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# Soil Properties and Grain Yield of Maize as Influenced by Organic Wastes Amendment in Abakaliki, South East Nigeria

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**Abstract**
Soil properties and grain yield of maize as influenced by amendment of rice mill wastes and saw dust were studied at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The field was laid out in randomized complete block design (RCBD). The treatments were burnt rice mill waste (BRMW), unburnt rice waste (URMW), sawdust (SD) and control (C) which were applied at 20 t $ha^{-1}$ equivalent to 8 kg/plot. The treatments were replicated five times. Maize (Oba super II hybrid variety) was used as a test crop. Core and auger were used to collect soil samples at 0-20 cm depth before and after planting for soil properties determination. Data were subjected to analysis of variance (ANOVA) and means were separated with Fisher's least significant difference. Result showed that bulk density was significantly ($P<0.05$) lower in wastes amended plots relative to control. Total porosity, hydraulic conductivity and gravimetric moisture content (GMC) of wastes amended plots were significantly ($P < 0.05$) higher than the control. The total porosity, hydraulic conductivity and gravimetric moisture content were 26, 39 and 38 % higher in sawdust amended plots relative to control, respectively. Hydraulic conductivity under saw dust treatment was 14 and 23% higher relative to burnt rice mill waste (BRMW) and unburnt rice mill waste (URMW) amendments. Similarly, percent organic matter, available P, CEC and % BS of wastes amended soil were significantly ($P < 0.05$) higher when compared to control. Available P and total N were 64 and 56 % higher for URMW amended plots when compared to BRMW and SD treatments, respectively. Organic wastes amendment produced taller maize plants at 14, 28, 42, 56 and 70 days after planting. Unburnt rice mill waste and burnt rice mill waste significantly ($P<0.05$) increased grained yield of maize compared to control and sawdust treatment. Organic wastes positively influenced physicochemical properties of soil and increased yield of maize. Rice mill wastes and sawdust could be recommended for enhancement of soil physicochemical properties and grain yield of maize in Abakalik agroecology.
**Keywords:** Amendment, influenced, grain yield of maize, organic wastes, soil properties.

## Introduction

Organic wastes are those materials such as agricultural wastes, plant debris, animal dungs or their by-products used as soil amendments. These kinds of wastes are becoming increasingly important in addressing soil low fertility problem due to scarcity and high cost of inorganic fertilizers. The local poor resource farmers had long resorted to use of these materials since they are cheap, easily available and environmental friendly. Besides, organic wastes have physical and chemical properties which facilitate aggregation of mineral particles such as clays which in turn influence soil water regime (Mbagwu, 1990). They are also fundamental source of energy for the soil biota and in that way influence many biologically mediated processes in the soil (Stephenson, 1994).

Furthermore, several studies have been carried out and they indicate positive effect of organic wastes on soil. They contain nutrients needed for crop growth and development. Organic matter from such wastes improves soil tilth, increase water holding capacity; reduce wind and water erosion, and increase aeration status (Tisdall, 1996). Organic wastes from sawdust improve cation exchange capacity (CEC), available P, total nitrogen and buffering capacity which are important in soil productivity restoration (Olayinka and Adebayo, 1983).

Abakaliki agro ecological area is inundated with rice husk dust and sawdust. This is because of the numerous rice mill industries and saw mills in nooks and crannies of the state. The state capital which is Abakaliki is housing the biggest rice mill industry in southeast of Nigeria. The rice mills are fed from abundant rice farms from the rural areas throughout the year. The sawdust is generated from the timber shade market situated in the Abakaliki urban. Lack of suitable and viable disposal alternative (Nnabade and Mbagwu, 1999) cause abandonment of these wastes to fire hazards and consequently giving rise to environmental pollution (Omaliko and Agbim, 1983). It is on that basis that this work was conceived. Organic wastes, though, had been studied in the area especially rice mill wastes, yet not exhaustive as it is believed that findings from the study would add to existing knowledge. Furthermore, it could identify other areas of interest in organic wastes amendment of soil. The objective was to find out the influence of burnt rice mill waste, unburnt rice mill waste and sawdust on soil properties and yield of maize in Abakaliki agro ecological zone.

