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Full Length Research.

EFFECT OF DECOMPOSED RICE HUSK DUST ON SOIL PROPERTIES AND YIELD OF MAIZE

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An experiment to monitor the effect of decomposed rice husk dust with urea fertilizer, Gliricidia sepium *(GS)* and poultry manure(PM) on soil physico-chemical properties and the yield of maize was conducted at Ebonyi State University, Abakaliki. The study was conducted using a randomized complete block design. Bulk density was significantly reduced with application of rice husk dust (decomposed and undecomposed) with the lowest bulk density of 1.04g cm^{-3} obtained in plots amended with undecomposed rice husk dust (URHD). The total porosity, gravimetric moisture content and infiltration rate were signifiantly (P=0.05) increased relative to the control with the application of rice husk dust . Results of the study showed increased soil pH , organic matter, total N, available P and the exchangeable cations in amended plot relative to the control. The highest soil N of 1.26g kg^{-1} N was obtained in plots amended with DRHD+GS, while available P was highest in the DRHD+PD amended plots (28.04mg kg^{-1}). Observed improvement in soil physical and chemical properties in amended plots resulted in higher plant height,shoot dry weight and grain yield compared to the control.

Keywords: Rice husk dust, Bulky density, Porosity, Infiltration.

INTRODUCTION

Soil fertility maintenance is a major concern in the tropics, particularly in Abakaliki in the Southeast agro-ecological zone of Nigeria. Abakaliki is greatly regarded as the food basket of the southeast agro-ecological zone. The traditional farming systems of the area for sustaining fertility include: bush fallow, shifting cultivation, use of plant residue, household refuse, animal manure and other organic wastes. Although the reliance on biological nutrient sources for soil fertility regeneration is adequate for low–cropping intensities, it becomes unsustainable with more intensive cropping that is characteristic of the study area, thus resulting in low fertility. The rapid depletion of nutrients and poor physical condition of the soil are strong limitations to crop production (Igwe *et al.,*1995). The decline in soil productivity has led farmers in the area to embrace the use of inorganic (chemical) fertilizers.

In Nigeria, inorganic fertilizers are expensive, particularly with the reduction of fertilizer subsidies by Government at all levels. This has brought untold hardship on the peasant farmers, who can hardly afford to meet the high cost of inorganic fertilizers. However, frequent use of inorganic fertilizers for a prolonged period deteriorates the surface soil characteristics and affects the availability and uptake of nutrients by plants (Kerenhap *et al*.,2007).

In view of the poor economic resource base of rural farmers and the need to prevent the degradative effect of inorganic fertilizers, it becomes exigent to optimize the use of organic wastes. The positive effects of organic wastes on soil productivity have been reported by several workers (Mbagwu 1992,Mbagwu and Piccolo, 1990,Nnabude *et al.,* 2000).

In Abakaliki, rice husk dust as a solid organic waste is very common in all the milling centres. About 100t are produced daily. The rice husk dust is disposed, to the extent that mountainous hills of it abound in all the milling centres. The overgrown heaps of rice husk dust can cause erosion and loss of valuable nutrients to runoff water ,which reduces water quality. Some exogenous substances like humic acid from these wastes can react with soil components to cause changes in the soil physical properties (Piccolo and Mbagwu,1997). Rice husk dust is rich in K, low in P, poor to medium in N (Balasubramanian and Nnadi, 1980). However, organic waste amended soils have been reported to have high organic matter contents (Anikwe,2000). Soil organic matter influences the degree of aggregation and aggregate stability (Nnabude and Mbagwu 1999, Mbagwu and Piccolo, 1990) and it can reduce bulk density and increase total porosity and hydraulic conductivity in heavy clay soils (Anikwe,2000). This study therefore evaluated the effect of rice husk dust decomposed with different additives on soil physico-chemical properties and maize yield under field conditions.

