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Effect of Rice Husk as an Amendment On The Physico-Chemical Properties of Sandy-Loam Soil In Lafia, Southern-Guinea Savannah, Nigeria

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ABSTRACT

Soil physical and chemical properties are important phenomena in agriculture, hydrological, ecological and environmental processes that affect the productive capacity of the soil. This study was conducted at the Nasarawa State University, Faculty of Agriculture Demonstration Farm, Shabu-Lafia, Nasrawa State, Nigeria to determine the effect of rice husk on physio-chemical properties of sandy-loam soil. Four treatments were laid out in a Randomized Complete Block Design (RCBD) with three replicates. The treatment were RH_0 *(Control),* RH_2 *(2 t/ha),* RH_4 *(4 t/ha) and* RH_6 *(6 t/ha). Soil samples were collected from the top soil depth (0 - 30 cm) before and after treatments for the determination of selected soil physical properties (particle size, bulk density and total porosity) and chemical properties (soil pH, organic matter, total nitrogen, available phosphorus, exchangeable bases and cation exchange capacity). The results indicated that increasing rice husk from 0 to 6 t/ha significantly increased soil pH, total porosity, organic matter, exchangeable bases (*Mg^{2+}*,* K^+ *and* Na^+*) and cation exchange capacity between treatments in both seasons while bulk density and electrical conductivity decreased between treatments. Available P and exchange base,* Ca^{2+} *were not significant in the first season, however, became significant in the second season. Total nitrogen was not significant in both seasons. All physical and chemical properties showed improvement when the second season was compared to the first season. It can therefore, be concluded that application rate of 6 t/ha performed best with the highest improvement of the physical and chemical properties of the soil.*

Key words: *Rice Husk, Soil Amendment, Soil Physical Properties, Soil Chemical Properties.*

Introduction

Soil fertility maintenance is a major concern in the tropics (Okonkwo *et al.*, 2011). When a soil is cultivated continuously its productivity gradually decreases due to depletion of organic matter which is believed to be a reservoir of plant nutrients (Eneje and Uzoukwu, 2012; Ebaid and El-Refaee, 2007). Cropping may lead to erosion and leaching of soil nutrients which in turn, adversely affect the physical and chemical properties of the soil and are strong limitations to crop production (Igwe *et al.*, 1995). Organic material added to the soils with the help of therapeutic effects on the soil properties is to ensure the sustainability of the land and to protect the productivity. Organic waste used as regulators meets especially the nutrient requirements of the plants as well as many functions of soils (Demir and Gulser, 2015; Alabadan *et al.*, 2009).

Frequent use of inorganic fertilizers for a prolonged period deteriorates the surface soil characteristics and affects the availability and uptake of nutrients by plants (Kerenhap *et al*., 2007). To minimize these hazards, naturally occurring organic manures, namely, animal and plant manures, crop residues, and food and urban wastes are better alternate to commercially available inorganic fertilizers. The main advantages of organic manure are organic matter and nutrient supply not only for plants but also for soil organisms (Cherr *et al*., 2006). The use of organic waste improves soil composition, fertility, and soil fauna which in the long run have a beneficial effect on crop production (Yadav *et al.,* 2013). Recent studies had shown that organic wastes increased soil organic matter, total nitrogen, phosphorus, pH and cation exchangeable capacity (CEC) and reduced soil exchangeable acidity (Adeleye *et al.*, 2010; Ayeni *et al.*, 2008; Ebaid and El-Refaee, 2007; Mbah, 2006). The positive effects of organic wastes on soil productivity have been reported by several works (Njoku and Mba, 2012; Tekwa *et al.*, 2010; Mbah and Onweremadu, 2009; Ekpe, 2008; Mbagwu, 1992, Nnabude and Mbagwu, 1998).

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally, approximately 600 million tons of rice paddy is produced each year (Giddel and Jivan, 2007). Rice husk is the natural sheath or productive cover, which forms the cover of rice grains during their growth. Rice husk represents about 20 % by weight of the rice harvested, about 80 % by weight of the raw husk is made of organic matter such as cellulose, lignin etc. and the rest mineral components such as silica, alkalis and trace elements (Anonymous, 1979; Madhumita *et al.,* 2003). It is of little commercial value and because of its high silicon dioxide content, it is not useful to feed either to human or animals. Rice husk is valuable for its roles in increasing soil fertility, substituting for inorganic fertilizer, and improving soil characteristics by its addition of organic matter to the soil (Njoku *et al.*, 2011).

