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OYSTER SHELL COMPOST EFFECT ON SOME PHYSICAL AND CHEMICAL PROPERTIES OF AN INLAND VALLEY SOIL

Eneje, R. C.[1] and Ukut, A. N.[1]

[1]Department of Soil Science and Agro-climatology, Michael Okpara University of Agriculture Umudike, Nigeria. Email: chizma2001@yahoo.com

ABSTRACT

An experiment was conducted in the Soil Science laboratory of Michael Okpara University of Agriculture, Umudike to investiage the effect of oyster shell composted with goat and poultry droppings on some physical and chemical properties of an inland valley soil. The experiment was 4x3 factorial in completely randomized design. Soil samples were collected from 0-30cm depth. The treatments applied were compost of combinations of goat (G) droppings, poultry (P) droppings and oyster shell (OY) (G+P+OY, P+OY, G+OY, G+P) and the amendment rates were 0%, 10% and 20% respectively. Each treatment was replicated three times. The results showed that application of the manure composts improved soil pH, ECEC, available phosphorus, total nitrogen organic carbon, exchangeable acidity and aggregate stability of the soil. The improvements in soil properties were relative to the rate of application of these amendments and sampling duration, G+P+OY treatments influenced total nitrogen, ECEC, available P most while P+OY was most effective on aggregate stability, exchangeable calcium and pH of the soil.

Keywords: Oyster shell, goat dung, aggregate stability, manure compost, ECEC

INTRODUCTION

Soils and their potentials differ apreciably from location to location depending on the nature of the parent material and other environmental factors. Adequate knowledge of their characteristics is needed before proper management practices can be applied to ensure sustainable productivity. In Nigeria, the pressure from a rapidly expanding population and the concomitant increasing demand for food necessitate a rational exploitation of the limited land resources for the production of more food. Soils in waterlogged environment are a part of the land resources that can be made available for such a purpose. Research reports indicate that waterlogged soils, because of their fluctuating water tables and periodical flooding, in most cases show fluctuation in their acidity level (Udo, 2001). Soil pH is regarded as a very important property since it influences other properties like the degree of base saturation and control the availability of all plant nutrients, thus in soils with low pH, iron, aluminum and manganese are present in their toxic levels while other basic cations like calcium and potassium are fixed in the soil.

However, according to Mullins (2002), livestock manure contains nutrient elements that can enhance the chemical and physical properties of soils and support crop production. These amendments do not drastically alter soil chemical properties over a short term, but promote and build up organic matter, thereby improving soil physical properties; they also improve soil tilth and water holding capacity through improved soil structure, biological activity and aggregate stability. Also, Sobulo and Jayeola (1977), reported that organic amendments incorporated into the soil, greatly improved texture, loosened heavy/compacted soils and bind together light textured ones making the soil more friable, warmer, more retentive of moisture and more congenial to plant in every way.

It is therefore, important to investigate the possibility of using organic amendments under the prevailing structurally and chemically limiting conditions of waterlogged soils to increase the potentials of this scarce resource (land) for crop production. The objectives of the study therefore, are to;

(i) determine the effect of organic amendments on the physico-chemical properties of waterlogged soils;
(ii) provide information on interactive effects of organic amendments on soil fertility and structural stability of waterlogged soils.

MATERIALS AND METHODS

Study site

The soil sample used for the experiment was collected from an inland valley created by Ibakwa River, after the Ibakwa Military Barracks in Abak Local Government Area of Akwa Ibom State. This area lies between latitutes 4^{o}33'N and 5^{0}30'N and longitude 7^{0}35'E and 8^{0}25'E and is characterized by heavy rainfall (2500-4000mm), high relative humidity (79%) and heavy cloud cover. The temperature of the area is generally high and changes slightly during the year (UNIUYO Consult Limited, 2002). The area is located within the South-South Geo-political zone (Niger Delta Region) of Nigeria.

Sample Collection and Preparation

The soil samples were collected with soil auger to a depth of 0-30cm, air-dried and sieved using 2mm mesh. Oyster is a sea food with the fleshy part eaten as meat and the shells are discarded in dumping sites near market places in Uyo Local Government Area of Akwa Ibom State. The oyster shells were collected dried, ground and sieved through a 2mm mesh. Poultry and goat droppings were collected from the University Livestock Farm air-dried, crushed and passed through 2mm mesh.

