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Effect of Rice Husk Dust on Selected Soil Physical Properties and Maize Grain Yield in Abakaliki, South Eastern Nigeria

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This study was carried in 2012, 2013 and 2014 cropping seasons at Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki to evaluate the effects of rice husk dust on soil particle size distribution, bulk density, total porosity, hydraulic conductivity and maize grain yield in Abakaliki South Eastern Nigeria. The experiment was laid out in randomized complete block design (RCBD) with sixteen treatments replicated three times. Data collected were analysed using the General Linear Model of SAS software in RCBD. The results showed same values of particle size distribution were observed in both the control and amended plots throughout the three cropping seasons. There was significant ($P < 0.05$) increase in total porosity, hydraulic conductivity and maize grain yield and a significant ($P < 0.05$) decrease in rice husk dust amended plots relative to control. Unburnt + burnt rice husk dust recorded the highest improvement in soil physical properties and maize grain yield studied. Unburnt rice husk dust improved the selected physical properties higher than burnt rice husk dust and the improvement increased with an increase in quantity of rice husk dust applied. While 10 tha-^{1} of unburnt + 15 tha-^{1} of burnt rice husk gave the highest maize grain yield. Higher bulk density, lower total porosity and higher saturated hydraulic conductivity were recorded in 90 days after planting than 45 days after planting. Therefore, since these rice husk dusts are cheap in the study area and causes environmental degradation if not well dispose, this study recommended that they should be used as soil amendments since it improved selected soil physical and maize grain yield studied.

Keywords: Grain yield, physical properties, rice husk dust and Ultisol

Novelty Statement

They are many heaps of rice husk dust in the study area. These rice husk dusts are solid wastes from rice processing in the study area and consititute environmental hazards if not properly disposed. It is also very cheap to obtain in the study area. We use these rice husk dust as soil amendment in 2012, 2013 and 2014 cropping seasons to determine its effect on soil physical properties and maize grain yield. The results showed that rice husk dusts can improve soil physical properties and maize grain yield.

INTRODUCTION

Returning organic wastes to the soil could lead to its structural modifications and increase crop yields (Mbagwu, 1999; Mbagwu *et al.*1994; Obi and Ebo 1995; Nnabude and Mbagwu 1999). Anikwe (2000) obtained significant decrease in soil dry bulk density in plots amended with 4.5 and 6.0 t ha^{-1} of rice husk dust at 48 and 60 days after planting (DAP), and according to Mbagwu (1989) and Nnoke (2005), organic wastes amendment reduces soil bulk density and increases soil total porosity. The decrease in bulk density was attributed to the low density of compost and its tendency to increase pore size and volume at high doses (Gallardo-lara and Nogales, 1987). In another study, Mbagwu (1992a) showed that the decrease in bulk density obtained with rice-shaving and poultry manure treated soils were directly related to increased organic matter content which played a significant role in reducing the degree of compaction in the soil studied. Porosity greatly affects water movement and gas exchange. Equally, Nnabude and Mbagwu (1999) observed that application of fresh and burnt rice-mill waste at the rate of 25.0 and 50.0 $Mgha^{-1}$ decreased soil bulk density and increased total porosity. Using rice mill wastes as soil amendment, Mbah *et al.* (2011) obtained lower bulk density and higher total porosity in 45 DAP than 90 DAP. The authors attributed the differences in bulk density and total porosity in 45 and 90 DAP to a combination of many factors such as content of organic matter, natural process of settling and structural collapse due to total raindrop impact on the soil surface. Zebarth *et al.* (1999) working with organic amendments obtained higher soil bulk density and lower porosity in control plot after three years of treatment application than in the amended plots. Durtart *et al.* (1993) observed from the soil they studied that the amount and composition of organic materials, particularly the humic substances, influence the structure of sandy soils.