Rice husk removal during rice refining, creates disposal problem due to less commercial interest. Also, handling and transportation of rice husk is problematic due to its low density (Kumar *et al.*, 2012). Much of the husk produced from processing of rice is either burnt or dumped as waste creating great environment threat to surrounding area where it is dumped. Therefore, agricultural use of rice husk as organic manure is an alternative solution to disposal problem. The objective of this study is to determine the effect of rice husk on the physical and chemical properties of a sandy loam soil.

Materials and Methods

The experiment was conducted in 2012 and 2013 cropping seasons at Faculty of Agriculture Demonstration Farm, Nasarawa State University, Keffi, Shabu-Lafia, Nigeria. The area is located on latitude 08^0 33’N, longitude 08^0 33’E and at an altitude of 162 m in Southern–Guinea Savannah zone of Nigeria. The mean annual rainfall is 1132 mm and a mean temperature range of between 24.8 ^{0}C and 33 ^{0}C as minimum and maximum, respectively. The soil is well drained, porous and brownish red below the surface, made of kaolinite clay. The soil type is mostly sandy loam and has a pH range of 5 - 6.5.

Experimental Layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and four treatments. The treatments consists: Control plot (RH_0), 2 t ha^{-1} rice husk (RH_2), 4 t ha^{-1} rice husk (RH_4) and 6 t ha^{-1} rice husk (RH_6). The experimental plots were marked out after clearing and tilled using manual hoe. Each treatment plot had an area of 4 m x 3 m (12 m^2). Each plot was separated between block and replicate by 1m each with a total area of about 221 m^2. The treatments were spread uniformly over the plots and incorporated manually into the seedbed. Two grains of maize (Early maturing variety) were planted per hill at a spacing of 25 cm x 75 cm and depth of 2 - 5 cm ten days after incorporation of amendments. The maize shoots were thinned down to one per planting hill 2 weeks after germination.

Collection of Soil Sample

Soil samples were collected from six points on the field to form a composite sample and used to determine soil physical and chemical properties of the soil before amendment was applied. Soil samples were also taken from three points on each plot at a depth of 0 – 30 cm after harvest and bulked together to form composite samples. Soil samples were collected using soil auger.

Laboratory Analysis

The samples were taken to the laboratory in well labeled polyethene bags. The soil samples were air dried at room temperature for 7 days and sieved through a 2mm sieve. The samples were then analyzed for the following physical and chemical properties; physical properties selected include: Particle size distribution, Bulk Density, and Porosity. Chemical properties were Organic Carbon, pH, Total Nitrogen, Available P, C.E.C, and Exchangeable Cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+). Particle size analysis was determined by Gee and Bauder (1986) method. The textural classes were determined from the USDA soil textural triangle. Bulk density was obtained by the method of Blake and Hartage (1986). Total Porosity was calculated from the values of the Bulk density using the method described by Vomicil (1965). Total Nitrogen was determined by the macro-Kjeldhal method of Bremmer and Mulvaney, (1982). Electric conductivity (EC) was determined by conductivity method in soil water solution (Rhoades, 1996). Soil pH was obtained in 1:25 soil/water extract of the composite samples according to Mclean (1982) method. Soil organic carbon (OC) and Soil organic matter was determined by Nelson and Sommers (1982) method. Soil organic matter was obtained by multiplying percentage carbon by 1.724. Available P was determined by Bray 2 extract Olsen and Sommers (1982). Total exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) were determined using 1N NH_4OAC extractant method (Thomas, 1982) and Cation exchange capacity (CEC) was estimated by summation of the exchangeable bases.

Statistical Analysis

All the data were subjected to analysis of variance (ANOVA) as outlined by Steel and Torrie (1980). The Fisher's Least Significant Difference (FLSD) at 5% probability level was used to separate the means.

Results and Discussion

The result of the pre-planting soil properties is shown in Table 1. The soil texture was sandy loam with a pH value that shows slightly acidic soil. The organic matter, total N and available P were low. The exchangeable cations and CEC were also low as a result of low organic matter and silt content of the soil.