## Materials and Methods

### Experimental Site

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The area is located (06$^o$4'N and 08$^o$65'E) in the derived savannah of the southeast agro- ecological zone. Bimodal pattern of rainfall is experienced in the area which starts from April – July and September – November. There is short spell in August called "August break". The total mean annual rainfall ranges from 1700 mm for minimum to 2000 mm for the maximum respectively. The minimum and maximum temperatures are 27$^o$C and 31$^o$C. The relative humidity is 80% during rainy season but declines to 60% under dry weather condition (Ofomata, 1975). The soil is derived from successive marine deposit from cretaceous and tertiary period. Abakaliki agro zone lies within 'Asu river' and is associated with sedimentary rocks, fine grained sand and mudstone. The soil is unconsolidated to 1 m depth and belongs to the order ultisol classified as Typic Haplustult (FDALR, 1985).

### Field design/layout/treatment application

A total land area that measured 15 m x 10.5 m approximately 0.016 ha was used for the experiment. The field was cleared of existing vegetation with cutlass and debris removed. The area was demarcated into plots that measured 2 m x 2 m with 0.5 m space and with replications of 10 m x 2 m which had 1m alley. The design used was a randomized complete block design (RCBD). The treatments were control and 20 t ha$^{-1}$ (8 kg ha$^{-1}$) each of burnt rice mill waste, unburnt rice mill waste and sawdust. The burnt rice mill waste and unburnt rice mill waste were collected from agro rice mill industry and sawdust from timber shade market, Abakaliki. These organic wastes were spread on each plot and later incorporated into the soil with hoe during seedbed preparation. They were replicated five times to give a total of twenty experimental plots in the experiment.

Oba super II hybrid variety of maize sourced from Ebonyi State Agricultural development programme (EBADEP), Onuebonyi Izzi, Abakaliki was used as a test crop. The maize seed was planted two per hole at 5 cm depth and 25 cm x 75 cm spacing two weeks after treatment application. Two weeks after germination, the seedlings were thinned down to one per hole. Missing stands were replaced giving approximated 53,000 plants per hectare. Weeds were removed at three-weekly interval till harvest.

### Soil Sampling

Initial soil sample was collected with soil auger at 0 – 20 cm depth from different points of the field before cultivation and treatment application. The samples were composited for pre-planting soil analysis. Auger and core soil samples were further collected from each plot at 0 – 20 cm after planting for post harvest analysis.

### Agronomic Data

Twelve plants constituting 25% of plant population per plot were tagged and used for agronomic measurements. Plant height was measured with metric ruler from tallest leaf of a plant to base every two weeks till tasseling. The grain yield was determined by harvesting the cobs after drying of husks. The husks were removed, cobs shelled and maize grain were further dried and grain yield adjusted to 14% moisture content.

### Laboratory Determinations

Core samples were used for determination of soil physical properties. The auger samples were dried, grinded and passed through 2 mm sieve and used to determine chemical properties. Bulk density was determined using the method described by Gee and Or (2002). Total porosity determination was done as described by Obi (2000). The method of Klute (1986) was used to determine saturated hydraulic conductivity (Ks). Gravimetric moisture content determination was carried out as described by Obi (2000). The soil pH was carried out using 1:2.5 soil/water ratio. The values were read off using Beckman zeromatric pH meter (Peech, 1965). Total nitrogen was determined by the procedure described by Bremner and Mulllvancy (1982). Organic matter determination was by Walkley and Black (1992) method. Exchangeable Ca, Mg, K and Na were extracted using 1 N $NH_4OAC$. Their amounts in filtrate were determined by Perkin Elmer Atomic Absorption Spectrophotometer (Tel and Rao, 1982). Available phosphorus was determined by Bray 2 (Bray and Kurtz, 1945).

### Data Analysis

Data collected from the study were analyzed using analysis of variance (ANOVA) for Randomized Complete Block Design. Fishers least significant difference (Steel and Torrie, 1980) were used to separate means and significance was accepted at 5%.

