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Full Length Research Paper

Effect of Rice Mill Wastes Application on Selected Soil Physical Properties and Maize Yield (*Zea mays l.*) On an Ultisol in Abakaliki Southeastern Nigeria

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An experiment was carried out in 2008, 2009 and 2010 (residual) cropping season at Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki to determine the long term effect of burnt and unburnt rice mill wastes application on soil physical properties and maize yield. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. Seven treatments were included in the study: burnt rice mill waste at 10 and 20 t ha^{-1}(BW_{10}) and (BW_{20}), unburnt rice mill waste at 10 and 20 t ha^{-1}(UW_{10}) and (UW_{20}), mixture of burnt + unburnt rice mill waste (1:1) at 10 and 20 t ha^{-1}(BUW_{10}) and (BUW_{20}), and a control (C). The results showed that rice mill wastes significantly ($P < 0.05$) improved soil physical properties (hydraulic conductivity and aggregate stability) and maize yield, compared to control across the three cropping seasons. The order of increase in crop grain yield in 2008 and 2009 cropping seasons were $BW_{20}>BUW_{20}> BUW_{10}>UW_{20}>BW_{10}>UW_{10}>C$ and $BUW_{20}>BUW_{10}>BW_{20}> UW_{20}>BW_{10}>UW_{10}>C$. Control recorded the lowest value of crop grain yield (0.12 t ha^{-1}) in 2010 cropping season. At rate of 20 t ha^{-1} BW, BUW and UW recorded highest maize grain yield of 4.18, 4.06 and 1.70 t ha^{-1} in 2008, 2009 and 2010 cropping seasons, respectively. Therefore, rice mill wastes at these rates studied (10 and 20 t ha^{-1}) could be used as soil amendment since it improved soil physical properties and increased maize yield.

Key words: Aggregate stability, hydraulic conductivity, maize yield, organic matter, and rice mill wastes

INTRODUCTION

Agricultural wastes comprise of wastes generated from agricultural activities such as clearing of farm lands, weeding of farm lands, rearing of animals, milling of agricultural products etc. Amongst others they include grass chippings, leaves, stalks, hulls, rice mill wastes, stumps, dead animals, animal dung seepage etc. Rice mill wastes are organic material and can be composted or decomposed, however, their high lignin and cellulose content can make this a slow process. Rice mill wastes comprised of husk, bran, broken edible rice, stone and metals from milling equipment. Waste amended soils have been reported to have high organic matter content (Anikwe, 2000). Soil organic matter influences soil aggregation status and aggregate stability (Nnabude et al., 2000) and it can reduce soil bulk density, increase total porosity and hydraulic conductivity (Nnabude and Mbagwu, 2001). Andresen et al. (2002) found that the application of organic residues influences soil physical properties (bulk density, total porosity, hydraulic conductivity and aggregate stability) positively. Mbah et al. (2004) reported an increased total porosity and aggregate stability in a dystric leptosol in south eastern Nigeria after using a sewage sludge and animal wastes (cow dung, poultry and pig manure) as soil amendments. The improvement in soil physical properties is attributable to increase in soil organic matter content (Aluko and Oyedele, 2005). Meerow (1995) stated that the quantity, rather than the type, of organic wastes has a larger effect on splash detachment, shear strength, and aggregate stability. Organic wastes contain underutilized resources

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in the form of nutrient for soil productivity management and for proper soil fertility management, which should be balanced with mineral fertilizer (Njoku, 2008). Okonkwo et al. (2010) showed that continuous dumping of sawmills waste affected the physical and chemical properties but did not pose danger to animal health and could be harnessed to improve soil fertility and productivity. When rice mill waste management is properly carried out and carefully monitored to supply the nutrient need by crops, it reduces the cost of crop production and saves the cost of wastes disposal (Anikwe and Nwobodo, 2002). Oguike, et al. (2006) demonstrated that compared to the control, application of rice mill wastes at 30 t ha^{-1} increased saturated hydraulic conductivity and mean weight diameter of water stable aggregates by 368.2 and 155.8%, respectively. Nwite et al. (2011) observed an increased in hydraulic conductivity in organic wastes amended contaminated and uncontaminated soils relative. Anikwe (2000) showed that soils organic matter positively affect the hydraulic conductivity of heavy clay soils. Mbah and Nneji (2010) and Obi and Ebo (1995) observed that organic matter (OM) from wastes bound smaller aggregates into larger ones. Mbah et al. (2010) demonstrated significant ($p < 0.05$) increase in soil aggregate stability with wood ash application in an acid ultisol. Mbah and Onweremadu (2009) noted that additions of organic wastes failed to improve micro-aggregates (measured as dispersion ratio but increased macro-aggregate stability (measured as water stable aggregates > 0.5 mm). In addition, the use of mineral fertilizers continuously in tropical soils has been associated with reduced crops yield, increased soil acidity and nutrient imbalance (Ojeniyi, 2002; Mbah and Mbagwu, 2006). Mbagwu (1989) observed that soil differs in their response to organic waste amendments. It is, therefore, important to investigate more closely the influences of these organic wastes on hydraulic conductivity, aggregate stability, mean weight diameter and dispersion ratio of soils. Organic wastes differ widely in their properties and characteristics (Hornick and Parr, 1987); therefore, each organic waste has a unique property that could be thoroughly investigated. The aim of this study is to determine the effect of burnt and unburnt rice mill wastes application on soil physical properties and yield of maize.