Physical Properties

The effect of rice husk amendment on soil bulk density and total porosity are shown in Table 2. The control plots had the highest bulk densities values of 1.37 and 1.34 g/cm^3 while the lowest values (1.29 and 1.17 g/cm^3) was obtained in the plots amended with 6 t/ha of rice husk in both seasons, respectively. Also there were 6.5, 13.8 and 15.2 % reduction between the seasons with treatments RH_2, RH_4 and RH_6, respectively. The reduction in the bulk densities agrees with the findings of numerous studies (Njoku and Mba, 2012; Anikwe, 2000; Mbagwu, 1999). According to Mbah and Nwite (2008), management practices such as continuous cultivation and removing or burning of residues increase bulk density, while the addition of organic amendments decreases it, because higher soil organic matter helps to reduce the compaction of the soil (Anikwe and Nwobodo, 2002; Mbagwu, 1992).

The total porosity was a reverse of the bulk density. Total porosity values obtained ranged from 48.30 – 54.00 % and 49.30 – 55.80 % in the first and second seasons, respectively with the control plots having the least values and plots amended with 6 t/ha of rice husk having the highest values. The increase in porosity could be attributed to increase in percentage of micro-pores. Both total porosity and bulk density are dependent on the level of soil organic matter. In this study, treatments with high organic matter showed low bulk density and high total porosity in line with the observations of Anikwe (2000), Mbagwu (1992), Mbagwu (1989) and Nnoke (2005). Soils with low bulk density and high total porosity contain the required oxygen that are important for organisms that live in the soil to survive (Njoku and Mba, 2012), increases water movement and root penetration and hence, cumulative feeding area of the crops (Nnabude and Mbagwu, 1998).

Chemical Properties

The mean values of the effect of amendment on soil pH, available phosphorus, soil organic matter, total nitrogen and electrical conductivity is presented in Table 3. The organic matter content of plots amended with rice husk increased significantly with increase in amendment compared to the control in both seasons. Organic matter increased from 1.13% and 1.14% in the controls to 1.45% and 1.60% in plots amended with 6 t/ha, which equals 28.3% and 40.4% improvement in the first and second seasons, respectively. This agrees with the findings of Okonkwo *et al.* (2011) who showed that the highest organic matter content was obtained in the unburnt rice husk amended plots compared to the ash. The higher organic matter content level observed in amended plots could be attributed to the fact that organic material had major impact on mineralization rate and increase soil carbon directly.

The amendments increased the soil pH when compared with the control in both seasons. Observed pH in KCl ranged from 5.87 to 6.38 and 5.92 to 6.63 in the first and second seasons, respectively. The slight changes in the soil pH imply that continuous application could reduce soil acidity. This is in line with the observation of Odedina *et al.* (2003) who reported that organic wastes increased soil pH due to the abundance of alkaline earth materials. Similarly, Mbah and Onweremadu (2009) and Munecheru-Muna *et al.* (2007) observed increases in soil pH in plots amended with organic wastes. The increase in pH level could be attributed to the significant improvement in the exchangeable bases of the soil (Nwite *et al.*, 2011a).

Available P showed an increase with respect to treatments with the highest value (4.90 ppm) obtained in the 6 t/ha treatment of the second season. In the first season, there was no significant difference ($p = 0.05$) in the treatments, however, there was 7.0, 25.0 and 36.1% improvement in treatments RH_2, RH_4 and RH_6, respectively when both seasons are compared. The slight changes in the soil pH brought about by rice husk might have influenced the level of availability of phosphorus since the availability of phosphorus and its solubility is pH dependent. This finding agrees with Okonkwo *et al.* (2011) who showed low values of available P in the control and the unburnt rice husk plots.

The total soil nitrogen had highest values (0.092 and 0.131%) in the 6 t/ha amended plots in both seasons and represents 5.7 and 52.3% increase over the control plots in both seasons, respectively. There was no significant difference ($p = 0.05$) in the treatments in both seasons, however, there was 8.9, 41.3 and 42.4% improvement in treatments RH_2, RH_4 and RH_6, respectively when the two seasons are compared. This agrees with Nwite *et al.* (2011a) who stated that total nitrogen was not significantly improved by the amendment of rice husk dust and rice husk ash, however, reported better improvement on plots treated with rice husk dust. This also agrees with Okonkwo *et al.* (2011) who showed that among the amended plots, unburnt rice husk had the lowest soil N which they attributed to either immobilization of available N after incorporation by micro-organisms or the utilization of the native soil N to initiate decomposition in the soil. The low level of improvement in the N by rice husk could agree with Obatolu and Agboola (1993) and Sobulo and Osiname (1987) who reported that low N might be as a result of early mineralization of nutrients especially N for maize uptake.