MATERIALS AND METHODS

This study was conducted at the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki (Latitude 06^{o} 4^{1}N, Longitude 08^{0} 065^{1}E, and mean elevation 400m above sea level), with annual rainfall ranging between 1600mm-2000mm. The rainfall is characteristically intensive (begins in April and ends in November). The area has high temperature with a maximum daily temperature range of between 28-31°C. The climate is typical of the humid tropical zone.

Decomposition of Rice Husk Dust

Three pits marked A, B and C measuring 1m x 1m x 1m (length x width x depth) were dug and lined on the side and floor with perforated dark coloured polyethylene. Decomposition commenced in March, 2006.

Pit A

A layer of topsoil was placed on the floor of the pit and 25kg of rice husk dust was placed on the top of the soil while 2.5kg of Urea fertilizer was uniformly spread, followed by 25kg of rice husk dust and a thin layer of 2.5kg Urea (spread uniformly). Lastly, a layer of topsoil was spread on the surface. The reason for using fresh soil was to serve as inoculums.

Pits B and C

Similar processes as done in pit A were carried out in pits B and C, but the urea fertilizer was replaced with 10kg of fresh *Gliricida sepium* leaves (obtained from an existing alley cropping farm) in pit B. Poultry droppings weighing 10kg was introduced in pit C. Bamboo measuring 1.5m (high) x 3cm^{-3} (diameter) were inserted at the centre of the three pits to serve as a tester. The pits were watered every 14 days and the contents of the pits properly mixed every month. The decomposition in the pits lasted for 3 months. Samples of the decomposed rice husk dust were analysed for organic C (Nelson and Sommers, 1982), Organic matter (OM)was calculated from organic C by multiplying the organic C by 1.724, Total N (Bremner and Mulvaney, 1982) and available P were measured based on methods by Page et al.,(1983) and exchangeable Ca, Mg and K were determined using routine laboratory methodology.

Field Study

The study was laid out in a Randomised Complete Block design (RCBD) with four replications and five treatments. The treatments include:

- Control plots with no amendments
- 7.5 t ha^{-1} decomposed rice husk + 7.5 t ha-^{1}Urea (DRHD+U)
- 7.5 t ha^{-1} decomposed rice husk + 7.5 t ha-^{1} poultry droppings (DRHD+PD)
- 7.5 t ha^{-1} decomposed rice husk + 7.5 t ha-^{1} *Gliricida sepium* (DRHD+GS)
- 7.5 t ha^{-1} undecomposed rice husk dust (URHD).

The study site was cleared manually and all debris removed. Soil samples were taken from four points at a depth of 0-20cm. Soil samples was thoroughly mixed to form a composite sample. The composite soil sample was used to determine soil physical and chemical properties for the pre-planting soil analysis. The treatments were spread uniformly over 4m x 4m plots and incorporated manually into the seedbed. Two grains of maize (variety Oba Super II) were planted per-hill at a depth of 3cm ten days after incorporation of amendments.The maize grains were planted at a distance of 50cm x 50cm and thinned down to one per planting hill 2 weeks after germination. At 5weeks after planting (WAP), bulk density (Bd) was determined using the core method (Gee and Bauder, 1986), total porosity (Tp) was calculated from the bulk density using an assumed particle density (Pd) of 2.65gcm^{-3} in the following equation ;.

$$T_p = 100 \quad [1 - Bd/P_d]$$

While the aeration porosity (Ap) was computed from the following relationship.

$$Ap = Tp - Ø\ (10kPa)$$

Where Ø is the volumetric moisture content.

Particle size distribution was determined by the hydrometer methods (Gee and Bauder, 1986) while volumetric moisture content was determined using a pressure plate at 10kPa (Stolte,1997). Water infiltration into the soil was determined using the double ring infiltrometer (Bouwer,1986).