MATERIALS AND METHODS

Experimental site

The experiment was carried out in 2008, 2009 and 2010 cropping seasons at Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management (FARM), Ebonyi State University, Abakaliki. The area is located at latitude 6^{o} 19' N and longitude 8^{o} 06' E in the derived savannah of the southeast agro-ecological zone of Nigeria. The annual rainfall is 1700 – 1800 mm. The rainfall pattern is bimodal between April – July and September – November with short spell in August. According to Ofomata (1975) the minimum and maximum temperature of the area are 27 and 31^{o}C respectively. The soil belongs to the order Ultisol and classified as Typic Haplustult (FDALR, 1985).

Land preparation, treatment application and experimental design

Prior to the experiment, the field has been on fallow for two years and comprised of vegetations such as *Imperata cylindrical*, *Panicum maximum*, *Manihot* spp and *Odoratum* spp. The vegetation was cleared manually using matchet and debris was removed before making the beds using hoes. The field size was 0.336 ha (24 m × 14 m). It was plough and divided into 21 plots with a size of 3 m by 4 m (12 m^2). Each plot was separated by 0.5 m. A Randomized Complete Block Design (RCBD) with three replicates was used for the study. Seven treatments were included. Treatments were as follows:

1. 0 = Control (Non-application of amendment)
2. BW_{10} = 12 kg/plot burnt rice mill waste equivalent to 10 t ha^{-1}
3. BW_{20} = 24 kg/plot burnt rice mill waste equivalent to 20 t ha^{-1}
4. UW_{10} = 12 kg/plot unburnt rice mill waste equivalent to 10 t ha^{-1}
5. UW_{20} = 24 kg/plot unburnt rice mill waste equivalent to 20 t ha^{-1}
6. BUW_{10} = 6 kg BW + 6 UW kg/plot equivalent to 10 t ha^{-1}
7. BUW_{20} = 12 kg BW + 12 UW kg/plot equivalent to 20 t ha^{-1}

Burnt/unburnt rice mill waste for each treatment was spread uniformly in each plot using broadcasting method and incorporated into their plots using hoes immediately after cultivation. Two maize seeds (var. Oba super 11) were planted per hole 2 weeks after treatment application. The maize seed was planted at a spacing of 25 cm within rows and 75 cm between rows while the planting depth was 3 cm. The seedlings were thinned down to one plant/stand two weeks after germination (WAG). Lost stands were replaced. Weeding was done manually at three weeks interval till harvest. The same procedure was repeated in the second year and third year of the experiment but without application of wastes in the third year (to test the residual effect).

Soil sampling and laboratory analysis

Undisturbed core samples were collected from all the plots at 45 and 90 days after planting (DAP) at the depth of 0 – 20 cm from three observational points each cropping season, labelled and used for the determination of the following soil physical properties.
Hydraulic conductivity: This was determined as described by Landon (1991).

$$\text{Thus } K = \frac{Q}{At} \times \frac{L}{\Delta H}$$

Where:
K = Hydraulic conductivity
Q = Amount of water being collected constantly A
= Area of the core containing soil sample
t = Time interval collection
L = Length of the core containing core sample
ΔH = Constant water level height being maintained

Aggregate stability (AS): This was determined using the wet sieving method described by Kemper and Rosenau (1986). Thus:

$$WSA = \frac{M_{a+s} - M_s}{M_t - M_s} \times \frac{100}{1}$$

Where:
M_{a+s} = Mass of resistant aggregates plus sand (g)
M_s = Mass of the sand fraction alone (g)
Mt = Total mass of sieved soil (g)

Note that all soil samples that fell within 4.25 and 0.25 mm where used to express WSA greater than or equal to 0.25 mm as the index of stability.

Mean weight diameter (MWD): This was determined by calculation as described by Kemper and Rosenau (1986).

$$MWD = \sum_{I=i}^{n} X_1 W_1$$

Where MWD = Mean weight diameter
X_1 = mean diameter of each size fraction
W_1 = Proportion of the total sample weight

Dispersion ratio (DR): This was determined as outlined by Nkidi-Kizza et al. (1984).

$$DR = \frac{\text{Silt + Clay in water dispersed sample}}{\text{Silt + Clay in calgon dispersed sample}}$$

Crop parameters determined

Germination (%): This was determined using the formulae below at 2 weeks after germination (WAG) before thinning down to a plant/stand and replacing the lost stands.

$$\text{Germination (\%)} = \frac{\text{Number of seedlings}}{\text{Number of seeds planted}} \times \frac{100}{1}$$

Plant height (cm): Ten maize plants/plot selected within the centre of each plot were sampled for plant height at 45 and 90 DAP. Plant height was measured from the ground surface to the tip of the plant using a metre rule.

Crop yield (t ha^{-1}): At maturity 10 maize plants/plot were selected and tagged. The grain yields from the tagged plants were harvested, dried to 14 % moisture content. Grains/plot was weighed to get its yield per plot and then converts this value to its hectare equivalent.