Incubation and Composting of Material

The organic materials were mixed in the ratio of 1:1 in the following manner;
Poultry dropping + Goat dropping + Oyster shell (P+G+OY) or (OYM)
Poultry dropping + Oyster shell (P+OY)
Goat dropping + Oyster shell (G+OY)
Goat dropping + poultry dropping (G+P)

The mixed organic materials were incubated under shade for 10 days. During this period of incubation, adequate moisture and aeration were ensured by the addition of water and turning with a stick every two days to encourage microbial activities. At the end of the incubation period, these organic materials were used as soil amendment.

Incorporation of Amendment

The composted materials were mixed with the soil samples in 8-litre capacity buckets perforated at the bottom. The treatment rates were 0kg, 0.2kg and 0.4kg per 2kg of soil equivalent to 0%, 10% and 20% respectively. The treatement soils were watered at two-week intervals and samples taken at 2, 4 and 6 weeks. All the treatments were replicated three times.

Soil Analysis

The soil pH was determined in 1:2.5 soils to water ratio using pH meter (Mclean, 1965), the organic carbon was determined using the Walkley and Black (1934) dichromate wet oxidation method as modified by Piper (1942). Total nitrogen (N) was determined using the macro Kjeldahl method described by Jackson (1958) while available phosphorus (P) was determined using Bray II method as described by Bray and Kurtz (1945). The available phosphorus in the soil extract was determined colorimetrically using molybdate blue colour method of Murphy and Riley (1962). Exchangeable acidity was determined by the method of Mclean (1965). Exchangeable K, Ca, Mg and Na were determined by extracting soil samples in 1N NH_4OAc. Effective cation exchangeable capacity was computed as the sum of exchangeable properties and percent base saturation (BS %) computed as:

$$\% BS = \frac{Ca + Mg + k + Na}{ECEC} \times \frac{100}{1}$$

Aggregate stability was determined using the mean weight diameter method as described by Kamper (1965). Bulk density was determined usig the core method, while particle size distribution was determined using the method of Bouyoucos (1962).

Data Analysis

Data were analysed using the analysis of variance (ANOVA) as outlined by Steel and Torrie (1980) using a 4 x 3 factorial in CRD. The factors were; factor A = Type of amendment (G+P+OY, P+0Y, G+OY and G+D) factor B = Amendment rates (0%, 10% and 20%). The Fisher's Least Significant difference (FLSD) as 5% probability level was used to separate the means.

RESULT AND DISCUSSION

The properties of the soil used are shown in Table 1. The soil used was a slightly acidic clay loam with medium organic carbon, low exchangeable cation content and high availale P. The oyster shell had high neutralizing equivalent value ($CaCO_3$ = 116) suggesting that it is a good liming material. The Mg content of poultry dropping was very low (0.46%), but highest in the oyster shell (2.71%), while K and Na were low in all the materials.

Table 1: Physico-chemical properties of soil studies

Characteristics	Value
Sand (%)	68.52
Silt (%)	5.17
Clay (%)	26.31
Textural class	Sandy clay loam
pH H_2O (1:2.5)	5.27
Calcium (cmol/kg)	6.52
Magnesium (cmol/kg)	2.13
Potassium (cmol/kg)	0.16
Sodim (cmol/kg)	0.08
Exchangeable acidity (cmol/kg)	0.99
Organic carbon (g/kg)	13.17
Total Nitrogen (%)	0.04
Effective cation exchange capacity (ECEC) cmol/kg)	9.88
Available phosphorus (mg/kg)	23.34
% Base saturation	89

Table 2: Characteristics of materials used for composting

Properties	Materials		
	Poultry Manure	Goat Dropping	Oyster Shell
Available phosphorus (ppm)	0.18	0.72	0.06
Calcium (cmol/kg)	1.25	0.97	37.3
Magnesium (cmol/kg)	0.46	1.03	2.71
Potassium (cmol/kg)	0.37	0.29	0.01
Sodium (cmol/kg)	0.09	0.07	0.01
Nitrogen (%)	1.35	1.25	-
$CaCO_3$ equivalent	-	-	116