Post harvest soil samples (3 per plot and composited) were taken plot by plot at a depth of 0-20 cm with soil auger for soil analysis. Composite soil samples were analysed for pH in 1:2.5 mL soil - water suspension, organic carbon was determined method (Nelson and Sommers, 1982). Organic matter was obtained by multiplying the organic carbon by the Vanbameller factor of 1.724. Available P was extracted with Bray 2 (Page *et al.*,1983). Total N was determined by the macro-kjeldalh procedure (Bremner and Mulvaney,1982), exchangeable bases were obtained by methods outlined by Juo (1979).

At tasseling, ten randomly tagged plants were sampled per plot for plant height, shoot dry weight and lodging. Grain yield was obtained at harvest and shelled at 12 percent moisture content. The soil and crop data generated from this study were analysed statistically using the Fisher's least significant differences (FLSD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Nutrient Content of the Rice Husk Dust

The cumulative and nutrient content of the decomposed and undecomposed rice dust is shown in Table 1. Organic C decreased in the decomposed rice husk dust after adding urea urea, poultry dropping and *Gliricidia sepium* pruning. The lowest organic C content was observed in DRHD+GS (10.26gkg^{-1}). The decrease in the organic C content as indicated by the C/N ratio was a factor of the total N content of both rice husk dust and the additives used in the decomposition process. The low N content of the URHD resulted in a high C/N ratio. The high C/N ratio explained the high C low N content and slower rate of decomposition. Okonkwo and Ogu,(2002) observed that higher C/N ratios indicate a decreasing N status of the organic waste. Undecomposed rice husk dust(URHD) had the highest organic C content which was significantly ($p<0.05$) different from the others. The total N content was highest (1.98 g kg^{-1}) in the DRHD + GS. The order of increase in total N was DRHD+GS>DRHD+PD> DRHD+U> URHD. The rice husk dust that decomposed with urea did not have total N contents that were comparable to DRHD+GS and DRHD+PD. The result was unexpected since urea contains 46%N. However, the low N content could be attributed to leaching or immobilization by microbial organisms involved in the decomposition. The total N content in DRHD+GS showed 86% increase over the URHD, 23% over that of DRHD+U and 18% over the DRHD+ PD. The available P, after decomposition, ranged between 7.64 mg kg^{-1} in the URHD to 19.01mg kg^{-1} in the DRHD+PD. The result showed that addition of poultry droppings during decomposition improved available P by 44% over the URHD. The exchangeable Ca, Mg and K were high in the decomposed rice husk dust treated with additives. DRHD+GS were consistently the highest in exchangeable Ca, Mg and K. The result obtained in this study showed that available nutrients from rice husk dust could be improved when treated with high quality and decomposable materials.

Soil Properties

The result of the pre – planting soil properties is shown in Table 2. The soil texture was sandy loam and the pH of the soil was very strongly acid. The organic matter, total N and available P were low. The exchangeable cations and CEC were also low. The low exchangeable cations and CEC is associated with the low organic matter and clay content of the soil .

Table. 1Nutrient Content of decomposed and undecomposed rice husk dust

Treatments	Org C.	OM	N	C/N	P	Ca	Mg	K
	------	g kg^{-1}	-------		mg kg^{-1}	---------	cmol kg^{-1}	--
URHD	24.17	41.66	0.15	16.13	7.46	0.98	0.32	0.54
DRHD +U	16.64	28.68	1.24	13.14	12.96	1.92	0.51	0.07
DRHD + PD	12.10	20.86	1.40	8.64	19.01	2. 03	0.68	0.79
DRHD+GS	10.26	17.68	1.98	5.18	15.05	2.54	0.93	0.81
LSD (0.05)	2.21	3.22	0.07	3.11	1.73	0.81	0.14	NS

URHD = Undecomposed Rice husk dust
DRHD +U = Decomposed Rice husk dust and Urea.
DRHD +PD = Decomposed rice husk dust and poultry manure
DRHD +GS = Decomposed rice husk and *Gliricidia sepium*

Table 2. Pre- Planting. Soil Physical and Chemical Properties (0.20cm)

