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Evaluation of Organic Wastes on Some Selected Soil Physical Properties and Yield of Maize (Zea Mays L.) in an Ultisol of South Eastern Nigeria Previously Contaminated with Spent Lubricant Oil.

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Abstract
This study conducted in Abakaliki during 2007 and 2008 cropping years to evaluate the effect of organic wastes on soil physical properties and yield of maize **(Zea Mays L.)** in an ultisol previously contaminated with spent lubricant oil. The soils were contaminated with twenty (20) litres of spent lubricant oil sourced from the mechanic village Abakaliki and uniformly sprayed on each plot and amended with saw dust, unburnt rice husk dust and burnt rice husk dust. The control plot had no spent lubricant oil contamination. The experiment was laid out in Randomized Complete Block Design (RCBD). An improved variety of maize (Oba super II) was used as a test crop. The result indicated that there were ($P<0.05$) significant differences among the treatments and on grain yield, bulk density, hydraulic conductivity, macro porosity, aggregate stability and mean weight diameter. Similarly, the result showed that unburnt rice husk dust treatment recorded 5.08%, 25.49%, 46.43% and 25.35% increments for hydraulic conductivity, total porosity, macro porosity, respectively over control treatment. The result therefore, proved that remained organic wastes in the soil contaminated with spent lubricant oil could improve soil physical properties and agronomic yield of maize.
Keywords: Ultisol, Soil physical properties, spent lubricant oil, yield of maize, Abakaliki

INTRODUCTION

The hazardousness of an oil product depends on the properties of the oil, the base of the oil type (mineral oil, synthetic oil or natural oil), the additive type, as well as the concentration and viscosity of the oil (Kuokkanen *et al.*, 2005). Lubricant oil affect soil properties such as bulk density, soil porosity, infiltration rate, hydraulic conductivity, soil pH, moisture content, soil type and amount of major nutrients (Lee *et al.,* 1993). Hydrocarbons are common contaminants found in soil and groundwater as a result of past and present industrial activities (Caravaca and Roldan, 2003).
Soil physical properties (texture, structure, density, porosity, water content, consistence, colour and temperature) are dominant factors affecting the use of soils. The success or failure of agricultural projects and arable farming often hinges on the physical properties of soil, because they are more difficult to change than chemical properties (Chude *et al.,* 2011). There is need to emphasize on efforts that could as well address the physical constraints of the soil.
Observation by Amadi *et al.* (1993) in a greenhouse study on maize germination in oil polluted soils supported the findings of Schwindinger (1968), Udo and Fayemi (1975), and McGill and Nyborg (1975) that increasing the concentration of oil beyond 3% in soil reduces percentage germination by oil coating on seed surfaces thereby affecting physiological functions within the seed. However, by decreasing the soil bulk density with saw dust in the experiment of Amadi *et al.* (1993), the soil volume available for contact with oil was reduced. Consequently, the degree of inhibition of the physiological functions was reduced. This difference in oil effect was evident in the unpolluted soil when compared with oil-polluted, nutrient-supplemented and non-supplemented soils.
Spent lubricating oil includes mono-and - multi grade crankcase oils from petrol engines, together with gear oils and transmission fluids with significant levels of heavy metals and other undesirable properties present in all petroleum products. Atuanya (1987) observed that Nigeria accounts for more than 87 million litres of spent oil annually and most heavy metals such as Va, Pb, Ni, Cu and Zn which are below detection in unused lubricating oil, showed high values in waste motor oil.
The potential for improving soil organic levels and crop yields through the application of organic materials is widely studied (Titiloye, 1982; Agboola and Adeoye, 1990; Anikwe, 2000). However, rice husks (burnt and unburnt rice husk dust) have received less research attention compared with materials like compost and farmyard manures. These by-products are not effectively utilized and often disposed in such a way that can increase environmental pollution and sometimes pose a health hazard to the community. In Ebonyi State of southeastern Nigeria, large quantities of these fresh and partially burnt rice-mill wastes accumulate from numerous rice mills in different parts of the State. Despite the magnitude of these wastes generated daily and the possible effects on the environment, no serious attempts have been made either for their effective utilization or safe disposal (Nwite

et al., 2011). Ash which is a good acid neutralizing agent and has the ability to supply the soil with bases can be used to amend such soils with acidic characteristics. It has been stated that ash can be used to counteract natural and anthropogenic acidification of soil and loss of nutrients (Adekayode and Olojugba 2010). However, rice husk dust is an excellent source of organic matter and contains an estimated of 0.45%,0.25% and 0.45% nitrogen, phosphorus and potassium, respectively, and thus, plays a role in nutrient up-bringing (Nwite *et al.*, 2009).

