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Case Study.

Potentials of rice wastes as soil amendment:

Part 1: Effect on soil physical properties and maize (*zea mays* l) yield.

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Soil physico-chemical properties are very important to ensure its biological productivity. The present study aimed to assess the potential of different rice mill wastes under different forms (burnt, unburnt and mixture of both) to improve the soil physical properties and maize grain yield. Specifically the rice mill wastes were applied at different rates (0,10 t ha^{-1} and 20 t ha^{-1}) to an acid ultisol in South Eastern Nigeria during 2008, 2009 and the residual effect tested in 2010 cropping seasons. Results of the study showed significantly ($P < 0.05$) lower bulk density and higher values of total porosity, aggregate stability and hydraulic conductivity in waste amended plots relative to control. Waste application at the studied rates improved soil physical properties leading further to enhanced maize grain yield.

Keywords: Ultisol, physical properties, grain yield, wastes, productivity.

Introduction

Physical land degradation in the tropics resulting from soil erosion by water and mechanical land clearing using bulldozers has been extensively reported. Tropical forest soils have a good structure given by a low bulk density, high infiltration and hydraulic conductivity rates. However this stability can break rapidly once the forest is cleared and exposed to rain- induced weathering processes. Mbagwu (1988) and Mbah *et al.* (2004) reported that this degradation is manifested in high bulk density, low total porosity and macro-porosity, reduced infiltration and available water capacities within the root zone. These drastic physical changes added to poor nutrient status (Mbah, 2006) of such soils more often result inland abandonment or poor crop-productivity essential to sustain rural communities Mbagwu (1992) .

While several studies reported the use of fertilizers to improve physical conditions of soils in the tropical region (Mbagwu and Lal, 1985; Aina and Egolum, 1980) the large application of organic amendments is yet underappreciated. In the temperate region several studies have focused on the use of farm manure to improve soil structure (Nuttal, 1970; Salter and Williams, 1963). In the tropical region the use of animal manure, green manure and compost manures received less attention in the literature (Okonkwo and Ogu, 2002). Mbah *et al.* (2004) reported a decreased bulk density and increased total porosity and aggregate stability in a dystric leptosol in south eastern Nigeria after using sewage sludge and animal wastes (cow dung, poultry and pig manure) as soil amendments.. Similarly, Mbah and Mbagwu (2003a) and Nnabude and Mbagwu (1998) observed an improved soil- water relations following addition of organic wastes on soils.

In Nigeria, the reuse of waste materials resulted from agricultural, forestry and industrial activities has been largely ignored. In -Abakaliki , a region in southeastern Nigeria large quantities of burnt and unburnt rice wastes are produced but no serious attempts have been made for their effective utilization or safe disposal. The aim of this study was to evaluate the potentials of rice waste (burnt, unburnt and mixture of both) in improving the physical properties of a degraded Ultisol and its effect on maize (*Zea mays* L) yield.

Materials and Methods

Experimental Site:

The research was conducted in Abakaliki (08^o 031^E , 06^o 25^1N)at the Farm complex of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, in the savannah zone of south eastern Nigeria. It is characterized by a high annual temperature ranging usually between 24^{o}C and 28^{o}C. The rainfall starts appreciably in April and stop in October leaving a completely dry period between November and April. It is bimodal with two peaks in July and September. Its annual range is about 1500-2000mm. The soil is hydromorphic and belongs to the order Ultisol within Ezzamgbo soil association derived from shale and classified as Typic Haplustult (Federal department of Agriculture and land resources-FDALR, 1985).