The effects of the composts on the Mean Weight Diameter (MWD) of the soil showed that aggregate stability (AS) increased as the compost rate increased and with the duration of incubation. The values were highest with OY+P treatment and least in the control soil (Table 3). The effects of treatment, rate and treatment and rate interaction effects ($P<0.001$) on aggregate stability, were significant at all sampling times. The increase can be attributed partly to improvements in organic carbon content. Mullins (2002), observed that the incorporation of organic residue increased organic carbon and its various fractions which contribute to the formation and stabilization of soil aggregates. Also, Mbagwu and Piccolo (1990), reported that organic manure application improved the degree of soil aggregation and aggregate stability. In this study, compost-treated soils performed better than the control in affecting the physicochemical properties studied. The G+P+OY treatment was most effective in improving the exchangeable cations and ECEC with the largest increase obtained at the sixth week of improving the exchangeable cations and ECEC with the largest increase obtained at the sixth week of sampling, with highest rate of compost application. The improvement in ECEC is attributable to the decomposition of organic matter contained in the composts. Base saturation increased with G+OY treatment in line with the liming ability of oyster shell. Exchangeable calcium was high in the material which explained the significant increase in treated soils compared to the control. Edem *et al.* (1998) and Mullins, (2002), had reported increases in exchangeable magnesium, calcium and potassium content of soil, with application of poultry and goat manures which were enhanced by the addition of oyster shell. Therefore, the results from this study confirmed these observations and agree that organic manure with oyster shell has positive effect on soil exchange properties.

Table 3: Physico-chemical properties of compost amended soils at different sampling 'times