Nwite *et al*. (2011) showed that plots amended with burnt rice mill waste, unburnt rice mill waste and saw dust recorded higher saturated hydraulic conductivity relative to unamended in the three years of study. Similarly, Tiarks *et al.* (1974) found that after 2 years of manure application, the hydraulic conductivity ranged from 0.2 – 52 $cmhr^{-1}$. According to Biswas and Khosla (1971); Tiarks *et al* (1974); Weil and Kroontje (1979) application of organic wastes resulted to an increase in hydraulic conductivity in plots amended with organic wastes relative to the control plot. Mbagwu (1989) observed that incorporation of organic wastes significantly increased soil saturated hydraulic conductivity but the magnitude of increase is dependent on the rate of waste application. Similarly, Rawls et al (1982) compiled values of hydraulic conductivity of 1,323 soils collected from over 32 countries and observed that soils with large pores recorded higher hydraulic conductivity than soils with small pores.

Large quantities of unburnt and burnt rice mill wastes accumulated in numerous rice mill waste dumpsites in the study area resulting to the pollution of the environment. These rice husk dust can be used as soil amendment to provide nutrients to plant (Anikwe, 2000, Mbah and Onweremadu 2009 and Njoku *et al.,* 2011). Therefore, the objective of this study was to determine the effect of unburnt and burnt rice husk dust on soil bulk density, total porosity; hydraulic conductivity and maize grain yield of Tropical Ultisol in South East Nigeria.

MATERIALS AND METHODS

The Study Area

This study was conducted at the Teaching and Research Farm of Ebonyi State University, Abakaliki in 2008, 2009 and 2010 cropping seasons. The area lies on longitude 6.33674^0 N – 6.01177^0 N and latitude 8.11267^0 E – 8.14136^0 E in the derived savannah zone of south East Nigeria. It is characterized by high temperatures and high rain fall. The mean monthly temperature is 27^0. Rainfall starts appreciably in April and stops in October, leaving a completely dry period between November and April. The rainfall regime is bimodal, with peaks in the months of July and September. The total annual rainfall in the area ranges between 1500 to 2000mm, with a mean of 1,800mm. Humidity is high (80%) with lowest (60%) levels occurring during the dry season in April, before the raining season begins (ODNRI, 1989). The soil is hydromorphic and belongs to the order, Ultisol, within the Ezzamgbo soil association, derived from shale and classified as typic Haplustult (Federal Department of Agriculture and Land Resources, 1985).

Sources of Materials and Land Preparation

Burnt and unburnt rice husk dusts were collected from the rice mill factory, Abakaliki. Similarly, the test crop (Oba Super 11) was sourced from Ebonyi State Agricultural Development Programme. The land was cleared manually using cutlass, debris were removed and beds of 4m X 2m were prepared using hoes. Then, unburnt and burnt rice wastes were incorporated into the soil as soil amendments. The unburnt, burnt and mixtures of both were carefully weighed and uniformly spread on the plots and then incorporated into the soil using traditional hoe for 2008 cropping season. The treated plots were allowed to age for

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2 weeks before planting the test crop. Hand weeding was done on 3 weeks intervals until the crop harvest. The only source of water for the crop was rainfall. Also, there was non-application of fertilizers, herbicides or pesticides to the plots. The same procedure was repeated in 2009 and 2010 cropping seasons but without the application of the amendments in 2010 (to test the residual effect).

Experimental Design and Soil Sampling

An area of land that measured 384m^2 was used for the work. The field was demarcated into plots and replicates. The experiment was laid out in Randomized Complete Block Design (RCBD). There were a total of 48 plots each measuring 4 m X 2 m (8 m^2) used in the experiment. Plots and replicates were separated by 0.5 m buffer zone and 1 m alley, respectively. Sixteen treatments replicated three times were used for this study. Undisturbed core soil samples of 161.36 cm^3 were collected from all the plots at 45 and 90 days after planting (DAP) from three observational points each cropping season and used for the determination of the physical properties of the soil.