Land preparation, Experimental design and Treatment application:

Preliminary work on the area started in 2008 with the clearing of the vegetation.The experimental (measuring 24 m x 14 m) was cultivated using hoe. A total of 21 plots each measuring 3m x 4m (with plot alleys of 1m and 0.5m) were laid out in a randomized complete block design (RCBD) comprising 7 treatments replicated three times. The treatments (which were sourced from local rice mill industries) comprised 3 rates (0,10 t ha^{-1}, 20 t ha^{-1}) . The treatments used were as follows,:

1. O – control (no treatment)
2. BW_{10} – 12kg/plot burnt rice mill waste equivalent to 10 t ha^{-1}
3. BW_{20} – 24kg/plot burnt rice mill waste equivalent to 20 t ha^{-1}
4. UW_{10} – 12kg/plot unburnt rice mill waste equivalent to 10 t ha^{-1}
5. UW_{20} – 24kg/plot unburnt rice mill waste equivalent to 20 t ha^{-1}
6. BUW_{10} - 6kg BW + 6kg UW/plot equivalent to 10 t ha^{-1}
7. BUW_{20} – 12kg BW + 12kg UW/plot equivalent to 20 t ha^{-1}

The treatments were applied to the plots and left for two weeks. After two weeks the test crop maize (*Zea mays L*) was planted at 2 seeds per hole and at a spacing of 25cm within row and 75cm between rows. The maize grains planted at a depth of 2cm were thinned down to one maize plant per stand two weeks after germination. The experimental site was weeded at 3 weeks interval until maturity and harvest of maize. At maturity eight maize stands were selected per plot, tagged and their seeds harvested. The harvested seeds were air dried, threshed, weighed and yield data adjusted to 10% moisture content. The plots were re-ploughed and planted with maize in 2009 and 2010 cropping seasons, however, without application of treatments in 2010 cropping season to test the residual effect of the treatments.

Soil sample collection and laboratory analysis.

Four auger soil samples were collected (and composited) from the study area at the initiation of the study. Similarly, four core soil samples were collected from each plot at 45 and 90 days after planting (DAP) in each of the study year.. At the end of the study (90 DAP) each year two auger samples were also collected per plot. The collected auger and core soil samples were used in the laboratory to determine soil, aggregate stability, available water content and bulk density and hydraulic conductivity, respectively. Aggregate stability was determined by wet sieving techniques (Kemper and Rosanou, 1986), water retained at -10 kpa and – 1500 kpa was determined using pressure plate extraction according to Obi, (2000), soil bulk density was determined by the method described by Blake and Hartge, (1986) and total porosity (TP) calculated from the bulk density values as follows –

$$Tp = \left[1 - \frac{bd}{Pd}\right] \times \frac{100}{1}$$

Where:

Tp = total porosity
Bd = bulk density
Pd = particle density assumed to be $2.70 gcm^{-3}$ .Saturated hydraulic conductivity was determined by the constant – head soil core method (Klute and Dirksen, 1986).

Data Analysis

Statistical analysis of data collected was carried out using the general linear model of SAS software for Randomized complete Block Design (SAS Institute 1999) while treatment means were separated using Duncan’s multiple range test (DMRT).

Results

Soil characteristics variability

The results of the present study (Table 1) showed differences ($P<0.05$) in soil bulk density at 45 and 90 days after plating (DAP) for the whole studied period. . At 45 DAP in 2008 UW_{20} amendment recorded the lowest bulk density value of $1.33 Mgm^{-3}$. In 2009 and 2010 bulk density values in the amended plots ranged between 1.31 – 1.53 Mgm^{-3} and 1.33 – 1.58 Mgm^{-3}, respectively at 90 DAP. Recorded bulk density values at 45 DAP in waste amended plots were lower than the bulk density values at 90 DAP in the 3 years.

Table 1: Effect of burnt and unburnt rice wastes application on soil bulk density and total porosity