 

**Results and Discussion**

**Nutrient composition of organic wastes used for soil amendment**

Table 1 shows nutrient composition of organic wastes used for soil amendment. The exchangeable Ca values were 1.17, 0.50 and 0.30 cmolkg$^{-1}$ for burnt rice mill waste, unburnt rice mill waste and sawdust, respectively and higher than Mg, K and Na values in the wastes. Exchangeable Mg was dominant in burnt rice mill waste (0.27 cmolkg$^{-1}$) compared to other wastes. Total N value was higher (0.48%) in unburnt rice mill waste and sawdust. The values of total N were low (Enwezor *et al.*, 1981). Even though, the value for available P was highest (14.0 Mgkg$^{-1}$) for burnt rice mill waste relative to unburnt rice mill waste and sawdust, it was low (Landon, 1991).

Table 1. Nutrient composition of wastes

| Wastes | Element | Unit | Value |
|---|---|---|---|
| BRMW | | | |
| | Na | cmolkg$^{-1}$ | 0.04 |
| | K | cmolkg$^{-1}$ | 0.6 |
| | Ca | cmolkg$^{-1}$ | 1.17 |
| | Mg | cmolkg$^{-1}$ | 0.27 |
| | N | % | 0.30 |
| | P | mgkg$^{-1}$ | 14.0 |
| URMW | Na | cmolkg$^{-1}$ | 0.07 |
| | K | cmolkg$^{-1}$ | 0.24 |
| | Ca | cmolkg$^{-1}$ | 0.50 |
| | Mg | cmolkg$^{-1}$ | 0.12 |
| | N | % | 0.48 |
| | P | mgkg$^{-1}$ | 7.00 |
| SD | Na | cmolkg$^{-1}$ | 0.07 |
| | K | cmolkg$^{-1}$ | 0.13 |
| | Ca | cmolkg$^{-1}$ | 0.30 |
| | Mg | cmolkg$^{-1}$ | 0.10 |
| | N | % | 0.28 |
| | P | mgkg$^{-1}$ | 3.00 |

BRMW – burnt rice mill waste, URMW – unburnt rice mill waste, SD – sawdust

**Properties of soil at initiation of study**

Sand fraction (Table 2) was dominant compared to silt and clay fractions yielding a sandy loam texture. The pH (5.3) was slightly acidic (USDA SCS, 1974). Organic matter (3.35%) was moderate (Enwezor *et al.*, 1982). Total N (0.16%) was very low (Landon, 1991). Exchangeable Ca and Mg dominated the exchange complex. Cation exchange capacity (10.88 cmolkg$^{-1}$) was low (Asadu and Nweke, 1999). Available P (41.00 mgkg$^{-1}$) was rated high (Landon, 1996). Exchangeable acidity was 0.68 cmolkg$^{-1}$.

Table 2. Properties of soil at initiation of study

| **Soil properties** | **Values** |
|---|---|
| Sand % | 60 |
| Silt % | 27 |
| Clay % | 13 |
| Textural class | Sandy loam |
| pH in Kcl | 5.3 |
| OC % | 1.93 |
| OM % | 3.35 |
| N % | 0.16 |
| P mgkg$^{-1}$ | 41.00 |
| Na cmolkg$^{-1}$ | 0.91 |
| K cmolkg$^{-1}$ | 0.21 |
| Mg cmolkg-1 | 2.80 |
| Ca cmolkg-1 | 7.00 |
| CEC cmolkg-1 | 10.88 |
| EA cmolkg-1 | 0.68 |
| %BS | 94.00 |

**Physical properties as influenced by organic wastes amendment**

The particle size distribution (Table 3) did not vary appreciably among the treatments. However, the texture remained sandy loam in all the treatments. Obi (2000) pointed out that texture was a permanent property of soil and did not change after cultivation. The texture of soil influences its nutrient storage, water retention and aeration status.