Rate	OC (%)	Total N (%)	Avail. P PPM	Soil activity		Exchangeable cations (Cmol/kg)						BS(%)	AS
				H_2O	$CaCl_2$	Ca	Mg	Na	K	EA	ECEC		
Two Weeks													
Control (0%)	1.03	0.04	0.24	6.54	4.25	6.48	2.10	0.05	0.13	0.96	9.72	90.12	0.25
Oym(10%)	1.61	0.07	0.29	7.53	6.96	25.36	5.17	0.07	0.20	1.36	28.08	94.95	0.72
G+P(10%)	1.56	0.06	0.26	7.62	6.64	37.12	9.36	0.06	0.09	2.15	48.79	94.74	0.40
Oy+p(10%)	1.86	0.09	0.39	7.64	6.80	28.81	7.52	0.07	0.16	1.60	38.15	95.74	0.84
Oy+g(10)	1.82	0.08	0.58	6.83	6.17	15.44	4.35	0.07	0.29	1.16	21.31	94.28	0.33
Oym(20%)	1.92	0.08	0.26	7.72	7.00	38.64	9.69	0.07	0.11	1.56	50.07	96.09	0.44
G+P(20%)	1.69	0.29	0.39	7.63	6.75	33.92	7.35	0.07	0.21	1.68	43.23	96.11	0.87
Oy+p(20%)	1.62	0.07	0.61	7.54	6.47	21.12	6.42	0.09	0.35	1.52	29.50	94.83	0.36
Oy+g(20%)	1.53	0.07	0.45	7.77	6.78	42.40	9.57	0.07	0.23	1.32	53.60	97.48	0.81
F_{LSD}(0.05)T	0.136	0.01	0.052	0.309	0.237	8.16	2.581	0.006	0.021	0.255	10.09	1.04	0.015
F_{LSD}(0.05)R	0.118	ns	0.045	0.268	0.205	7.07	2.235	0.005	0.018	0.221	8.74	0.90	0.014
F_{LSD}(0.05)TR	0.237	ns	0.091	0.536	0.411	14.13	4.47	0.010	0.037	0.441	17.48	1.80	0.027
Four weeks													
Control (0%)	1.03	0.04	0.24	6.54	4.25	6.48	2.10	0.05	0.13	0.96	9.72	91.12	0.40
Oym(10%)	1.65	0.07	0.29	7.54	6.98	25.59	5.22	0.07	0.21	1.40	28.27	95.16	0.76
G+P(10%)	1.60	0.07	0.26	7.64	6.65	37.18	9.37	0.07	0.13	2.19	48.94	94.96	0.50
Oy+p(10%)	1.95	0.37	0.39	7.66	6.82	28.86	7.54	0.08	0.18	1.65	38.31	95.64	0.88
Oy+g(10)	1.83	0.08	0.58	6.83	6.18	15.45	4.36	0.08	0.31	1.19	21.39	94.28	0.40
Oym(20%)	1.97	0.08	0.26	7.74	6.98	38.76	9.70	0.08	0.17	1.60	26.31	96.04	0.55
G+P(20%)	1.73	0.09	0.39	7.65	6.77	33.98	7.36	0.08	0.25	1.25	43.38	96.01	0.89
Oy+p(20%)	1.58	0.07	0.45	7.79	6.90	43.21	9.59	0.08	0.26	1.36	50.52	97.46	0.94
Oy+g(20%)	1.66	0.08	0.61	7.54	6.48	21.13	6.44	0.08	0.37	1.55	29.56	94.83	0.43
F_{LSD}(0.05)T	0.144	0.129	0.05	0.309	0.241	8.20	2.577	0.007	0.025	0.375	9.17	1.01	0.019
F_{LSD}(0.05)R	0.124	0.112	0.05	0.268	0.209	7.10	2.232	0.006	0.022	0.325	7.94	0.87	0.017
F_{LSD}(0.05)TR	0.249	0.224	0.09	0.535	0.418	14.2	4.463	0.011	0.044	0.649	15.89	1.75	0.034
Six Weeks													
Control (0%)	1.03	0.40	0.24	6.54	4.25	6.48	2.10	0.05	0.13	0.96	9.92	90.12	0.52
Oym(10%)	1.71	0.08	0.30	7.57	7.01	25.59	5.26	0.08	0.25	1.42	29.10	95.21	0.76
G+P(10%)	1.57	0.08	0.26	7.65	6.68	37.23	9.38	0.07	0.13	2.22	49.18	95.63	0.56
Oy+p(10%)	2.06	0.11	0.39	7.73	6.85	28.93	7.77	0.08	0.22	1.67	38.68	94.24	0.92
Oy+g(10)	1.85	0.07	0.58	6.84	6.49	15.50	4.38	0.08	0.28	1.22	22.38	94.24	0.46
Oym(20%)	2.01	0.08	0.27	7.75	7.17	39.22	9.74	0.08	0.17	1.62	50.83	96.01	0.62
G+P(20%)	1.78	0.09	0.39	7.67	6.78	34.04	7.41	0.09	0.26	1.74	43.52	94.71	0.96
Oy+p(20%)	1.67	0.08	0.61	7.55	6.50	21.18	6.49	0.08	0.30	1.57	29.62	94.71	0.53
Oy+g(20%)	1.60	0.08	0.45	7.79	6.93	43.21	9.62	0.08	0.24	1.35	54.51	97.45	0.95
F_{LSD}(0.05)T	0.151	0.012	0.052	0.301	0.245	8.32	2.55	0.005	0.05	0.261	10.27	0.571	0.202
F_{LSD}(0.05)R	0.131	0.009	0.045	0.260	0.212	7.20	2.21	0.004	0.044	0.226	8.89	0.494	0.017
F_{LSD}(0.05)TR	0.262	0.019	0.089	0.521	0.424	14.41	4.43	0.009	0.089	0.453	17.78	0.988	0.034

The composted materials affected total N, avaialble P percent organic carbon and soil acidity, and there were increases in the strength of relationships between these properties with time). The trend of effect of the treatment on total N, available P and percent organic carbon relative to the control, irrespective of application rate, indicates that the improvements were highest with the combinations of G+P+OY. The pH (H_2O) of the treated soil was raised from moderately acidic to neutral (7.54) which showed that the composts were effective in eliminating the soil acidity, with highest value obtained at the sixth week. Mullins (2002), had attributed these changes to the neutralizing effect of oyster shell and poultry droppings stressing that the liming effect is due to calcium carbonate in poultry feed. Generally, the relationship between selected properties with the compost type and rate of application indicated that the rate and type of compost amended soil was responsible for only about 38% and 17% of Na and organic carbon after two weeks of incubation. However, after four to six weeks of compost incorporation with the soil, this effect on available P was diminished by half while the exchangeable Na became higher.

This study has shown that composted organic materials from poultry manure, goat manure and oyster shell improved the pH, CEC, available P, total N, organic carbon, exchangeable acidity and aggregate stability of soil from an inland valley. The improvements increased with the rate of the amendments and sampling time. Specifically, the G+P+OY treatment influenced total N, cation exchange capacity and available P the most, while P+OY treatment was most effective in improving aggregate stability, pH, and exchangeable calcium content of the soil.

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