	Bulk Density (Mgm^{-3})						Total Porosity (%)					
	2008		2009		2010		2008		2009		2010	
Treatment	45DAP	90DAP	45DAP	90 DAP	45DAP	90DAP	45DAP	90DAP	45DAP	90DAP	45DAP	90DAP
C	1.64^{a}	1.66^{a}	1.65^{a}	1.67^{a}	1.66^{a}	1.69^{a}	38.11^{g}	37.36^{c}	37.73^{e}	36.98^{f}	37.36^{e}	36.23^{e}
BW_{10}	1.61^{b}	1.63^{ab}	1.47^{b}	1.58^{b}	1.55^{bc}	1.58^{b}	39.25^{f}	38.49^{bc}	44.53^{d}	40.38^{e}	41.51^{d}	40.38^{cd}
BW_{20}	1.58^{c}	1.59^{abc}	1.45^{b}	1.49^{c}	1.51^{c}	1.54^{b}	40.38^{e}	40.00^{abc}	45.29^{d}	43.78^{d}	43.02^{d}	41.89^{c}
UW_{10}	1.39^{f}	1.55^{bc}	1.35^{d}	1.36^{de}	1.35^{ef}	1.38^{d}	4s7.55^{b}	41.51^{ab}	49.06^{b}	48.68^{ab}	49.06^{ab}	47.93^{ab}
UW_{20}	1.33^{g}	1.49^{c}	1.29^{e}	1.30^{e}	1.31^{f}	1.33^{e}	49.81^{a}	43.65^{a}	51.32^{a}	50.94^{a}	50.57^{a}	49.81^{a}
BUW_{10}	1.50^{d}	1.55^{bc}	1.40^{c}	1.45^{cd}	1.41^{d}	1.44^{c}	43.40^{d}	41.51^{ab}	47.17^{c}	45.28^{cd}	46.79^{c}	45.66^{b}
BUW_{20}	1.46^{e}	1.50^{c}	1.38^{cd}	1.41^{d}	1.39^{de}	1.43^{c}	44.91^{c}	43.40^{a}	47.93^{bc}	46.80^{bc}	47.55^{bc}	46.04^{b}

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

Note: C = control, BW_{10} = burnt rice mill wastes at 10 t ha^{-1}, BW_{20} = burnt rice mill wastes at 20 t ha^{-1}, UW_{10} = unburnt rice mill wastes at 10 t ha^{-1}, UW_{20} = unburnt rice mill wastes at 20 t ha^{-1}, BUW_{10} = burnt + unburnt (6 kg of burnt + 6 kg of unburnt rice mill wastes/plot) rice mill wastes at 10 t ha^{-1}, BUW_{20} = burnt + unburnt (12 kg of burnt + 12 kg of unburnt rice mill wastes/plot) rice mill wastes at 20 t ha^{-1}, DAP = days after planting.

Similarly, soil bulk density values in amended plots varied significantly between years.. On the average highest bulk density values were recorded at 90 DAP in 2008 cropping season. On the other hand Table 1 also showed significantly (P =0.05) higher total porosity values in amended plots relative to the control at 45 and 90 DAP in the 3 years. At 90 DAP in 2009 the order of increase was UW_{20}>UW_{10}>BUW_{20}>BUW_{10}>BW_{20}>BW_{10}>C. In 2010 cropping season total porosity value in the control was 11%, 17%, 32%, 37%, 26% and 27% lower than recorded total porosity values in BW_{10}, BW_{20}, UW_{10}, UW_{20}, BUW_{10} and BUW_{20}, at 90 DAP, respectively. As with total porosity data, the incorporation of burnt, unburnt and mixtures of burnt + unburnt rice mill wastes at the rates studied significantly increased soil aggregate stability and hydraulic conductivity across the 3 years (Table 2).

Table 2: Effect of rice wastes application on soil aggregate stability (AS%) and hydraulic conductivity (HC-$Cmol^{-1}$) at 90 DAP.

	HC			AS		
Treatment	2008	2009	2010	2008	2009	2010
C	18.02^{e}	17.76^{g}	16.46^{e}	41.12^{d}	38.18^{f}	26.79^{d}
BW_{10}	24.27^{d}	28.26^{f}	26.40^{d}	50.33^{bc}	44.23^{d}	35.93^{b}
BW_{20}	29.92^{c}	33.91^{c}	32.02^{c}	55.01^{a}	49.01^{a}	41.02^{a}
UW_{10}	29.92^{c}	32.32^{d}	31.26^{c}	48.23^{c}	41.26^{e}	27.11^{d}
UW_{20}	39.07^{a}	43.22^{a}	36.86^{a}	51.14^{b}	46.16^{c}	39.91^{a}
BUW_{10}	24.94^{d}	29.93^{e}	27.46^{d}	49.03^{bc}	46.23^{c}	33.22^{c}
BUW_{20}	33.25^{b}	37.57^{b}	35.31^{b}	54.46^{a}	54.41^{a}	33.34^{c}