Data analysis

Statistical analysis of the data was conducted 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

Effect of burnt and unburnt rice mill wastes on soil hydraulic conductivity and aggregate stability

Changes in soil hydraulic conductivity and aggregate stability following addition of burnt and unburnt rice mill waste are shown in Table 1. The increase in soil hydraulic conductivity of amended plots was found in the first and second cropping seasons. Increasing the rates of rice mill waste also increased soil hydraulic conductivity across the two seasons of waste application. At 45 DAP of first cropping season control plot had the lowest value of soil hydraulic conductivity of 21.12 $cmhr^{-1}$ while plot amended with UW_{20} had the highest soil hydraulic conductivity of 42.29 $cmhr^{-1}$. At 90 DAP of the first cropping season recorded hydraulic conductivity in control plot decreased by 35, 66, 66, 116, 38 and 85% relative to BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} amended plots, respectively. The order of increase in soil hydraulic conductivity at 45 and 90 DAP in 2009 cropping season was $UW_{20}>BUW_{20}>BW_{20}>UW_{10}>BUW_{10}>BW_{10}>C$.

Similarly, the residual effect of waste application on hydraulic conductivity showed a significant ($P < 0.05$) increase relative to the control. At 45 DAP in the residual cropping season soil hydraulic conductivity values ranged between 19.32 - 38.10 $cmhr^{-1}$ with the plot treated with UW_{20} and control plot recording the highest and lowest value, respectively. Whereas at 90 DAP in that residual cropping season UW_{20} plot recorded the highest hydraulic conductivity value of 36.86 $cmhr^{-1}$. This recorded value of hydraulic conductivity in UW_{20} was higher than that of C, BW_{10}, BW_{20}, UW_{10}, BUW_{10} and BUW_{20} by 124, 40, 15, 18, 34 and 4%, respectively. Similarly, waste addition at various rates led to significant ($P < 0.05$) changes in soil aggregate stability in the first and second cropping seasons. The lowest soil aggregate stability value of 43.22% was observed in control plot at 45 DAP of first cropping season. This value was lower than the values recorded in the plots treated with BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} by 11, 21, 4, 14, 10 and 21%, respectively. At 90 DAP in 2008 cropping season the lowest aggregate stability value of 41.12% was observed in control plot while that of amended plots ranged between 49.03 – 55.01% with BW_{20} treated plot recording the highest value. Similarly, in 2009 cropping season the lowest aggregate stability values of 40.28 and 38.18% were recorded at 45 and 90 DAP, respectively in control plots. The observed soil aggregate stability value in control plot at 45 DAP was lower than that of BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} amended plots by 16 , 23 , 8 , 20 , 11 and 22 %, respectively. Similarly, at 90 DAP the observed soil aggregate stability value in control plot was lower than that of BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} amended plots by 16 , 28 , 8 , 21, 21 and 43%, respectively.

Table 1 also showed a significant ($P < 0.05$) increase in

Table 1. Effect of rice mill wastes application on soil hydraulic conductivity (cmhr^{-1}) and soil aggregate stability (%).

Treatment	Soil hydraulic conductivity (cm hr^{-1})						Soil aggregate stability (%)					
	2008		2009		2010		2008		2009		2010	
	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP
C	21.12^{f}	18.02^{e}	19.81^{f}	17.76^{g}	19.32^{e}	16.46^{e}	43.22^{e}	41.12^{d}	40.28^{d}	38.18^{f}	28.90^{e}	26 .79^{d}
BW_{10}	27.66^{e}	24.27^{d}	29.92^{e}	28.26^{f}	27.15^{d}	26.40^{d}	48.00^{c}	50.33^{bc}	46.01^{bc}	44.23^{d}	39.67^{bc}	35.93^{b}
BW_{20}	35.58^{c}	29.92^{c}	38.05^{c}	33.91^{c}	34.81^{b}	32.02^{c}	52.21^{a}	55.01^{a}	50.74^{a}	49.01^{a}	42.36^{a}	41.02^{a}
UW_{10}	32.32^{d}	29.92^{c}	33.65^{d}	32.32^{d}	33.01^{c}	31.26^{c}	45.03^{d}	48.23^{c}	43.36^{cd}	41.26^{e}	36.28^{d}	27.11^{d}
UW_{20}	42.29^{a}	39.07^{a}	45.22^{a}	43.22^{a}	38.10^{a}	36.86^{a}	49.32^{b}	51.14^{b}	48.23^{ab}	46.16^{c}	41.10^{ab}	39.91^{a}
BUW_{10}	31.65^{d}	24.94^{d}	32.58^{d}	29.93^{e}	28.16^{d}	27.46^{d}	47.65^{c}	49.03^{bc}	44.79^{c}	46.23^{c}	37.05^{d}	33.22^{c}
BUW_{20}	38.04^{b}	33.25^{b}	39.76^{b}	37.57^{b}	37.28^{a}	35.31^{b}	52.18^{a}	54.46^{a}	49.14^{ab}	54.41^{a}	39.53 ^{c}	33.34^{c}

Means on the same column with the same letter do not differ significantly (P < 0.05).

soil aggregate stability in waste amended plots relative to control plot in residual cropping season. The order of increase in soil aggregate stability at 45 and 90 DAP was BW_{20}>UW_{20}>BW_{10}>BUW_{20}>BUW_{10}>UW_{10}>C. At the rate of 20 t ha^{-1} application of burnt, unburnt and mixture of burnt + unburnt wastes at 90 DAP in the residual cropping season increased soil aggregate stability by 53, 49 and 25%, respectively, relatively to control.