Treatments details are:

1. U_0B_0 (Control) – No amendments
2. U_0B_1 – 5 t ha^{-1} burnt rice husk dust (4kg/plot)
3. U_0B_2 – 10 t ha^{-1} burnt rice husk dust (8kg/plot)
4. U_0B_3 – 15 t ha^{-1} burnt rice husk dust (12kg/plot)
5. U_1B_0 – 5 t ha^{-1} unburnt rice husk dust
6. U_1B_1 – 5 t ha^{-1} unburnt + 5 t ha^{-1} burnt rice husk dust
7. U_1B_2 – 5 t ha^{-1} unburnt + 10 t ha^{-1} burnt rice husk dust
8. U_1B_3 – 5 t ha^{-1} unburnt + 15 t ha^{-1} burnt rice husk dust
9. U_2B_0 – 10 t ha^{-1} unburnt rice mill wastes
10. U_2B_1 – 10 t ha^{-1} unburnt + 5 t ha^{-1} burnt rice husk dust
11. U_2B_2 – 10 t ha^{-1} unburnt + 10 t ha^{-1} burnt rice husk dust
12. U_2B_3 – 10 t ha^{-1} unburnt + 15 t ha^{-1} burnt rice husk dust
13. U_3B_0 – 15 t ha^{-1} unburnt rice husk dust
14. U_3B_1 –15 t ha^{-1} unburnt + 5 t ha^{-1} burnt rice husk dust
15. U_3B_2 – 15 t ha^{-1} unburnt + 10t ha^{-1} burnt rice husk dust
16. U_3B_3 – 15 t ha^{-1} unburnt + 15 t ha^{-1} burnt rice husk dust

Laboratory Analyses

The following soil physical properties were determined:

i. Bulk density and total porosity: Bulk density was determined at 45 and 90 DAP as described by Blake and Hartage (1986).

ii. Total porosity: This was calculated from bulk density using the formular:

$Tp = 100 (1 – Db/Dp)$

Where: Dp is particle density assumed to be 2.65 gcm^{-3} Db is bulk density, Tp = Total porosity

iii. Particle size distribution: Particle size distribution was determined by the Gee and Bauder (1986) method.

iv. Saturated hydraulic conductivity: This was determined according to Reynolds (1993) as adapted from Elrick *et al*. (1981).

Grain Yield

At maturity 10 maize plants/plot were selected and tagged. The grain yields from the tagged plants were harvested, dried to 11 % moisture content. Grains/plot was weighed and then converted to its hectare equivalent.

Data Analysis

Statistical analysis of the data was carried out using the General Linear Model of SAS software for Randomized Complete Block Design (SAS Institute, Inc., 1999) while treatment means were separated using the Duncan's Multiple Range Test (DMRT).

RESULTS

Particle Size Distribution and Texture of the Soil Studied

Table 1 shows the particle size distribution and the text of the soil studied. The textural class of the soil was sandy loam while the particle size distribution was 560, 300 and 140 gkg^{-1} for sand, silt and clay, respectively.

Effect of Rice Husk Dust Application on Soil Bulk Density

Table 2 shows a significant ($p < 0.05$) increase in bulk density in control relative to rice husk dust amended plots during the three cropping seasons. At 45 DAP in the first cropping season control recorded the highest bulk density value of 1.65 gcm^{-3}. This observed bulk density in control at 45 DAP in first cropping was higher than that of U_0B_1, U_0B_2, U_0B_3, U_1B_0, U_1B_1, U_1B_2, U_1B_3, U_2B_0, U_2B_1, U_2B_2, U_2B_3, U_3B_0, U_3B_1, U_3B_2, and U_3B_3 by 5%, 5%, 7%, 6%, 7%, 7%, 8%, 10%, 10%, 10%, 11%, 8% ,10%, 11% and 6%, respectively. Similarly, at 90 DAP of first cropping

Table 1: Particle Size Distribution (gkg^{-1}) **and Texture of the Soil Studied**

Sand	Silt	Clay	Texture
560	300	140	Sandy loam

Table 2: Effect of rice husk dust application on soil bulk density (gcm^{-3})