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

Note: C = control, BW_{10} = burnt rice mill wastes at 10 t ha^{-1}, BW_{20} = burnt rice mill wastes at 20 t ha^{-1}, UW_{10} = unburnt rice mill wastes at 10 t ha^{-1}, UW_{20} = unburnt rice mill wastes at 20 t ha^{-1}, BUW_{10} = burnt + unburnt (6 kg of burnt + 6 kg of unburnt rice mill wastes/plot) rice mill wastes at10 t ha^{-1}, BUW_{20} = burnt + unburnt (12 kg of burnt + 12 kg of unburnt rice mill wastes/plot) rice mill wastes at 20 t ha^{-1}, DAP = days after planting.

Relatively lower magnitude of increase was observed in aggregate stability and hydraulic conductivity at 10 t ha^{-1} compared to 20 t ha^{-1} rate of application. For instance unburnt rice mill waste (UW_{10}) at 10 t ha^{-1} increased soil hydraulic conductive relative to the control by 66%, 82% and 90%, respectively, for 2008, 2009 and 2010 cropping seasons compared to 117%, 143% and 124% increase recorded in 20 t ha^{-1} amended plots in same cropping seasons. The order of improvement in soil aggregate stability was BW_{10}>BUW_{20}>UW_{20}>BW_{10}>BUW_{10}>UW_{10}>C, BUW_{20}>BW_{20}>BUW_{10}>UW_{20}>BW_{10}>

UW_{10}> C and BW_{20}>UW_{20}>BW_{10}>BUW_{20}>BUW_{10}> UW_{10}> C for 2008, 2009 and 2010 cropping seasons, respectively. In 2010 cropping season observed hydraulic conductivity values were 59% (BW_{10}) 91% (BW_{20}), 82% (UW_{10}), 143% (UW_{20}), 69% (BUW_{10}) and 112% (BUW_{20}) higher than recorded value in control.

Maize crop variability

Table 3 shows that application of burnt, unburnt and mixtures of burnt + unburnt rice mill wastes at the rates studied increase maize yield relative to the control for the whole studied period.However, observed differences in grain yield values in control and UW_{10}, and BUW_{10} and BUW_{20} in 2008 cropping season was not significant. (P = 0.05). Similarly, non-significant treatment effect was observed between C and BW_{10}, and UW_{10} and BUW_{10}

Table 3: Effect of rice mill wastes application on maize grain yield (t ha^{-1})

Treatment	2008	2009	2010
C	3.54^{d}	0.51^{g}	0.12^{e}
BW_{10}	3.89^{c}	1.36^{e}	0.17^{e}
BW_{20}	4.18^{a}	2.71^{c}	0.93^{c}
UW_{10}	3.63^{d}	1.11^{f}	0.71^{d}
UW_{20}	3.96^{bc}	2.12^{d}	1.70^{a}
BUW_{10}	4.05^{ab}	3.26^{b}	0.72^{d}
BUW_{20}	4.11^{ab}	4.06^{a}	1.44^{b}

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

Note: C = control, BW_{10} = burnt rice mill wastes at 10 t ha^{-1}, BW_{20} = burnt rice mill wastes at 20 t ha^{-1}, UW_{10} = unburnt rice mill wastes at 10 t ha^{-1}, UW_{20} = unburnt rice mill wastes at 20 t ha^{-1}, BUW_{10} = burnt + unburnt (6 kg of burnt + 6 kg of unburnt rice mill wastes/plot) rice mill wastes at10 t ha^{-1}, BUW_{20} = burnt + unburnt (12 kg of burnt + 12 kg of unburnt rice mill wastes/plot) rice mill wastes at 20 t ha^{-1}, DAP = days after planting.