Table 1: Physical and chemical properties of soil sample before amendment.

Characteristics	**Values**
Sand %	87.5
Silt %	1.5
Clay %	11.0
Textural class	Sandy loam
Bulk density (g/cm^3)	1.37
Total porosity (%)	50
pH H_2O (1:25)	6.16
pH KCL (1:25)	5.89
Total N (%)	0.086
Organic Carbon (%)	0.68
Organic Matter (%)	1.17
Avail. P (ppm)	3.4
Electric Conductivity (mmhos cm^{-1})	55.0
Ca^{2+} (cmol kg^{-1})	3.55
Mg^{2+} (cmol kg^{-1})	1.82
K^+ (cmol kg^{-1})	0.31
Na^+ (cmol kg^{-1})	0.59

Table 2: Effect of rice husk on soil bulk density and total porosity

Treatment Rate	**Bulk density (g cm^{-3})**		**Total porosity (%)**	
	2012	**2013**	**2012**	**2013**
Control (RH_0)	1.37	1.34	48.3	49.3
RH_2	1.33	1.29	49.8	51.3
RH_4	1.26	1.19	52.5	55.1
RH_6	1.22	1.17	54.0	55.8
Mean	1.29	1.26	51.2	52.9
Significance	0.001**	0.002**	0.007**	0.016**
C.V (%)	0.1	0.50	0.50	0.20
LSD $_{(0.05)}$	0.0283	0.0384	1.729	4.303

RH_2= Rice husk at 2 tons ha^{-1}, RH_4= Rice husk at 4 tons ha^{-1}, RH_6 = Rice husk at 6 tons ha^{-1},
C.V= Coefficients of variation, LSD= Least significant difference, **= Significant at 5%.

Table 3: Effect of rice husk on pH, available P, organic matter, total nitrogen and electrical conductivity.

Treatment	Soil acidity (pH)				Available P (ppm)		Soil organic matter (%)		Total nitrogen (%)		Electrical Conductivity (mmhos/cm)	
	KCl		H_2O									
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control	5.87	5.92	6.15	6.16	3.50	3.40	1.13	1.14	0.087	0.086	52.5	47.5
RH_2	6.01	6.22	6.28	6.50	3.55	3.80	1.32	1.41	0.090	0.098	40.0	15.0
RH_4	6.22	6.47	6.53	6.57	3.56	4.45	1.38	1.51	0.092	0.130	30.0	10.0
RH_6	6.38	6.63	6.67	6.78	3.60	4.90	1.45	1.60	0.092	0.131	25.0	10.0
Mean	6.12	6.50	6.40	6.50	3.55	4.14	1.32	1.42	0.090	0.111	36.9	20.6
Fprob.	<0.001**	<0.001**	<0.001**	<0.001**	NS	0.002**	<0.001**	<0.001**	NS	NS	0.012**	0.008**
C.V (%)	0.2	0.2	0.2	0.2	2.9	2.1	1.0	0.8	0.6	10.0	7.2	4.3
LSD $_{(0.05)}$	0.0850	0.0121	0.0672	0.0450	0.3182	0.3375	0.0426	0.0536	0.0043	0.0439	10.77	14.16

Table 4: Effect of rice husk on exchangeable bases and cation exchange capacity.

Treatment	Exchangeable bases (Cmol/kg)								Cation Exchange Capacity (Cmol/kg)	
	Ca^{2+}		Mg^{2+}		K^+		Na^+			
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Control	3.49	3.43	1.82	1.84	0.31	0.31	0.59	0.66	6.20	6.23
RH_2	3.57	3.61	1.84	1.96	0.34	0.40	0.60	0.70	6.34	6.66
RH_4	3.63	3.81	1.87	1.97	0.36	0.41	0.66	0.75	6.53	6.94
RH_6	3.68	3.85	1.90	2.20	0.38	0.48	0.69	0.80	6.62	7.33
Mean	3.59	3.67	1.82	1.99	0.35	0.40	0.63	0.73	6.42	6.79
Fprob.	NS	0.011**	0.007**	0.036**	0.006**	0.009**	0.024**	0.008**	0.010**	0.007**
C.V (%)	0.6	0.4	0.4	1.9	2.0	0.9	0.8	2.1	0.8	0.8
LSD$_{(0.05)}$	0.1463	0.1674	0.0260	0.1991	0.0216	0.0566	0.0532	0.0486	0.1574	0.3400