Effect of burnt and unburnt rice mill wastes on soil mean weight diameter (MWD) and soil dispersion ratio

Table 2 showed that application of rice mill wastes significantly (P < 0.05) increased soil MWD relative to control at 45 DAP in first and second cropping seasons. At 45 DAP control plot recorded the lowest MWD value of 2.92 and 2.74 mm in first and second cropping seasons, respectively while that of amended plots ranged between 3.01 – 3.23 mm and 3.12 – 3.24mm in corresponding periods of the study with the plot amended with UW_{20} recording the highest MWD value of 3.23 mm and 3.24 mm, respectively. However, the Table showed non-significant (P < 0.05) change in MWD at 90 DAP in first cropping season. At 90 DAP in second cropping season control plot had the lowest MWD value of 2.72mm. This observed MWD value in control plot was lower than that of the plots amended with BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} by 1, 21, 20, 24, 19 and 22%, respectively.
Significant (P < 0.05) increase in waste amended plots relative to control plot in MWD was observed in residual cropping season. The order of increase at 45 and 90 DAP was UW_{20}>BUW_{20}> UW_{10}>BUW_{10}>BW_{20}>BW_{10}>C. At the rate of 20 t ha^{-1} application of burnt, unburnt and mixture of burnt + unburnt wastes at 90 DAP in the residual cropping season soil MWD increased by 42, 53 and 52%, respectively, relatively to control.

The results of effect of amendments on soil dispersion ratio is shown in Table 2. At 45 DAP in first cropping season there was non-significant (P < 0.05) change in dispersion ratio among the various treatments. However, the results indicated a significant (P < 0.05) increase in soil dispersion ratio in rice mill waste amended plots relative to the control at 90 DAP of first and second cropping seasons. The lowest dispersion ratio value of 0.77 was recorded in control at 90 DAP of first cropping season. This observed value represents 5 - 21% decrease in dispersion ratio in control plot relative to amended plots. At 45 DAP of second cropping season the control plot had the lowest dispersion ratio value of 0.75. This value (0.75) in control plot decreased by 15, 21, 7, 11, 9 and 13% relative to BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} amended plots, respectively. Similarly, at 90 DAP of second cropping season dispersion ratio had it lowest value of 0.74 in control plot while recorded values in amended plots varied from 0.79 – 0.90 with the plot amended with BW_{20} recording the highest value. With regard to the residual effect, significant (P < 0.05) increase was observed in dispersion ratio in amended plots relative to control plot. The order of improvement in the value of soil dispersion ratio at 45 in residual cropping season was BW_{20}>BUW_{20}>

Table 2. Effect of rice mill wastes application on soil mean weight diameter (mm) and soil dispersion ratio.

Treatment	Soil mean weight diameter (mm)						Soil dispersion ratio					
	2008		2009		2010		2008		2009		2010	
	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP	45 DAP	90 DAP
C	2.92^{c}	2.90^{a}	2.74^{c}	2.72^{e}	2.19^{e}	2.06^{b}	0.82^{a}	0.77^{e}	0.75^{e}	0.74^{d}	0.72^{d}	0.71^{d}
BW_{10}	3.01bc	3.21^{a}	3.12^{b}	3.19^{d}	2.99^{d}	2.86^{a}	0.87^{a}	0.88^{b}	0.86^{b}	0.84^{b}	0.80^{bc}	0.79^{bc}
BW_{20}	3.13^{ab}	3.27^{a}	3.20^{ab}	3.29^{bc}	3.03^{c}	2.92^{a}	0.91^{a}	0.93^{a}	0.91^{a}	0.90^{a}	0.88^{a}	0.87^{a}
UW_{10}	3.12^{ab}	3.15^{a}	3.18^{ab}	3.25^{dc}	3.12^{b}	3.08^{a}	0.83^{a}	0.81^{d}	0.80^{d}	0.79^{c}	0.77^{c}	0.76^{cde}
UW_{20}	3.23^{a}	3.32^{a}	3.24^{a}	3.37^{a}	3.18^{a}	3.15^{a}	0.86^{a}	0.84^{c}	0.83^{bcd}	0.82^{bc}	0.80^{bc}	0.79^{bc}
BUW_{10}	3.12^{ab}	3.18^{a}	3.16^{ab}	3.23^{dc}	3.10^{b}	3.06^{a}	0.85^{a}	0.84^{c}	0.82^{cd}	0.83^{b}	0.81^{b}	0.78^{bc}
BUW_{20}	3.22^{a}	3.28^{a}	3.23^{a}	3.32^{ab}	3.16^{a}	3.13^{a}	0.88^{a}	0.87^{bc}	0.85^{bc}	0.84^{b}	0.83^{b}	0.81^{b}

Means on the same column with the same letter do not differ significantly ($P < 0.05$).