during the 2010 (residual) cropping season. The table also show that increasing the rates of each amendment increased grain yield value. For instance at 20 t ha^{-1} observed yield value in BUW_{20} was 1% and 25% higher than recorded values in BW_{10} in 2008 and 2009 cropping seasons, respectively. The table showed that highest grain yield values of 4.18 (2008), 4.06 (2009) and 1.70 t ha^{-1} (2010) were recorded in BW_{20}, BUW_{20} and UW_{20} amendments, respectively. Observed grain yield in UW_{20} (1.70 t ha^{-1}) in 2010 was 93%, 90%, 45%, 58%, 58% and 15% higher than C, BW_{10}, BW_{20}, UW_{10}, BUW_{10} and BUW_{20}, respectively.

DISCUSSIONS

Differences in soil bulk density between the years could be attributed to a combination of many factors such as soil content of organic matter (OM), natural process of settling and structural collapse due to total raindrop impact energy on the soil surface. On the other hand observed higher bulk density values at 90 DAP relative to 45 DAP could be due to break down of some of the 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 reduced compaction as a result of lower soil bulk density. Several studies (Mbah *et al*., 2004; Mbah and Nneji, 2010; Mbagwu, 1992) reported an improvement in soil physical properties when they used organic wastes as soil amendments. The observed high total porosity values may have contributed to the higher hydraulic conductivity values observed on the waste amended plots. 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. In a study on analysis of the physical conditions of a contaminated and uncontaminated typic haplustult amended with organic wastes, Nwite *et al.* (2011) reported increased hydraulic conductivity in organic wastes amended contaminated and uncontaminated soil relative to the control. The recorded high values of hydraulic conductivity in waste amended plots indicated higher water transmission, reduced erosion and lower run-off compared to control plots. Observed increase in soil aggregate stability in waste amended plots could be attributed to the positive effect of organic matter (OM) in soils. Mbah and Nneji (2010) and Obi and Ebo (1995) 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 the control. The authors attributed the increase to the role of OM in aggregation of soils.

The recorded increases in maize grain yield in waste amended plots compared to the control could be as a result of improvements on the studied soil physical properties. The reduced bulk density and increased total porosity may have increased root penetration while the improved hydraulic conductivity may have increased water transmission. The improvements in soil physical properties may have led to increase in cumulative feeding area of maize crop translating to higher grain yield in line with the observations of Nnabude and

Mbagwu, (1998). The higher grain yields recorded in BW_{20} and BUW_{20} in 2008 and 2010 cropping seasons could be as a result of decomposition process or ability of waste to mineralize and release its nutrient for use by maize. In a study on decomposition, mineralization rate and biochemical oxygen demand of organic wastes, Mbah and Mbagwu (2003b) reported that waste with high decomposition and mineralization rate releases their nutrients faster for crop use compared to wastes with low rate of decomposition and mineralization. The results of this study seem to suggest that BW_{20} decomposed easily and released its nutrients leading to higher crop yield in 2008 cropping season while BUW_{20} released its nutrients slowly leading to higher yield in 2010 (residual) cropping season.

Conclusion

Results from this study show that application of burnt, unburnt and mixtures of burnt + unburnt rice mill wastes at the studied rates improved soil physical conditions. This led to higher grain yield in amended plots. The study recommends the use of BW_{20} and BUW_{20} for short and long term improvements in the poor physical conditions of the studied soil.

REFERENCES

Aina P.O and Egolum E. (1980). The effect of cattle feed lot manure and inorganic fertilizer on the improvement of subsoil productivity of two soils. Soil Sci. 129, 212 – 217.

Blake G.R and Hartge K.H. (1986). Bulk density; In: Kute A. (ed). Methods of soil analysis, part 1. Physical and mineralogical methods. American Soc. Of Agronomy, Madison Wisconsin, USA 365 – 375.

FDALR (1985). Reconnaisance soil survey of Anambra State Nigeria. Soil Report, FDALR, 1985.

Kemper W.D. and Rosanou R.C. (1986). Aggregate stability and size distribution. In: Klute, A (eds). Methods of soil Analysis. Part 1. Am Soc. Agron. Monographa: 425-442.