Sand (%)	68
Silt (%)	18
Clay (%)	14
Texture	Sandy loam
pH (H_2O)	4.5
Org C (g kg^{-1})	1.04
Org. matter (g kg^{-1})	1.76
N (g kg^{-1})	0.076
P (mg kg^{-1})	11.60
Ca (Cmol kg^{-1})	1.90
Mg (Cmol kg^{-1})	0.44
K(Cmol kg-1)	0.22
Na (Cmol kg^{-1})	0.17
Total acidity (Cmol kg^{-1})	3.01
CEC (Cmol kg^{-1})	2.71

Soil Chemical Properties

The result of the post harvest soil chemical properties (Table 3) showed that the pH of the soil ranged from strongly acid in the URHD, DRHD+ U and DRHD+PD to moderately acid in DRHD+GS amended plots. The control plots remained very strongly acid (pH 4.9). The changes in the soil pH due to the decomposed rice husk dust implied that continuous application could reduce soil acidity. However, Nnabude *et al.,* 2000 reported no change in the pH values in their study on fresh and burnt rice dust.

The highest organic matter content was obtained in the URHD amended plots (3.06g kg^{-1}). The organic matter content of the URHD represented 19.77% over the control, 19% over the URHD+U, 14% when compared with DRHD+PD and 19% to the DRHD+ GS, the high organic matter of plots amended with URHD is a reflection of the amount of organic matter added (Table 1). Contrary to expectation, the exchangeable Ca, Mg, K and Na were consistently highest in the DRHD+GS plots followed by the DRHD +PD plots. The order of increase in exchangeable cations is DRHD+GS>DRHD+PD>DRHD+U>URHD>C. This implies that both *Gliricida sepium leaves* and poultry manure contributed to exchangeable cations. For the exchangeable bases, K and Na did not show any statistical differences among treatments. This result did not agree with report of Balasabrameian and Nnadi [3 Balasubramanian and Nnadi,1980], which indicated that rice husk dust is enriched with K. The highest CEC of 7.32 $cmolkg^{-1}$ was recorded in the DRHD+GS amended plots. There were significant differences ($p<0.05$) between the CEC of soils amended with DRHD+GS and the other treatments.

The total soil N was highest in the DRHD+GS amended plots. Using the Landon,(1991) N ratings, the control plots and plots amended with URHD were low. The total soil N in plots amended with DRHD+U, DRHD+PD and DRHD+GS would be rated high, but the highest soil N of 1.26g kg^{-1} N was obtained in plots amended with DRHD+GS. This represents a 58% increase over the DRHD+U amended plots. The value of total N obtained in the DRHD+U was unexpected since urea fertilizer hada high percentage of N as the active ingredient. However, the explanation could be that urea fertilizer released N faster than *Gliricida sepium* or poultry dropping during decomposition process. Therefore, most of the N in the DRHD+U might have leached or volatilised out in the pit. But the high N values shown in the DRHD+GS amended plots was because *Gliricida sepium* incorporated during decomposition is a legume and nitrogen fixer and might have released its N content slowly.

Espiritu *et al.* (1995) had shown that the addition of nitrogen fixers could enrich and enhance the nutrient levels of any compost and thus facilitate supplementation or replacement of chemical fertilizer. Among the amended plots, URHD had the lowest soil N (Table 3). This could be attributed to either immobilization of available N after incorporation by micro organisms or the utilization of the native soil N to initiate decomposition in the soil.