BUW_{10}>UW_{20}=BW_{10}=UW_{10}>C. The control plot recorded the lowest dispersion ratio value of 0.71 at 90 DAP in residual cropping season. The observed dispersion ratio value (0.71) in control was lower than that of BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20} by 11, 23, 7, 11, 9 and 14%, respectively. At the rate of 20 t ha^{-1} application of burnt, unburnt and mixture of burnt + unburnt wastes at 45 DAP in the residual cropping season increased soil dispersion ratio by 22, 11 and 15%, respectively, relatively to control.

Effect of burnt and unburnt rice mill wastes on seed germination

Maize seed emergency started from 4 DAP and stopped on 14 DAP. Germination count was done on 14 DAP. The application of burnt and unburnt rice mill wastes showed non-significant ($p < 0.05$) difference among treatments for the three cropping seasons with respect to germination percent.

Effect of burnt and unburnt rice mill wastes on maize height

Figures 1 and 2 showed the effect of burnt and unburnt rice mill wastes on average height of maize crops. The result showed that there was a significant ($P < 0.05$) increase in crop height in the amended plots relative to control plot. The figure also showed that increasing the rates of each amendment resulted to an increase in plant height and maize grain yield. At 45 DAP of the first cropping season the plot amended with UW_{20} recorded the highest crop height of 103.57 cm. The recorded value was higher than crop height in C, BW_{10}, BW_{20}, UW_{10}, BUW_{10} and BUW_{20} by 28, 22, 15, 26, 19 and 17%, respectively. Similarly, at 90 DAP of first cropping season control had the lowest value of 145.23 cm while plant height values ranged between 172.97 – 198.87 cm in the amended plots with BUW_{20} recording the highest value. The order of increase in crop height in second cropping season was BW_{20}>BUW_{20}>UW_{20}>BUW_{10}>BW_{10}>UW_{10}>C. At rate of 20 t ha^{-1} application of burnt, unburnt and mixture of burnt and unburnt rice mill wastes at 90 DAP in second cropping season increased maize height by 89, 67 and 53%, respectively relative to control. Similarly, at the rate of 10 t ha^{-1} application of burnt, unburnt and mixture of burnt and unburnt rice mill wastes at 90 DAP in second cropping season increased maize height by 50, 31 and 50%, respectively relative to control. Control plot recorded the lowest plant height value of 29.59 and 69.82 cm at 45 and 90 DAP in residual cropping season, respectively while amended plots ranged between 31.57 – 53.03 cm and 82.53 – 121.10 cm for corresponding periods with the highest value observed in UW_{20} amended plot. Similarly, at rate of 20 t ha^{-1} application of burnt, unburnt and mixture of burnt and unburnt rice mill wastes at 90 DAP of residual cropping season increased maize height by 70, 73 and 50%, respectively relative to control in residual cropping season. Whereas at rate of 10 t ha^{-1} application of burnt, unburnt and mixture of burnt and unburnt rice mill wastes at 90 DAP in residual cropping season increased maize height by 19, 18 and 49%, respectively relative to control.

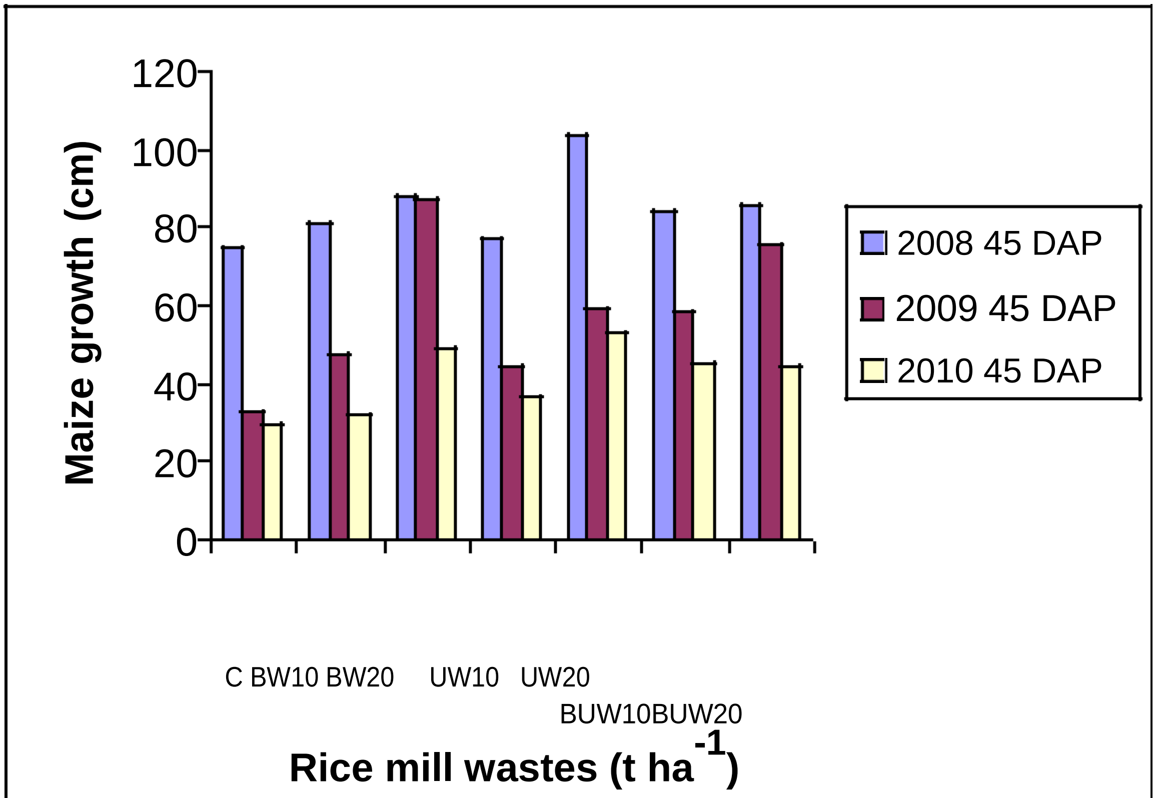

Figure 1. Effect of burnt and unburnt rice mill wastes application on maize growth at 45 DAP.