The application of organic wastes significantly ($P<0.05$) decreased bulk density and increased total porosity, hydraulic conductivity and gravimetric moisture content of soil relative to control, respectively. Bulk density had inverse relationship with total porosity. Furthermore, bulk density was lower under saw dust amendment relative to burnt rice mill waste and unburnt rice mill waste treatments. This translated to 16% decrease in bulk density for SD amended plots compared to control. The findings are in agreement with the report of Mbagwu and Piccolo (1990) that organic wastes incorporation reduced bulk density and increased total porosity (Gou, 1987). This could be attributed to loosening effect on soil by decomposing materials applied to the soil. Furthermore, it could partly be a reflection of organic matter content of the soil (Table 4). Similarly, saturated hydraulic conductivity and gravimetric moisture content obtained in saw dust treated plots were higher relative to the application of burnt rice mill waste and unburnt rice mill waste amendments. Hydraulic conductivity value under saw dust amended plots was higher by 14 and 23% when compared to burnt rice mill waste dust and unburnt rice mill waste amendments. This suggests that saw dust application in soil could create channel of water flow and capable of influencing positively soil conditions to absorb and retain moisture for production of maize.

Table 3. Physical properties of soil following organic wastes amendment

| Treatment | ← | | | Soil physical properties | | | → |
|---|---|---|---|---|---|---|---|
| | % sand | % silt | % clay | Texture | BDgcm$^{-3}$ | TP% | HCcmh$_r^{-1}$ | GMC% |
| Control | 60 | 27 | 14 | SL | 1.81 | 32 | 51 | 20 |
| BRMW | 59 | 28 | 13 | SL | 1.57 | 41 | 72 | 30 |
| URMW | 60 | 27 | 14 | SL | 1.66 | 38 | 65 | 32 |
| SD | 58 | 29 | 15 | SL | 1.54 | 43 | 84 | 32 |
| FLSD (0.05) | | | | | 0.08 | 6.7 | 3.6 | 1.4 |

BRMW-burnt rice mill waste, URMW- unburnt rice mill waste, SD – saw dust, BD – bulk density, TP – Total porosity HC – hydraulic conductivity, GMC – gravimetric moisture content, SL – Sandy loams

**Chemical properties of soil as influenced by organic wastes application**

Table 4 shows chemical properties as influenced by organic wastes application. The result indicates that organic matter, available P, total N, exchangeable Mg, cation exchange capacity and base saturation of organic wastes amended plots were significantly ($P<0.05$) higher than those of control ones. Percent organic matter of unburnt rice mill waste was significantly ($P<0.05$) higher than that of saw dust amended plot. Available P value of mgkg$^{-1}$ was obtained in unburnt rice mill waste and saw dust treated plots and this significantly ($P<0.05$) increased over burnt rice mill waste amended one and control, respectively. Similarly, significantly ($P<0.05$) higher total N was obtained under unburnt rice mill waste amendment relative to those amended with burnt rice mill waste and saw dust. Exchangeable Mg and CEC were 11 , 78% and 4, 11% higher for burnt rice mill waste when compared to saw dust waste amendment, respectively. Though, soil pH and exchangeable Ca, Na and K were statistically not different among the treatments, their values were higher under organic wastes treatments compared to control. Soil pH exchangeable Na, Ca, K and EA varied among the organic wastes amendments. Exchangeable Ca and K were 14 and 67% higher under saw dust waste amendment relative to unburnt rice mill waste treatment. Significant increase in percent organic matter of soil amended with agro waste had been reported by Andrews *et al*. (1999) and Clark *et al.* (1998). Similarly, sharply *et al.* (1994) earlier noted that soil amended with organic wastes increased available P. The findings of significant increase of percent total N is in conformity with the work of Sharpley *et al.* (1993) of agro waste amended soil relative to control. The positive influence of applied wastes on these soil properties could be attributed to their release of these nutrient elements into the soil upon their decomposition. The improved soil pH of wastes amended soil could be due to improvement of organic matter content and exchangeable cations especially Mg content of the soils (Table 4). Perucci (1992) observed that exchangeable Mg significantly increased in organic wastes treated soil relative to control. Furthermore, Andrews *et al.* (2002) and Agboola and Fagbenro (1985) in their studies observed that organic wastes amendment increased cation exchange capacity (CEC) and %BS when compared to control. This, they attributed to releases into soil of exchangeable cations during decomposition of organic wastes.