In regard to the above reports, continued crop production in soils treated with such amendments like rice husk dust can gradually decrease the organic matter content of the soils and, hence, soil fertility and crop yields. Therefore, applying ash to farmland after recycling has been one effective way to improve the physical properties of soils.

The general objective of this study is to investigate and determine the effect of organic wastes on physical properties of an Ultisol previously contaminated with spent lubricant oil as well as the growth and yield of hybrid maize, and the specific objectives are to (1) Investigate the physical properties of the soils (2) Ascertain the effects of organic waste amendments on the physical properties of the soils and (3) Determine effects of various organic amendments on crop performance indicators and yield.

MATERIALS AND METHODS

Description of study location

This experiment was conducted at the Teaching and Research Farm of the faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The site is located by latitude $0^{0}6\ 45^{/}$N and longitude $08^{0}\ 30^{/}$E in the derived savannah agroecological zone of Nigeria. The area experiences bimodal pattern of rainfall with the first peak occurring between April and July and the second between September and early November. There is short spell in August, normally called " *August break*". The area has an average annual rainfall range of 1700 to 20000 mm and mean annual temperature ranging from 27^{0}C to 31^{0} C. The soil belongs to the order Ultisol and classified as Typic Haplustult (FDALR, 1985). The vegetation of the area is rainforest with mainly grass lands. The natural vegetation of the area consists mainly of secondary forest. The major land use types in the study area arable crop production, cash crop production and non-agricultural uses such as residential, commercial and local roads. The major combinations of crops were cassava/maize/yam and cassava/maize inter-cropping.

Field study

The experiment was carried out in 2007 and 2008 cropping seasons. The experimental site measuring 25 X 50.4 m (0.1260 ha) were cleared, ploughed and harrowed and made into seed beds. Taps, pegs and ropes were used to demarcate the area into blocks and plots. The experiment was laid out in a randomized complete block design (RCBD) with four treatments replicated five (5) times to give a total of twenty experimental plots. The plot measured 2m X 2m with a spacing of 0.5 m apart between plots and 1m space between blocks.

Twenty (20) litres of spent lubricant oil sourced from the mechanic village of Abakaliki was spread uniformly with a spraying machine on each plot except the control. It was allowed for one week to settle into soil. Thereafter, three treatments of organic wastes: sawdust (SD), unburnt rice husk dust (URHD) and burnt rice husk dust (BRHD) were applied at an equal rate of 20 tha^{-1} each to the plots except in the control plot. The nutrient contents of the organic amendments are shown in Table 1.

Maize seeds of hybrid variety (Orba Supper 11) sourced from Ebonyi State Agricultural Development Programme (EBADEP) was used. The seed was treated with apron plus before planting to avoid pre-germination attack by pests. It was planted at a spacing distance of 75 cm and 50 cm inter and intra rows, respectively. Two maize seeds were planted per hole and spaced 25 cm X 75 cm. They were later thinned down to one plant per hole giving twenty-one (21) plants per plot and 53,333 plants per hectare. Weeding was done two (2) weeks after planting (WAP).

Agronomic data

At two weekly intervals, six plants from a net plot of plants population per plot were sampled for plant height using calibrated meter rule. The plant height was taken at every two weeks interval until crop matured. Harvest was taken at maturity after four months of planting which was determined by drying off the husk.

Soil sample collection and laboratory analyses

Soil sampling was done at two intervals: pre-planting and post harvest. Eight soil samples (four core samples and four auger samples) were randomly collected from the experimental site after clearing at a depth of 0-20cm for initial soil characteristics. The core samples were used to determine the physical properties of the soil while the auger samples were used to determine the pre-planting chemical properties of the soil.

At harvest, another four core soil samples were randomly collected from all the plots for physical analyses to determine the changes that occurred due to treatments application. The auger soil samples were air-dried and sieved with 2-mm sieve, and analysis done using the soil fractions less than 2 mm. Bulk density was determined using the method described by Blake and Harte (1986).The textural class were determined from the USDA soil textural triangle. Total porosity was by Obi (2000) method. Hydraulic conductivity was by Klute (1998) method. Aggregate stability was determined using the mean weight diameter method as described by Kemper (1965).

Particle size distribution was determined using Gee and Bauder (1986) method.

Data analyses

All data collected were subjected to analysis of variance (ANOVA) using SAS version 8.1 of SAS Institute, Inc., Cary, NC., and the Fisher's Least Significant Difference (F-LSD) was used to separate treatment means.

RESULTS AND DISCUSSION

The result of pre-planting soil analyses are shown in Table 1. The values obtained in the particle size distribution indicated that %sand, %silt and %clay were 64.80, 20.40 and 14.80 respectively. The soil is sandy loam.