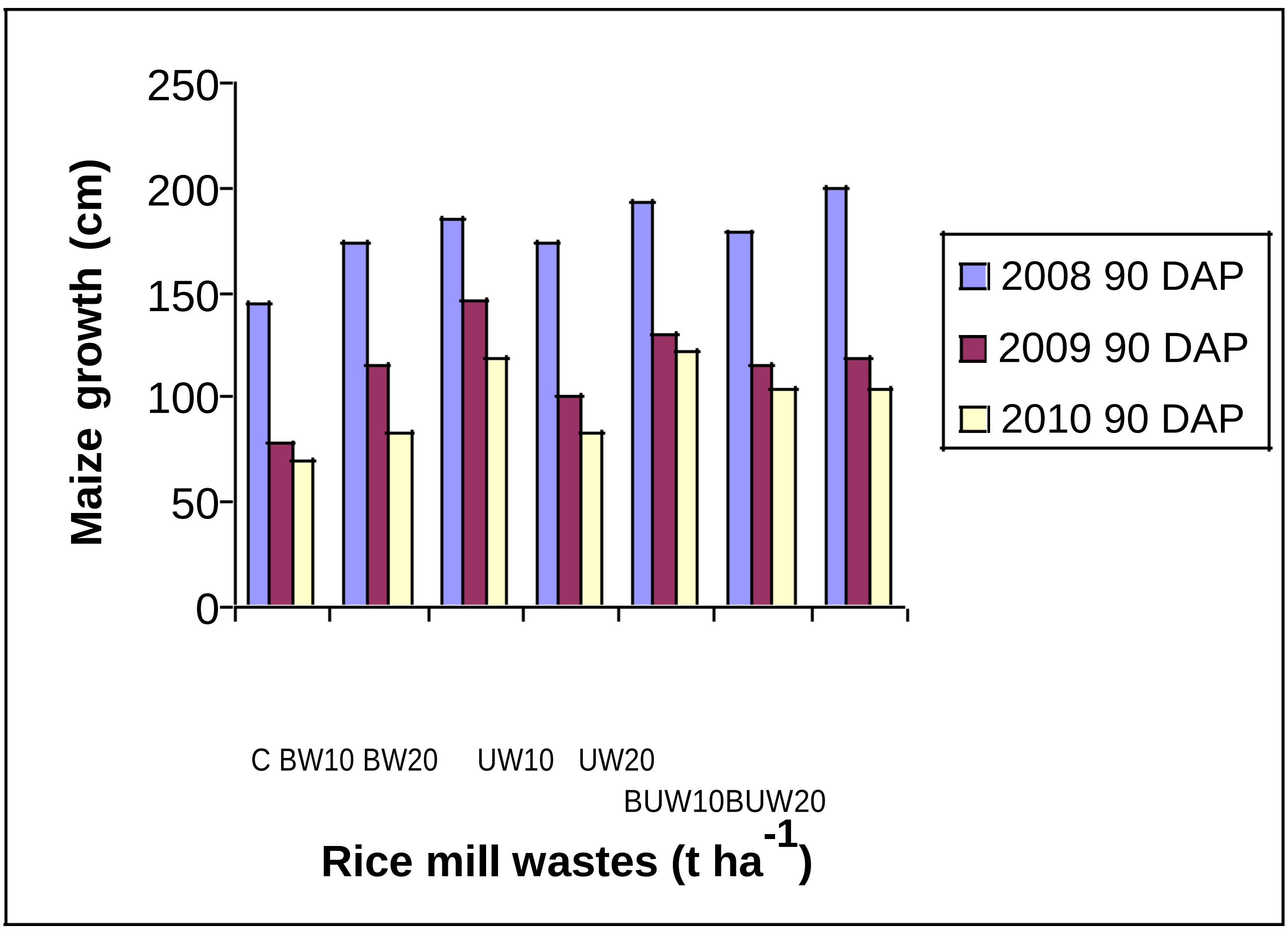

Figure 2. Effect of burnt and unburnt rice mill wastes application on maize growth at 90 DAP.