	2012		2013		2014	
Treatment	45DAP	90DAP	45DAP	90DAP	45DAP	90DAP
Control	1.65a	1.68a	1.66a	1.71a	1.68a	1.72a
U_0B_1	1.57b	1.63bc	1.59ab	1.65b	1.61b	1.67b
U_0B_2	1.56bc	1.63bc	1.57abc	1.64bc	1.59bc	1.66bc
U_0B_3	1.54cde	1.64b	1.57abc	1.65b	1.59bc	1.67b
U_1B_0	1.55bcd	1.60cde	1.56bcd	1.63bcd	1.59bc	1.65bcd
U_1B_1	1.53def	1.57efgh	1.54 bcd	1.61def	1.58cd	1.63def
U_1B_2	1.53def	1.58efg	1.54 bcd	1.61def	1.58cd	1.63def
U_1B_3	1.51efg	1.55ghi	1.53 bcd	1.59fg	1.56def	1.60g
U_2B_0	1.49fgh	1.57efgh	1.50 cd	1.60efg	1.54efg	1.63def
U_2B_1	1.48ghi	1.59def	1.51 cd	1.62cde	1.54efg	1.65bcd
U_2B_2	1.49fgh	1.58efg	1.50 cd	1.63bcd	1.52hij	1.65bcd
U_2B_3	1.47ij	1.56fghi	1.49d	1.59fg	1.52hij	1.61fg
U_3B_0	1.51efg	1.55ghi	1.53bcd	1.58gh	1.53ghi	1.67b
U_3B_1	1.48ghi	1.57efgh	1.51cd	1.60efg	1.49k	1.63def
U_3B_2	1.47ij	1.54hi	1.49d	1.56h	1.51ijk	1.66bc
U_3B_3	1.55bcd	1.56fghi	1.56bcd	1.61def	1.58cd	1.63def

Means on the same column with the same letter(s) do not differ significantly ($p<0.05$);
U_O, U_1, U_2, U_3 represent 0, 5, 10, 15t/ha unburnt rice husk dust;
B_0, B_1, B_2, B_3 represent 0, 5, 10, 15t/ha burnt rice husk dust

season the order of bulk density increase was Control>U_0B_3>U_0B_1=U_0B_2>U_1B_0>U_2B_1>U_1B_2=U_2B_2>U_1B_1=U_2B_0=U_3B_1> U_2B_2 =U_3B_3>U_1B_3=U_3B_0. The bulk density at 45 and 90 DAP in 2013 cropping seasons had the highest value of 1.66 gcm^{-3} and 1.71 gcm^{-3}, respectively in control plot. On the other hand bulk density values in amended plots at 45 and 90 DAP in 2013 cropping season ranged between 1.49 – 1.59 gcm^{-3} and 1.56 – 1.65 gcm^{-3}, respectively with U_3B_2 recording the lowest value in the both periods of bulk density observation. At 45 and 90 DAP of 2014 control recorded the highest bulk density value of 1.68 and 1.72 gcm^{-3}, respectively. These observed bulk densities in control at 45 and 90 DAP were higher than that of amended plots by 4 – 11% and 3 – 7%, respectively. The observed bulk density in 90 DAP was higher than that of 45 DAP in all the periods of the data collection. For example the recorded bulk density at 90 DAP in U_0B_1 was higher than the bulk density recorded at 45 DAP by 4%.

Effect of Rice Husk Dust Application on Soil Total Porosity

The application of amendments significantly ($p < 0.05$) increased the soil total porosity relative to control in the three cropping seasons studied as shown in Table 3. At 45

Table 3: Effect of Rice Husk Dust Application on Soil Total Porosity (%)