The C/N ratio of plots amended with DRHD+U, DRHD+PD and DRHD+GS were very low compared with the URHD. The C/N ratio of these plots were a function of the amount of organic C and total N. DRHD+GS plots with high N had the lowest C/N ratio of 0.96g kg^{-1} . Among the plots amended with decomposed rice husk dust, URHD+U plots had higher C/ N ratio. This goes to support the fact that the URHD +U lost greater part of N during decomposition in the pit. The low N level in the URHD plots (Table 3) showed that much of the N was from the soil. The high C/N ratio in the URHD plots is an evidence of low N status of the rice husk dust. Available P was highest in plots amended with DRHD+PD (17.04 mg $kg^{-1)}$. According to Enwezor *et al.*,(1989) ratings, available P in the control plots and the URHD plots were low, the DRHD+PD and DRHD+GS were high. Poultry manure is a rich source of nutrient besides serving as a soil conversing material (Eno,1996). Application of poultry manure at higher rates increased the soluble phosphorus concentration in soils (Warneke and Siregar, 1994). Therefore, its addition during rice husk decomposition enriched the decomposed material with P.

Soil Physical Properties

The results of the applied rice husk dust (decomposed and undecomposed) on bulk density, porosity, moisture content and water infiltration are shown in Table 4. The control plots (with no application) recorded the highest bulk density of 1.87g cm^{-3}. Plots amended with either decomposed or undecomposed rice husk dusts had their bulk densities reduced with the lowest bulk density of 1.04g cm^{-3} obtained in plots amended with URHD. There was a significant difference ($p<0.05$) between the bulk density of the control plots and the plots amended with either decomposed or undecomposed rice husk dust. Among the plots amended with decomposed rice husk dust, there was no statistical difference in their soil bulk densities. The reduction in the soil bulk densities of plots amended with rice husk dust was similar with the works already reported (Anikwe,2000,Nnabude and Mbagwu 1999, Mbagwu, and Piccolo, 1990].

Plots amended with rice husk dust showed no statistical differences in moisture content of the soil. Both URHD and DRHD+ GS had the highest moisture content (45% respectively). The values obtained in the amended plots represented improvement in soil water retention at 10kPa over the control plots (20%). This indicates the positive effect of incorporated rice husk dust in reducing soil bulk density ..

The total porosity was a reverse of the bulk density. Those treatments with the lowest soil bulk density had the highest total porosity. The amendment of soil with rice husk dust improved significantly total porosity over the control. Among the amended plots URHD had the highest total porosity (60%),which was significantly different ($p<0.05$) from the DRHD+U plots. There were no statistical differences between URHD, DRHD+GS and DRHD+PD plots. Both total porosity and bulk density depended on the level of soil organic matter. In this study, plots with high organic matter (Table 3) also had a low bulk density and high total porosity in line with the observations made by Nnabude and Mbagwu (1999), Mbagwu,(1992), Anikwe,(2000), when they studied the influence of organic wastes on physical properties of heavy clay soils.. The aeration porosity differed significantly among treatments. The lowest aeration porosity occurred in the control plots (9%). All the plots amended with rice husk dust were significantly different from the control ($p<0.05$). However, aeration porosity when compared to the total porosity was very

low. The low values obtained for aeration porosity is a reflection of the ability of the amendment to retain moisture, and the nature of the fine particles of the rice husk dust may have clogged the pore spaces.
Infiltration (cm/hr) was generally highest in plots amended with URDH (Table 4). The variation in the organic matter (Table 3), bulk density and total porosity of soils depended greatly on the organic matter content of the waste applied. Invariably, the highest water infiltration occurred in the URHD plots with highest total porosity and lowest bulk density. Hence, the ability of organic waste to improve infiltration depended among other things on improved aggregation (Anjaiah *et al.*,1997), pore space (Prove *et al.*,1990) and organic matter status (Foth,1979). The ability of the DRHD+PD and DRHD+G to enhance infiltration among the amended treatments could be that addition of *Gliricida sepium* and poultry manure during decomposition helped the rice husk dust to improve the granulation of soil and therefore better soil aggregation. However, it took more time for final infiltration to be reached in the control (98mins). Thus infiltration rate in this study depended on the available pore space, which in turn depended on the level of organic matter in the soil. The ability of rice husk dust to effect changes relative to the control is a reflection of their potentials to sustain the physical conditions of the soil.