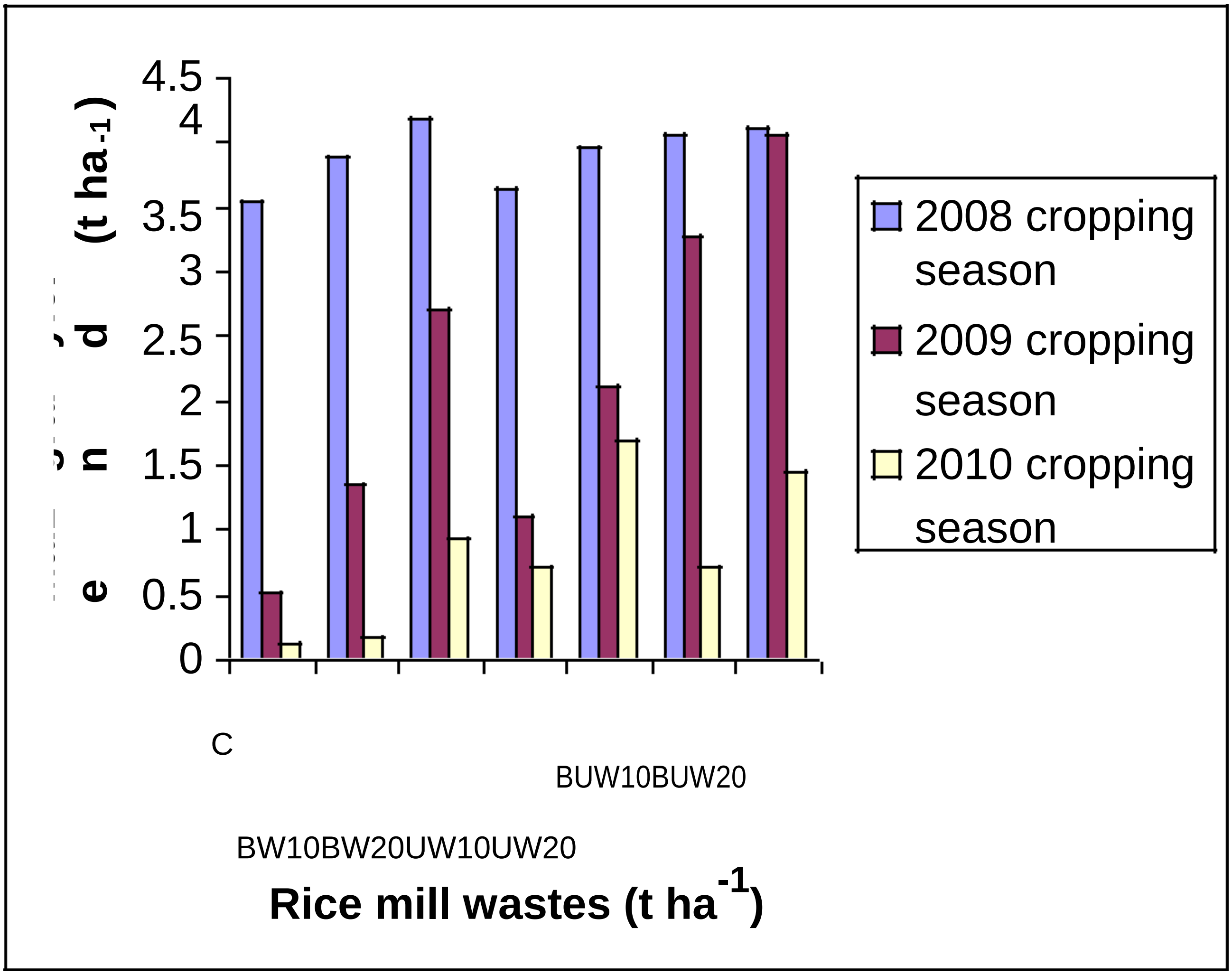

Figure 3. Effect of burnt and unburnt rice mill wastes application on maize grain yield (t ha^{-1}).

Effect of burnt and unburnt rice mill wastes on maize grain yield

Figure 3 showed the result of maize grain yield across the three cropping seasons of the study. In first cropping season control plot recorded the lowest maize grain yield value of 2.54 t ha^{-1} whereas that of amended plots ranged between 3.63– 4.18 t ha^{-1} with BW_{20} amended plot recording the highest value. The observed crop grain yield in amended plots represented 43 - 65% increase in crop grain yield relative to control plot. The order of increase in crop grain yield in second cropping season was BUW_{20}>BUW_{10}>BW_{20}>UW_{20}>BW_{10}>UW_{10}>C. Plots amended with UW_{20} had the highest value of crop grain yield (1.70 t ha^{-1}) in residual cropping season. The observed residual value represented an increase of 1317, 900, 83, 139, 136 and 18% in UW_{20} amended plot relative to C, BW_{10}, BW_{20}, UW_{10}, BUW_{10} and BUW_{20} plots, respectively. Similarly, at 20 t ha^{-1} application of burnt, unburnt and mixture of burnt and unburnt rice mill wastes in residual season increased maize grain yield by 675, 1317 and 1100%, respectively relative to control.