	2012		2013		2014	
Treatment	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP
Control	37.74^{j}	36.60^{f}	37.36^{h}	35.47^{f}	36.60^{j}	35.09^{b}
UoB_1	40.75^{i}	38.49^{def}	40.00^{g}	37.74^{e}	39.25^{hi}	36.98^{c}
U_0B_2	41.13^{hi}	38.49^{def}	40.75^{fg}	38.11^{de}	40.00^{gh}	37.36^{c}
U_0B_3	41.89^{fghi}	38.11^{ef}	40.75^{fg}	37.74^{e}	40.00^{gh}	36.98^{c}
U_1B_0	41.51^{hgi}	39.62^{bcde}	41.13^{def}	38.49^{cde}	40.00^{gh}	37.74^{bc}
U_1B_1	42.26^{efgh}	40.75^{abc}	41.89^{cdef}	39.25^{bcde}	40.38^{fgh}	38.49^{abc}
U_1B_2	42.26^{efgh}	40.38^{abcd}	41.89^{cdef}	39.25^{bcde}	40.38^{fgh}	38.49^{abc}
U_1B_3	43.02^{cde}	41.51^{ab}	42.26^{bcde}	40.00^{bcd}	41.13^{defg}	39.62^{a}
U_2B_0	43.77^{bcd}	40.75^{abc}	43.40^{ab}	39.62^{bcde}	41.89^{bcdef}	38.49^{abc}
U_2B_1	44.15^{ab}	40.00^{abcde}	43.02^{abc}	38.87^{cde}	41.89^{bcdef}	37.74^{bc}
U_2B_2	43.77^{bcd}	40.38^{abcd}	43.40^{ab}	38.49^{cde}	42.64^{bcd}	37.74^{bc}
U_2B_3	44.53^{a}	41.13^{ab}	43.77^{a}	40.00^{bcd}	42.64^{bcd}	39.25^{ab}
U_3B_0	43.02^{cde}	41.51^{ab}	42.26^{bcde}	40.38^{bc}	42.26^{bcde}	36.98^{c}
U_3B_1	44.15^{ab}	40.75^{abc}	43.02^{abc}	39.62^{bcde}	43.77^{b}	38.49^{abc}
U_3B_2	44.53^{bc}	41.89^{a}	43.77^{a}	41.13^{ab}	43.02^{ab}	37.36^{c}
U_3B_3	43.84^{bcd}	39.62^{bcde}	40.88^{efg}	42.39^{a}	43.86^{a}	38.49^{abc}

Means on the same column with the same letter(s) do not differ significantly ($p<0.05$);
U_O, U_1, U_2, U_3 represent 0, 5, 10, 15t/ha unburnt rice husk dust;
B_0, B_1, B_2, B_3 represent 0, 5, 10, 15t/ha burnt rice husk dust

DAP in the first cropping season the order of total porosity increase was $U_2B_3=U_3B_2>U_2B_1=U_3B_1>U_3B_3>U_2B_0=U_2B_2>U_1B_3=U_3B_0>U_1B_1=U_1B_2>U_0B_3>U_1B_0>U_0B_2> U_0B_1>$Control. Similarly, at 90 DAP of first cropping season control recorded the lowest soil total porosity value of 36.60% while that of amended plots ranged between 38.11 – 41.89% with U_3B_2 recording the highest total porosity. In 2013 cropping season control recorded lowest total porosity of 37.36% and 35.47% at 45 and 90 DAP, respectively. These observed soil total porosities at 45 and 90 DAP in 2013 cropping season in control represented a decrease of 7 – 17% and 6 – 20% in amended plots. At 45 DAP in residual (2014) cropping season the observed total porosity of 36.60% in control was lower than the total porosity in U_0B_1, U_0B_2, U_0B_3, U_1B_0, U_1B_1, U_1B_2, U_1B_3, U_2B_0, U_2B_1, U_2B_2, U_2B_3, U_3B_0, U_3B_1, U_3B_2, and U_3B_3 by 7%, 10%, 10%, 9%, 10%, 10%, 12%, 15%, 15%, 17%,17%, 16%, 20%, 18% and 20%, respectively. Also, control recorded the lowest total porosity value of 35.09% at 90 DAP in 2014 cropping season while that of amended plots ranged between 36.98 – 39.62%. Throughout the observation periods, total porosity was higher at 45 DAP than 90 DAP.