Table 4. Chemical properties of soil following organic wastes amendment

| Treatment | Soil chemical properties | | | | Cmolkg$^{-1}$ | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH(Kcl) | OM% | Pmgkg$^{-1}$ | N% | Ca | Mg | K | Na | CEC | EA | %BS |
| Control | 5.1 | 3.1 | 28.0 | 0.2 | 6.4 | 3.3 | 0.2 | 0.2 | 7.9 | 0.8 | 90 |
| BRMW | 5.4 | 3.5 | 39.0 | 0.3 | 7.2 | 3.6 | 0.5 | 0.3 | 12.0 | 0.6 | 95 |
| URMW | 5.4 | 3.7 | 64.0 | 2.2 | 7.2 | 3.2 | 0.2 | 0.2 | 11.5 | 0.6 | 96 |
| SD | 5.3 | 3.3 | 64.0 | 0.2 | 8.4 | 0.8 | 0.6 | 0.2 | 10.7 | 0.7 | 93 |
| FLSD (0.05) | NS | 0.3 | 7.0 | 1.0 | NS | 1.4 | NS | NS | 1.0 | 0.2 | 0.1 |

BRMW – burnt rice mill waste, URMW – unburnt rice mill waste, SD – saw dust, OM – organic matter, P – Phosphorus, N – Nitrogen, CEC – cation exchange capacity, EA – exchangeable acidity, %BS – percent base saturation.

**Agronomic parameters**

Plant height at different sampling periods and grain yield of maize are shown in Table 5. The results indicate that plant height under unburnt rice mill waste amendment significantly (P<0.05) increased relative to control except at 56 days after planting (DAP). Furthermore, plant higher of BRMW amended plots was significantly (P<0.05) higher than control at 28 and 42 DAP compared to control. Generally, unburnt rice mill waste treatment at different sampling periods (14 = 18.66 cm, 28 = 53.23 cm, 42 = 102.05 cm, 56 = 170.24 cm and 70 = 176.52 cm) produced taller maize plants when compared to plots where burnt rice mill waste and saw dust were applied. This observation is in consonance with the findings of Agbim (1981) that organic wastes incorporation into soil increased growth of maize compared to control.

The grain yield of maize in organic wastes treated plots except for SD was significantly (P<0.5) higher than control. Significantly (P<0.05) higher grain yield of maize was obtained under unburnt rice mill waste amendment relative to burnt rice mill waste and saw dust treatments. The grain yield of maize for unburnt rice mill waste and burnt rice mill waste amended soil is medium and saw dust treatment rated as low (NPFS, 2010). Agbim (1985) reported that higher grain yield of maize was obtained where organic wastes were applied relative to control.

Table 5. Effect of organic wastes amendment on agronomic yield of maize

| Treatments | Plant height (DAP) cm | | | | | |
|---|---|---|---|---|---|---|
| | 14 | 28 | 42 | 56 | 70 | Grain yield (tha$^{-1}$) |
| Control | 11 | 30 | 53 | 97 | 99 | 1.8 |
| BRMW | 15 | 43 | 82 | 128 | 136 | 2.3 |
| URMW | 19 | 53 | 102 | 170 | 177 | 2.6 |
| SD | 11 | 37 | 61 | 102 | 110 | 1.9 |
| FLSD (0.05) | 5.0 | 15.6 | 34.5 | NS | 37.6 | 0.3 |

DAP – days after planting, BRMW – burnt rice mill waste, URMW – unburnt rice mill waste, SD- sawdust

**Conclusion**

This study was carried out to find out influence of organic wastes amendment on soil properties and maize yield. The results indicate that organic wastes application influenced soil properties and maize yield positively. The applied organic wastes reduced bulk density and increased total porosity, aggregate stability, mean weight diameter and enhanced water retention and transmission. Similarly, amendment of organic wastes significantly increased percent organic matter, available P, total N, exchangeable Mg, cation exchange capacity and base saturation, respectively. The application of organic wastes increased plant height and grain yield of maize. The over all performance of the organic wastes in influencing soil properties and maize yield follows the trend: URMW >BRMW >SD>C. However, saw dust treatment proved more superior in improving soil physical properties than other wastes.

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