Table 3. Post- Harvest Soil Chemical Properties (0-20)

Treatment	pH H_2O	Org C.	OM	N	C/N	AVL.P mg kg^{-1}	K	Ca	Mg	Na	CEC
		----- g kg^{-1} ------					Exchangeable -------c mol kg^{-1} --------------				
Control	4.4	1.19	2.05	0.09	13.22	9.64	0.41	2.01	0.98	0.12	3.52
URHD	5.2	1.78	3.06	0.11	16.18	12.31	0.64	2.14	1.35	0.18	4.31
DRHD+U	5.1	1.23	2.12	0.34	3.61	17.86	0.81	2.53	1.74	0.25	5.33
DRHD+PD	5.4	1.34	2.31	0.98	1.36	28.04	0.88	2.82	1.91	0.31	5.92
DRHD+GS	5.6	1.21	2.08	1.26	0.96	25.61	0.97	3.43	2.51	0.41	7.32
LSD (0.05)	0.25	0.03	0.17	0.01	1.24	2.04	NS	0.14	NS	0.41	1.30

Table 4. Effect of decomposed and undecomposed rice husk dust on bulk density, Total porosity, Aeration porosity, moisture content and infiltration.

Treatment	Bd gcm^{-3}	Mc	Tp	Ap	Inf cm/hr
		---------	% -------	--	
Control	1.87	20	29	9	110
URHD	1.04	46	60	14	430
DRHD +U	1.24	43	53	10	295
DRHD +PD	1.12	45	57	12	311
DRHD +GS	1.09	46	58	12	400
LSD (0.05)	0.17	3.67	4.62	1.97	23.1

Bd = Bulk Density
Mc = Moisture Content
Tp = Total Porosity
Ap= Aeration Porosity
Inf = Infiltration
T = time

Crop Performance

The effect of rice husk dust on crop performance is shown in Table 5. Among the decomposed rice husk dust plots with URHD had the lowest plant height (63.18cm) and shoot dry weight (49.16g $plant^{-1}$). Plots treated with DRHD+GS and DRHD+PD recorded higher plant heights (99.25cm and 87.27cm respectively). Similarly, maize plant height in plots amended with rice husk dust (either decomposed or undecomposed) was significantly higher (p>0.05) than the control plots. In this study, shoot dry weight reflected the plant height. The high vegetative growth observed in plots amended with DRHD+GS resulted in the highest shoot dry weight of 88.04g $plant^{-1}$. The low plant height and shoot dry weight observed in the DRHD+U when compared to that of DRHD+GS and DRHD+PD was unexpected. It could be that most of the nutrients particularly N was released before the critical growth period of the test crop. Lodging did not show any difference among treatments. In most cases, the plants pulled from the soil, thus showing poor anchorage of the root system.

Grain yield ranged from 0.42t ha^{-1} in the control plots to 2.18 t ha^{-1} in the DRHD+GS plots. The differences in grain yield depended to a greater extent on the amount of nutrients released and were made available for plant growth. Both DRHD+GS and DRHD+PD amended plots gave higher grain yields and were significantly different ($p<0.05$) from the other treatments.

Table 5. Crop performance under decomposed and undecomposed rice husk dust

Treatments	Plant Height (CM)	Lodging (%)	Shoot dry weight (g plant^{-1})	Grain yield (t ha^{-1})
Control	52.09	15	37.82	0.42
URHD	63.18	11	49.16	1.01
DRHD +U	87.27	8	57.77	1.52
DRHD +PD	94.35	5	75.06	1.94
DRHD + GS	99.25	4	88.04	2.18
LSD (0.05)	8.12	NS	7.48	0.39

CONCLUSION

The results obtained from this study have shown that both physical and chemical properties were significantly improved by the application of rice husk dust. Higher nutrient release was observed with the introduction of *Gliricidia sepium* and poultry manure during decomposition of the rice husk dust. The nutrients released improved yield of maize. Therefore, harvest of nutrient availability and improved soil conditions, the decomposition of rice husk dust with legumes and animal manure could be a better option.

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