Effect of Rice Husk Dust Application on Hydraulic Conductivity

The effect of rice husk dust on soil hydraulic conductivity is shown in Table 4. There was a significant ($p < 0.05$) increase in hydraulic conductivity in rice husk dust amended plots compared to control. At 45 and 90 DAP in 2012 cropping season control recorded the lowest hydraulic conductivity value of 25.47cmhr^{-1} and 26.64 cmhr^{-1}, respectively while the hydraulic conductivity in amended plots ranged between 28.59 – 35.03 cmhr^{-1} and 29.46 – 36.59 cmhr^{-1} at 45 and 90 DAP in 2012 cropping season. The order of increase in hydraulic conductivity at 45 DAP in 2013 cropping season was $U_3B_1>U_3B_2=U_4B_0>U_2B_3>U_3B_3>U_2B_2>U_3B_0>U_1B_1=U_2B_1>U_1B_3>U_0B_3>U_1B_2>U_2B_0>U_0B_2>U_1B_0>U_0B_1>$ Control. At 90 DAP of 2013 cropping season control recorded the lowest hydraulic value of 22.82crnhr^{-l} and hydraulic conductivity in amended plots varied between 25.88 – 34.88crnhr^{-l}. Similarly, at 45 and 90 DAP in the residual cropping season control recorded the lowest hydraulic conductivity values of 16.70crnhr^{-l} and 18.11crnhr^{-l}, respectively. These observed hydraulic conductivity values in control at 45 and

Table 4: Effect of rice husk dust application on saturated hydraulic conductivity (cmhr^{-l})

	2012		2013		2014	
Treatment	45 DAP	90 DAP	45DAP	90 DAP	45DAP	90DAP
Control	25.47^{i}	26.64^{i}	20.78^{k}	22.82^{k}	16.70^{n}	18.11^{l}
U_0B_1	28.59^{h}	29.46^{hi}	23.23^{j}	25.88^{j}	19.53^{m}	21.17^{k}
U_0B_2	30-16^{gh}	30.82^{ghi}	25.88^{hi}	26.23^{j}	22.11^{k}	24.00^{j}
U_0B_3	30. 73^{fgh}	31.88^{fghi}	27.88^{fg}	29.59^{hi}	24.76^{j}	26.29^{hi}
U_1B_0	29.66^{gh}	30.76^{ghi}	24.82^{i}	26.88^{j}	21.16^{l}	24.64^{ij}
U_1B_1	30.73^{fgh}	31,11^{fghi}	28.94^{def}	29.88^{ghi}	25.75^{fg}	28.22^{fg}
U_1B_2	31.59^{efg}	32.53^{cdefgh}	27.30^{gh}	30.23^{fgh}	26.11^{e}	28.00^{fgh}
U_1B_3	32.16^{def}	33.57^{bcdef}	28.23^{efg}	30.53^{fg}	26.82^{d}	28.94^{ef}
U_2B_0	30.16^{gh}	31.88^{fghi}	26.88^{gh}	27.88^{ij}	23.40^{j}	26.29^{hi}
U_2B_1	32.39^{cdef}	34.38^{abc}	28.94^{def}	30.53^{fg}	25.17^{hi}	27.23^{gh}
U_2B_2	34.16^{abc}	35.23^{ab}	29.87^{dc}	31.53^{defg}	27.82^{bc}	28.94^{ef}
U_2B_3	35.03^{a}	36.17^{a}	31.17^{bc}	32.88^{abc}	28.23^{c}	30.64^{cde}
U_3B_0	34.16^{abc}	34.46^{abcd}	29.53^{de}	31.88^{def}	28.17^{cd}	30.29^{de}
U_3B_1	34.59^{ab}	36.23^{a}	32.23^{a}	33.59^{ab}	31.52^{a}	32.35^{ab}
U_3B_2	34.16^{abc}	36.59^{a}	31.23^{ab}	34.88^{a}	31.59^{a}	32.69^{a}
U_3B_3	32.16^{def}	33.59^{bcdef}	31.15^{bc}	32.03^{bcd}	30.53^{ab}	31.14^{bcd}

Means on the same column with the same letter(s) do not differ significantly ($p<0.05$);
U_O, U_1, U_2, U_3 represent 0, 5, 10, 15t/ha unburnt rice husk dust;
B_0, B_1, B_2, B_3 represent 0, 5, 10, 15t/ha burnt rice husk dust

90 DAP in residual cropping season were lower than the hydraulic conductivity values in the amended plots by 18 – 89% and 17 – 81%, respectively.