The findings of Njoku and Mba (2012) however contradicts this as their result showed that the unburnt waste and a mixture of burnt and unburnt waste at 20 t/ha significantly increased total nitrogen in all three years, while unburnt at 10 t/ha increased total nitrogen, as did the mixture at same rate.

Table 4 shows the effect of the treatments on exchangeable bases and cation exchange capacity. CEC produced significant effects ($p=0.05$) when the amended plots were compared with the controls. Control had 2.3, 5.3 and 6.8 % lower CEC than RH_2, RH_4 and RH_6 respectively in the first season while in the second season, control had 6.9, 11.4 and 17.7 % lower CEC than RH_2, RH_4 and RH_6, respectively. The higher CEC values recorded within the amended plots could be attributed to the level of organic matter in the rice husk material and also the quantity of organic material elements released from the organic matter when mineralized. This is in line with the observation of Mbagwu *et al.* (1991) who reported that organic matter contributed to the cation exchange capacity of soil with low activity clays, while Owolabi *et al.* (2003) showed that organic matter tended to buffer soils and cause the release of exchangeable cations during mineralization of organic matter. Recent studies (Adeleye *et al.*, 2010; Ayeni *et al.,* 2008; Mba, 2006) have shown similar results.

The exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) showed significant difference ($p = 0.05$) between treatments in both seasons except Ca^{2+} that was not significant in the first season. However, there were 5.4 and 12.2 % increase in Ca^{2+} in plots amended with 6 t/ha in the first and second seasons compared to the control. Mg^{2+} had 4.4 and 19.6 % increase in plots amended with 6 t/ha over the controls in both season with the highest value (2.20 Cmol/kg) in the second season. Similarly, plots amended with 6 t/ha had the highest values of 0.38 and 0.48 Cmol/kg which represent an increase of 22.6 and 54.8% in K^+ for the two seasons. It was observed that the rice husk contributed more K^+ to the soil than any other exchangeable base.

Na^+ was increased at 16.9 and 21.2% with values of 0.69 and 0.80 Cmol/kg in plots amended with 6 t/ha in both seasons. This agrees with the findings of Njoku and Mba (2010). They showed that the application of rice husk significantly increased exchangeable bases of the soil relative to the control and in general, the increase was proportionate to rate of application. Adeleye *et al*., (2010) also showed that application of organic amendment increased soil exchangeable Mg, Ca, K, and Na, and lowered exchangeable acidity.

Electric conductivity (EC) was reduced in amended plots than control plot and its value reduced relative to application rate. The second season had the lowest EC value (10 mmhos/cm) compared to the first season having a value of (25mmhos/cm) on plot amended with 6 tons/ha of rice husk.

Conclusion

The results obtained from this study have shown that both physical and chemical properties were significantly improved by the application of rice husk dust. The improvement relative to control increased as the rate of application was increased; the improvements were higher in the second year than in the first which shows that the rice husk decomposed at a slow rate. Application of rice husk encouraged stability, maintenance and improvement of soil physical and chemical properties which in turn enhances soil productivity.

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Sandy loam soils are dominated by sand particles, but contain enough clay and sediment to provide some structure and fertility. There are four different types of sandy loam soil that are classified based on the size of the sand particles in the soil. You can determine whether your ...Â Sandy loam soils are dominated by sand particles, but contain enough clay and sediment to provide some structure and fertility. There are four different types of sandy loam soil that are classified based on the size of the sand particles in the soil. You can determine whether your yard has this kind of soil using a simple test. Classification. Sandy loam soils are broken down into four categories, including coarse sandy loam, fine sandy loam, sandy loam and very fine sandy loam. Soil properties were compared in adjacent 50-year-old Norway spruce, Scots pine and silver birch stands growing on similar soils in south-west Sweden. The effects of tree species were most apparent in the humus layer and decreased with soil depth. At 20â€“30cm depth in the mineral soil, species differences in soil properties were small and mostly not significant. Soil C, N