The result of the residual effect of organic wastes on particle size distribution of soil contaminated with spent lubricant oil are shown in Table 2. There were no changes in particle size distribution of the soil. In all the amended soils, the texture as expected remained the same (sandy loam) as it was before the application of the amendments.

Effects of soil amendments on the soil bulk density, hydraulic conductivity and total porosity are shown in Table 3. The results show that control treatment recorded the highest bulk density value of 1.79 gcm^{-3} while unburnt rice husk dust treatment had the lowest value of $1.50cm^{-3}$ thus indicating a lower trend with addition of amendments. Pauletto *et al.* (1990) have noted that residual effect of organic wastes in soil reduce bulk density of the soil. Mbagwu (1992) showed that the decrease in bulk density obtained with rice-shaving and poultry manure treated soil were directly related to increased organic matter which played a significant role in reducing compaction of soil. Werner (1997) reported increase in total porosity as a result of low bulk density. As source of organic matter the organic amendments promotes soil faunal activity and plays a major role in the build up and stabilization of soil structure. The significant decrease in soil bulk density could be attributed to the direct and indirect effect of soil organic matter (SOM) levels. Indirectly, the decrease is as a result of bulk density decrease and improved structure as is partly substantiated by increased porosity.

The results (Table 3) showed that the residual effect of organic wastes on hydraulic conductivity of soil contaminated with spent lubricant oil had significant ($P<0.05$) differences. It also showed that unburnt rice husk dust treatment recorded the highest value of $1.81cmhr^{-1}$ while the control treatment had the lowest value of 1.12 $cmhr^{-1}$. These observations are synonymous with Mbagwu (1992) who noted that organic wastes affect the hydraulic conductivity of soil.

Total porosity was significantly ($P<0.05$) improved in all amended plots compared to the control plots. The result further indicated that unburnt rice husk dust treatment had the highest total porosity value of 0.28% , while control treatment had the lowest value of 0.15%. Mbagwu (1989) similarly observed the effects of organic wastes amendments soil total porosity. Earlier studies by Haynes and Naidu (1998) showed improvements in soil physical properties as a result of addition of organic and inorganic amendments.

The results in Table 4 showed the effects of macro porosity, micro porosity, aggregate stability and mean weight diameter. The result indicated that macro porosity was significantly ($P<0.05$) enhanced by the treatments. Unburnt rice husk dust treatment had the highest macro porosity value of 0.28%, while control treatment had the lowest value (0.15%). Generally, all the treated plots improved macro porosity higher than the control. Mbagwu (1989) noted the positive effects of organic waste amendments on some physical properties of the soil, macro porosity inclusive.

Micro porosity result indicated that there were significant ($P<0.05$) differences among the treatments (Table 4). The results also showed that unburnt rice husk dust treatment had the highest micro porosity value of 43.27% while control treatment had the lowest value of 32.30%. Jojnston (1986) observed that the remains of organic wastes affect soil use and management.

The results of aggregate stability showed significant differences among the treatments at ($P<0.05$) in table 4. The result also indicated that unburnt rice husk dust treatment recorded the highest aggregate stability value of 34.92% while control treatment recorded the lowest value of 29.96%. The result shows that statistical higher aggregate stability was obtained from UBRHD amended plots compared to BRHD and SD treated plots. Kemper and Resonau (1986) observed the significant effect of organic wastes on aggregate and size distribution of soil.

The results of total mean weight diameter indicated that the treatments showed significant differences among treatments at ($P>0.05$) with each of the amended plots showing higher value than the control in table 4. The results also showed that unburnt rice husk dust treatment had the highest mean weight diameter value of 2.02% while the control treatment had the lowest value of 1.64%. Humbling and Davies (1977) noted that remains of organic wastes influence the mean weight diameter of the soil.

Result in Table 5 showed that there were no significant ($P>0.05$) difference among the treatments. The result further indicated that unburnt rice husk dust gave the highest mean value (188.05) of plant height than plots treated with burnt rice husk dust (182.90) and sawdust (183.54). It was also observed that at 8 WAP, plots treated with unburnt rice husk dust statistically performed better than other amendments including the control plots. The observed high yield reduction in amended plots could be due to higher decomposition rates and rapid loss of nutrients through erosion and massive leaching (Haynes and Naidu, 1998) as reported by Mbah and Onweremadu (2009).

Table 7 showed the effects of soil amendments on leaf area index of soil contaminated with spent lubricant oil. The result indicated that there were no significant differences among the treatments at ($P<0.05$) at all the sampling periods in leaf area index. The result also showed that unburnt rice husk dust treatment had the highest leaf area index values of 26.50, 37.70, 67.90 and 74.17 for 2, 4, 6 and 8 sampling periods (WAP) respectively. It was observed that there was better performance in number of leaves of plots treated with unburnt rice husk dust when compared to burnt rice husk dust and saw dust. The performances on the mean plant height and leaf area index also reflected on the maize yield performance as plots treated with unburnt rice husk dust at 8 WAP gave the highest maize grain yield weight.