Klute A. and Dirksen C. (1986). Hydraulic conductivity and diffusivity: Laboratory methods in Methods of soil Analysis, 2nd Ed., Part 1, A. Klute (ed). Agronomy 9, Soil Sci. Am., Madison, W.I. pp. 687 – 784.

Mbagwu J.S.C. (1988). Physico-chemical properties and productivity of an Ultisol in Nigeria as affected by long term erosion. Pedologie, 38, 137 – 154.

Mbagwu J.S.C. (1992). Improving the productivity of a degraded Ultisol in Nigeria using organic and inorganic amendments part 1: chemical properties and maize yield Biores. Technol. 42, 149 – 154.

Mbagwu J.S.C. and Lal R. (1985). Effect of bulk density and irrigation frequency on the root growth and dry matter yields of corn and cowpea for three Nigerian top-soil and sub-soil profiles. Beith. Trop. Landwirtsch. Vet. Med. 23, 277-285.

Mbah C.N. (2006). Influence of Organic wastes on plant growth parameters and nutrient uptake by maize (zea mays L.) Nig. Journ. of Soil Sci. 16, 104 – 108.

Mbah C.N. and Mbagwu J.S.C. (2003a). Changes in structural stability and water retention of a sandy clay loam amended with organic wastes. Journal of Agric., Food Tech and the Environment. 3, 16 – 21.

Mbah C.N. and Mbagwu J.S.C. (2003b).Studies on decomposition, mineralization rate and biochemical oxygen demand of organic wastes. Int. Journ. of Agric. And Biol. Sci. 2, 51 – 54.

Mbah C.N., Mbagwu J.S.C., Onyia V.N. and Anikwe M.A.N.(2004). Effect of application of biofertilizers on soil densification, total porosity, aggregate stability and maize grain yield in a dystric leptosol at Abakaliki – Nigeria. Journal of Science and Tech. 10, 74 – 850.

Mbah C.N. and Nneji R.K .(2010). Effect of different crop residue management techniques on selected soil properties and grain production of maize. Journal of Applied Science Res. 6(2) 151 - 155.

Mbah C.N., Nwite J.N., Njoku C. and Nweke A. (2010).Response of maize (*zea mays* L) to different rates of wood ash application in acid ultisol in SE Nigeria. African Journ. of Agric. Res. 5(7), 580 – 583.

Nnabude P.C. and Mbagwu J.S.C (1998). Soil water relation of a Nigerian Typic Haplustult amended with fresh and burnt rice mill wastes. Soil Till Res. 50: 207-214.

Nuttal W.F. (1970). Effect of organic amendments on some physical properties of luvisolic soils in relation to emergence of rapeseed in a growth chamber .Can. J. Soil Sci., 50, 397 – 402.

Nwite J.N., Mbah C.N.,Okonkwo C.I. and Obi M.E. (2011). Analysis of the physical conditions of a contaminated Typic Haplustult amended with organic wastes. Int. Res. Journ. of Agric. Sci. 1(2) April 2011 (In press).

Obi M.E. (2000). In soil physics. A compendium of lectures. Altanta Publishers, Nsukka, Nigeria.

Obi M.E. and Ebo P.O. (1995). The effects of organic and inorganic amendments on soil properties and maize production in a severely degraded sandy soil in Southern-Nigeria. Biores. Technol; 51: 117 – 123.

Okonkwo C.I. and Ogu L (2002). Assessment of the potentials of *Glurcidia sepium* and *panicum maximum* biomass used as green manure in soil nutrient improvement and yield of maize. Journal of Arid Agric, 12, 51-56.

Rawls WJ., Brakensick D.L. and Saxton K.E. (1982). Estimation of soil water properties. Trans ASAE 25: 1316 – 1328.

SAS Institute Inc. (1999). SAS/STATS users guide, Version 6, 4th ed. SAS Institute., Cary, NC.

Salter P. J. and Williams, J. B. (1963). The effect of farm yard manure on the moisture characteristics of a sandy soil. J. Soil Sci. 14, 73-81.