Effect of Rice Husk Dust Application on Maize Grain Yield

The effect of rice husk dust on maize grain yield is shown in Table 5. The result shows a significant ($P < 0.05$) increase in maize grain yield in rice husk dust amended plots relative to control. In 2012 cropping season control plot recorded the lowest maize grain yield content of 3.58 t ha-^{1}. This maize grain yield obtained in 2012 cropping season was lower than maize grain yield in amended plots by 18 – 53%. Likewise, the lowest maize grain yield of 1.23 t ha-^{1} was obtained in control in 2013 cropping season while maize grain yield in amended plot ranged between 1.84 – 2.67 t ha-^{1}. In 2014 cropping season control recorded the lowest maize grain yield of 0.66 t ha-^{1}. This maize grain yield obtained in control was lower than that of U_0B_1, U_0B_2, U_0B_3, U_1B_0, U_1B_1, U_1B_2, U_1B_3, U_2B_0, U_2B_1, U_2B_2, U_2B_3, U_3B_0, U_3B_1, U_3B_2, and U_3B_3 by 67%, 67%, 26%, 92%, 65%, 165%, 67%, 67%, 139%, 146%, 199%, 92%, 165%, 92%, 165%, and 165%, respectively.

DISCUSSION

Soil Physical Properties

The soil in the study area was sandy loam in texture (Table 1) and has been observed to be acidic, low in organic matter status, cation exchange capacity and other essential nutrients (Enwezor *et al*., 1988, Asadu and Akamigbo, 1990, Nnabude and Mbagwu 1999 and Ogbodo and Nnabude, 2004). According to Anikwe and Nwobodo (2002) sandy loam is highly permeable and allows large quantities of leachates to pass through it. Irrespective of the treatment applied in the amended plots, the textural class of both the treated and control plots remained unchanged throughout the period of the study. Obi (2000) has shown that texture was a permanent property of soil and cannot be easily changed by the application of amendment in a short period.

Table 5: Effect of Rice Husk Dust Application on Maize Grain Yield (t ha-^{1})

Treatment	2012	2013	2014
Control	3.58^{n}	1.23^{j}	0.66^{k}
U_oB_1	4.64^{jk}	1.88^{gh}	1.40^{e}
U_oB_2	4.81^{hi}	2.10^{def}	1.40^{e}
U_oB_3	4.24^{m}	2.06^{ef}	0.83^{j}
U_1B_0	4.86^{gh}	1.54^{i}	1.27^{h}
U_1B_1	4.38^{lm}	2.23^{cd}	1.09^{i}
U_1B_2	4.68^{ij}	2.10^{def}	1.75^{b}
U_1B_3	5.25^{bc}	1.84^{h}	1.40^{e}
U_2B_0	4.42^{k}	2.23^{cd}	1.40^{e}
U_2B_1	4.64^{ijk}	2.45^{abc}	1.58^{d}
U_2B_2	5.47^{a}	1.97^{fgh}	1.62^{c}
U_2B_3	5.03^{e}	2.67^{a}	1.97^{a}
U_3B_0	5.08^{cd}	2.01^{efg}	1.27^{h}
U_3B_1	4.42^{k}	2.14^{de}	1.75^{b}
U_3B_2	4.86^{gh}	2.32^{bc}	1.27^{h}
U_3B_3	4.94^{fg}	2.58ab	1.75^{b}

Means on the same column with the same letter(s) do not differ significantly ($p<0.05$);
U_O, U_1, U_2, U_3 represent 0, 5, 10, 15t/ha unburnt rice husk dust;
B_0, B_1, B_2, B_3 represent 0, 5, 10, 15t/ha burnt rice husk dust

