2006), Okonkwo *et al*., (2009), and Ayeni *et al*., (2008) with the application of organic wastes.
The result of the effect of the combinations of SD and PM on soil Total N in 2011 and 2012 planting seasons as shown in Table 5 indicates that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 20t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 8t/ha PM in 2012. The increased soil Total N may be due to the mineralization of organic-bound nutrients from the decomposition of the organic wastes. The increased soil

Table 7: Effect of Sawdust and Poultry Manure on Soil Exchangeable Acidity ($cmol^{+}/kg$)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	4.153	3.960	3.673	3.673	3.433	3.785	2.943	2.550	2.477	2.263	2.077	2.462
2	3.733	3.593	3.590	3.353	3.040	3.462	2.557	2.393	1.923	1.897	1.777	2.109
4	2.953	2.140	3.067	1.967	1.653	2.156	2.433	2.420	2.273	2.077	1.953	2.231
6	1.947	1.827	1.327	1.147	1.047	1.459	1.250	1.770	1.293	1.773	1.420	1.501
8	0.967	1.307	1.227	1.147	0.820	1.093	1.300	1.437	2.017	2.043	1.590	1.677
Mean	2.751	2.565	2.380	2.257	2.003		2.097	2.114	1.997	2.011	1.763	
LSD (0.05) for SD = 0.036							LSD (0.05) for SD = 0.028					
LSD (0.05) for PM = 0.036							LSD (0.05) for PM = 0.028					
LSD (0.05) for SD * PM = 0.081							LSD (0.05) for SD * PM = 0.062					

total N observed agrees with the reports of Mukiibi (2008), Mbah, *et al.,* (2010), and Adeleye *et al*., (2010) with the application of organic wastes.
The result of the effect of the combinations of SD and PM on soil organic matter in 2011 and 2012 planting seasons as shown in Table 6 indicates that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 20t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 8t/ha PM in 2012. The increased soil organic carbon could be attributed to the high C: N ratio of the organic waste and the release of organic-bound nutrients from the decomposition of the organic wastes. The increased soil

Table 8: Effect of Sawdust and Poultry Manure on Soil Total Exchangeable Bases (cmol^{+}/kg)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	3.957	4.415	4.804	4.609	4.819	4.521	4.603	5.648	5.838	5.833	5.452	5.475
2	4.607	4.616	4.637	5.058	5.269	4.837	5.429	5.970	5.626	6.675	5.753	5.891
4	4.798	4.828	5.043	5.353	5.373	5.079	5.235	5.436	6.887	6.615	6.480	6.171
6	5.007	5.638	5.452	5.973	6.207	5.656	6.264	6.258	6.222	6.047	6.813	6.320
8	5.025	5.446	5.667	5.888	6.935	5.792	6.224	6.258	6.680	6.481	6.913	6.511
Mean	4.679	4.989	5.121	5.377	5.721		5.551	5.913	6.251	6.370	6.282	
LSD (0.05) for SD = 0.011							LSD (0.05) for SD = 0.140					
LSD (0.05) for PM = 0.011							LSD (0.05) for PM = 0.140					
LSD (0.05) for SD * PM = 0.024							LSD (0.05) for SD * PM = 0.312					

organic carbon observed agrees with the reports of Eneje and Ukwuoma (2005), Adeleye *et al*., (2010), and Ayuba *et al*., (2005) with the application of organic wastes.
The result of the effect of the combinations of SD and PM on soil Exchangeable acidity in 2011 and 2012 planting seasons as shown in Table 7 shows that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 20t/ha SD + 8t/ha PM in 2011 and 0t/ha SD + 6t/ha PM in 2012. The reduction in soil exchangeable acidity could be attributed to the ability of

Table 9: Effect of Sawdust and Poultry Manure on Soil Effective Cation Exchangeable Capacity (cmol^{+}/kg)

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	8.110	8.375	8.477	8.283	8.273	8.304	7.546	8.190	8.314	8.096	7.527	7.935
2	8.340	8.209	8.227	8.411	8.309	8.299	7.986	8.363	7.883	8.571	7.529	8.067
4	7.751	6.955	7.110	7.320	7.027	7.233	7.668	7.856	9.160	8.892	8.433	8.402
6	6.954	7.398	6.779	7.120	7.254	7.101	7.514	8.024	7.516	7.753	8.233	7.808
8	5.992	6.752	6.894	7.035	7.755	6.885	7.523	7.695	8.696	8,524	8.503	8.188
Mean	7.429	7.538	7.497	7.634	7.723		7.648	8.026	8.314	8.367	8.046	
LSD (0.05) for SD = 0.032							LSD (0.05) for SD = 0.171					
LSD (0.05) for PM = 0.032							LSD (0.05) for PM = 0.171					
LSD (0.05) for SD * PM = 0.072							LSD (0.05) for SD * PM = 0.381					

Table 12: Effect of Sawdust and Poultry Manure on Soil % Base Saturation

	2011 cropping season						2012 cropping season					
	SD (t/ha)						SD (t/ha)					
PM (t/ha)	0	5	10	15	20	Mean	0	5	10	15	20	Mean
0	48.79	52.72	56.67	55,65	58.26	54.42	61.00	68.96	70.21	72.05	72.42	68.93
2	55.24	56.23	56.37	60.13	63.41	58.28	67.98	71.16	71.60	77.87	76.41	73.01
4	61.90	69.43	70.94	73.14	76.48	70.38	68.27	69.20	75.18	76.65	76.84	73.23
6	72.01	76.21	81.91	83.90	85.57	79.92	83.42	77.94	82.76	78.00	82.75	80.97
8	83.87	80.65	82.21	83.70	89.42	83.97	82.72	81.33	76.81	76.03	81.30	79.64
Mean	64.36	67.05	69.62	71.30	74.63		72.68	75.31	76.12	77.94	73.72	
LSD (0.05) for SD = 0.485							LSD (0.05) for SD = 0.870					
LSD (0.05) for PM = 0.485							LSD (0.05) for PM = 0.870					
LSD (0.05) for SD * PM = 1.088							LSD (0.05) for SD * PM = 1,945					

the organic wastes to release calcium and magnesium on decomposition, thus precipitating $Al(OH)^3$. Similar results were reported by Asawalam and Onyegbule (2009), and Adeleye *et al*., (2010) with the application of organic wastes.

The result of the effect of the combinations of SD and PM on soil Total Exchangeable bases in 2011 and 2012 planting seasons as shown in Table 8 indicates that there was a statistical difference ($p < 0.05$) in the treatment combinations with the highest values obtained with 20t/ha SD + 8t/ha PM in both 2011 and 2012. The increased soil TEB could be attributed to the greater capacity of nutrient retention of the amended soils. Similar results were reported by Kparmwarp *et al*., (2004), and Ano and Agwu (2005) with the application of organic wastes.

3.0 Conclusion

The results from this study have shown that the incorporation of organic wastes such as poultry manure and sawdust, solely or in combination improved the chemical properties of the soil. the organic wastes such as sawdust are important due to their high carbon content, and poultry manure, due to its high N and exchangeable bases. The supply of N sources such as poultry manure increases the rate of organic matter decomposition and prevents N immobilization, and the high organic carbon content of sawdust produced great benefits to soils. Proper organic manuring requires the combinations of single manures that will encourage maximum microbial activity, enhance the release of soil nutrients in available forms, and reduce nutrient loss through fixation, immobilization, and leaching. Therefore, organic wastes such as poultry manure and sawdust could be used by poor farmers, who cannot afford fertilizers due to their high cost, for sustainable agricultural production.

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