DISCUSSION

Soil physical properties

Results of this study (Table 1) showed significantly higher values of saturated hydraulic conductivity in the rice mill wastes amended plots relative to control. This is inline with the observation of Anikwe (2000) who reported significant increase in value of saturated hydraulic conductivity of soil after rice husk dusts application. Nwite et al. (2011) reported increased in hydraulic conductivity in organic wastes amended contaminated and uncontaminated soil relative to control. Results also showed that increasing the rates of burnt and unburnt rice mill wastes led to an increase in hydraulic conductivity with unburnt rice mill wastes recording the highest value of hydraulic conductivity in the three cropping seasons. The increase in saturated hydraulic conductivity as a result of increased rates of waste application may attributed to higher total porosity in plots amended with greater quantity of rice mill wastes. Higher saturated hydraulic conductivity means better water transmission and hence reduction in water-logging. Lower conductivity in the control plot, may mean increased in water-logging and hence reduction in physiologic activity which may translate to lower plant height and seed yield (Anikwe, 2000). Biswas and Khosia (1971); Gupta et al. (1977); Tiarks, et al. (1974) and Weil and Kroontje (1979) showed increase in hydraulic conductivity in plots amended with organic wastes compared to control plots. The fact that the hydraulic conductivity increased in the second cropping season and decreased in the third cropping season showed that the saturated hydraulic conductvity responded greatly to the application of rice mill wastes.

Tremblay and Levy (1993) showed that high level of organic matter, good colloidal nature of the soil and more importantly the presence of aluminum ions promote high soil aggregate stability. The increase in aggregate stability observed with increasing rice mill wastes was as a result of cementing effects of the organic matter in soil particles. The increase in organic matter (OM) content of the wastes resulted to an increase in total organic chemical (OC) leading to an increase in the size of the aggregates. Mbah and Nneji (2010) and Obi and Ebo (1995b) observed that OM from wastes bound smaller aggregates into larger ones. In a study on the response of maize (Zea mays L) to different rates of wood ash application in an acid Ultisol in South Eastern Nigeria, Mbah et al. (2010) reported significant ($p < 0.05$) increase in soil aggregate stability relative to control. The authors attributed the increase to the role of OM in aggregation of soils. Soil OC influences stability by reducing the rate of wetting and increasing the resistance to stress generated during wetting as was observed by Caron et al. (1996). Perfect et al. (1990) observed that structural stability of a soil has an impact on a wide range of processes that influence crop growth, erosion and runoff. Table 2 showed significant increase in MWD in rice mill wastes amended plots relative to control. In line with this, Mbagwu et al. (1991) observed increase in MWD of waste amended plots relative to control. The authors attributed this increase in MWD in amended plots to the positive influence of organic matter which bound smaller aggregates into larger ones that are essential for the production of good tilt. Results of the study (Table 2) showed non-significant change in soil dispersion ratio at 45 DAP in first cropping season. This is inline with the observation of Mbah and Onweremadu (2009) who noted that additions of organic wastes failed to significantly ($p < 0.05$) improve micro-aggregates (measured as dispersion ratio but significantly increased macro-aggregate stability measured as water stable aggregates WSA> 0.5 mm) relative to control plot. On the other hand, Table 2 showed significantly higher value of dispersion ratio in rice mill waste amended plots relative to control in residual, second and at 90 DAP of first cropping seasons. Using wood ash as soil amendment, Mbah et al. (2010) reported significant ($p < 0.05$) increase in soil dispersion ratio in amended plots relative to control.

Crop performance parameters

The application of rice mill wastes on the plots did not influence maize germination. The failure to achieve 100% germination in each cropping season was due probably to non-viability of some seeds rather than to the amendments. Gajri et al. (2002) observed that seed germination and crop emergence are affected by seed-zone, soil-water potential, soil temperature, oxygen diffusion rate and mechanical impedance whereas seedling survival depends on post-emergence edaphic environment in the root and above ground environment. The differences in crop height recorded could be as a result of differences in plant nutrients in the wastes. The order of crop height increase in residual cropping season showed that unburnt rice mill wastes has a longer residual effects than burnt rice mill wastes. Increase in plant height following addition of organic amendments were reported by Mbah et al. (2002), Obi and Ebo (1995) and Mbagwu (1992). From the result BW_{20}, BUW_{20} and UW_{20} recorded the highest value of maize grain yield in first, second and residual cropping seasons, respectively. The higher grain yield observed in amended plots than the control could be attributed to higher content of nutrients in the rice mill wastes than the soil. According to Kumar and Mittal (2007) increase in plant grain yield in waste amended plots was as a result of nutrients release by these wastes. Mbah et al. (2010) working with wood-ash observed that wood-ash generally improved soil properties which in turn enhanced maize grain yield. Rice mill wastes mineralized and released their nutrients gradually making them available to crops thereby enhancing their growth and grain production. Similarly, Mutuo et al. (2000) reported that treatments that had received organic biomass had a high residual effect of 50% yield increase above control. After two years of application of burnt rice mill waste most of the nutrients it contained might have been released, whereas nutrients in unburnt rice mill waste are still been released and made available for the crop to utilize. The fact that burnt rice mill wastes released their nutrients faster than unburnt rice mill wastes may have led to highest crop yield in plot amended with BW_{20} in the first cropping season and UW_{20} amended plot to give the highest grain yield in the residual cropping season.

Conclusion

This study showed that burnt, unburnt and burnt + unburnt rice mill wastes at the rates studied improved the soil hydraulic conductivity and aggregate stability, crop yield. Similarly, increasing the rates of application of rice mill waste resulted to an increase in the parameters studied. Apart from improving soil productivity as shown in this study it will save the farmer the cost of buying artificial fertilizer as these wastes are obtained free in the study area.

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