Tables 2 and 3 showed significant ($P < 0.05$) increase in bulk density and decrease in total porosity in control relative to rice husk dust amended plots during the three cropping seasons. This is in-line with Nnabude and Mbagwu (1998) who observed that application of fresh and burnt rice-mill waste at the rate of 25.0 and 50.0 Mgha^{-1} decreased soil bulk density and increased total porosity. Equally, Anikwe (2000) obtained significant decrease in soil dry bulk density in plots amended with 4.5 and 6.0 t ha^{-1} of rice husk dust at 48 and 60 days after planting (DAP). Lower bulk density and higher total porosity was observed in 45 DAP than 90 DAP through-out the period of the study which is in agreement with (Mbah *et al*, 2011). These differences in bulk density and total porosity in 45 and 90 DAP could be attributed to a combination of many factors such as content of organic matter, natural process of settling and structural collapse due to total raindrop impact on the soil surface. On the other hand observed higher bulk density values at 90 DAP relative to 45 DAP could be due to breakdown of some of organic materials in the soil matrix due to increased compaction at this stage. Similarly, increased total porosity at 45 DAP compared to 90 DAP could be attributed to reduce compaction as a result of lower soil bulk density. Total porosity was significantly higher in soil amended with unburnt rice husk compared with the burnt rice mill amended plots in the three seasons. Equally, the highest total porosity at 45 and 90 DAP in 2012 planting season were obtained from the plots treated with the mixtures of both unburnt and burnt rice husk dust at the rate of 10 and 15 tha^{-1} which was in line with (Nicou and Chopart, 1979) who reported that maize root density increased by over 300 percentages in a total porosity range of 43 – 48% which resulted in doubling of gain yield of maize. There were significantly lower bulk densities in unburnt rice husk treatment, which suggested that unburnt rice husk contributed more in bulk density reduction. On the other hand, unburnt rice mill waste could have long residual effect on bulk density of soil. This disagreed with (Nwite, 2012) which showed that lower bulk densities were obtained in the plots treated with burnt rice husk dust when compared to the plots treated with the unburnt rice husk dust.

Results from the study showed improved soil hydraulic conductivity with organic wastes application relative to control (Table 4). This is in an agreement with the observation of Nwite *et al.* (2011) who showed that plots amended with burnt rice mill waste, unburnt rice mill waste and saw dust recorded higher saturated hydraulic conductivity relative to unamended plots in the three years of study. Similarly, Rawls *et al.* (1982) compiled values of hydraulic conductivity of 1,323 soils collected from over 32 countries and observed that soils with large pores recorded higher hydraulic conductivity than soils with smaller pores. Higher saturated conductivity means better water transmission and hence reduction in water-logging. Lower conductivity in the control plot, may mean increase in water-logging and hence reduction in physiological activity which may translate to lower plant yield (Njoku *et al.,* 2011). Anikwe (2000) equally, reported that rice husk dust amendment of clay soil significantly improved hydraulic conductivity and consequently soil water transmission.

Maize Grain Yield

Results of the study showed that application of the amendments significantly increased maize grain yield. The differences in maize grain yield could be as result of differences in plant nutrients in the amendments. According to Kumar and Mittal (2007) increase in plant grain yield in waste amended plots was as a result of nutrients released by these wastes. Increases in crop grain yield following addition of organic amendments were reported by Mbah *et al.* (2002), Obi and Ebo (1995) and Mbagwu and Ekwealor (1990). Equally, high grain yield of maize were observed in plots with low bulk density and high total porosity (Tables 2 and 4) as well as the mixtures of unburnt and burnt rice husk dust at 10 and 15 t ha^{-1}. This result agreed with that of Nnabude and Mbagwu (1999) who reported that reduction in bulk density may increase water transmissivity, root penetration and hence cumulative feeding area of the crops, all of which translated to better yield. The grain yields of maize in control and amended plots in the first cropping season were comparable to average global maize yields of 2.5 t ha^{-1} (Harper, 1999). Similarly, Mutuo *et al.* (2000) reported that treatments that received organic biomass had a high residual effect of 50 % yield increase above control. The failure to sustain the increase of grain yield of maize recorded in first season in second and third cropping seasons could be attributed to low in nutrient reserve as well as continuous cropping. Mbah *et al.* (2004) reported that continuous cropping without application of amendment reduced grain yield of maize. In all, the results showed that rice husk dust as soil amendment could sustain grain yield of maize.

CONCLUSION

The result showed that rice husk dust improved soil physical properties and maize grain yield. Rice husk dusts are very common in the study area in such way that the arable land that supposed to be used for crop production are been occupied by them. These rice husk dusts can be used as soil amendment to increase crop productivity and also to serve as a means of disposing this waste, thereby making the environment friendlier.

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