Table 6 shows the residual effect of organic wastes on grain yield of maize on soil contaminated with spent lubricant oil. The result showed that there were significant ($P<0.05$) differences among the treatments in grain yield of maize. It also indicated that unburnt rice husk dust treatment recorded the highest grain yield (1.40 tha^{-1}) while the control treatment recorded the lowest yield value of 0.64 tha^{-1} .This further indicated unburnt rice husk dust treatment increased maize grain yield by 28.57%, 21.43% and 54.29% over saw dust, burnt rice husk dust and control treatments respectively. Rainer (2001) noticed that treatment of contaminated soil with organic wastes improved the humus content of the soil, which enhanced good yields of crops.

CONCLUSION

Soils of the tropics which are known to be so poor in nutrients, low in pH and exchange capacity can be appreciably improved by the application of soil amendments like unburnt rice husk dust and burnt rice husk dust and saw dust that is affordable and easily accessible to farmers, thereby improving the quality of the tropical soils and thus increased crop yield. The result of the residual effect of organic wastes on soil physical properties and maize yield contaminated with spent lubricant oil showed that the plots with remains of organic wastes improved greatly over the control plot in almost all the parameters studied. In all the amended soils, the texture as expected remained the same (sandy loam) as it was before the application of the amendments. Also, plant height , leaf area index and grain yield of maize of unburnt rice husk dust treatments recorded the highest values thereby increasing in the order UBRHD>BRHD>SD when compared to the treatment respectively.

Generally, it was observed that the amended plots of the three soil amendment types increased the soil physical properties and better yields more than the control.

Therefore, it is recommended that farmers should improve their soil application of organic wastes especially unburnt rice husk dust to remediate soil contaminated with spent lubricant oil.

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Table 1. Selected properties (pre-planting) of the experimental site and organic wastes applied.

Parameters	Soil	SD	UBRHD	BRHD
Particle size distribution				
Sand (%)	64.80	-	-	-
Silt (%)	20.40	-	-	-
Clay (%)	14.80	-	-	-
Textural class	Sandy loam	-	-	-
pH (H_2O)	5.0			
Available phosphorus (Cmol/kg)	41.50	45.70	42.50	43.65
Nitrogen (%)	0.04	0.05	0.09	0.06
Calcium (Cmol/kg)	4.80	5.20	5.30	6.00
Magnesium (Cmol/kg)	3.25	3.80	3.90	3.90
Potassium (Cmol/kg)	0.14	0.18	0.25	0.16
Sodium (Cmol/kg)	9.10	11.10	11.20	10.60

SD = Saw dust, UBRHD = Unburnt rice husk dust, BRHD = Burnt rice husk dust, CO = Control.

Table 2: Residual Effect Of Organic Wastes On Particle Size Distribution Of Soil Contaminated With Spent Lubricant Oil.

Treatment	%Sand	%Silt	%Clay	Textural class
SD	60.80	18.40	13.80	sandy loam
UBRHD	61.20	17.40	13.70	sandy loam
BRHD	62.40	17.40	12.50	sandy loam
CO	64.80	20.40	14.80	sandy loam

SD = Sawdust, UBRHD = Unburnt Rice Husk Dust, BRHD = Burnt Rice Husk Dust, CO = Control

Table 3: Residual effects of soil amendments on bulk density, hydraulic conductivity and total porosity.

Treatment	Bulk density (gcm^{-3})	Hydraulic conductivity ($cmhr^{-1}$)	Total porosity (%)
SD	1.51	1.51	42.90
UBRHD	1.50	1.18	43.55
BRHD	1.74	1.13	34.49
CO	1.79	1.12	32.45
LSD	0.04	0.01	1.61

SD = Saw dust, UBRHD = Unburnt rice husk dust, BRHD = Burnt rice husk dust, CO = Control

Table 4: Residual effects of soil amendments on macro porosity, micro porosity, aggregate stability and mean weight diameter.

Treatment	Macro Porosity (%)	Micro porosity (%)	Aggregate stability (%)	Mean weight diameter (%)
SD	0.26	42.64	30.50	1.66
UBRHD	0.28	43.27	34.92	2.02
BRHD	0.17	34.32	32.84	1.94
CO	0.15	32.30	29.96	64
LSD	0.03	1.59	0.81	0.04

SD = Sawdust, UBRHD = Unburnt Rice Husk Dust, BRHD = Burnt Rice Husk Dust, CO = Control

Table 5: Residual effect of organic wastes on plant height of soil contaminated with spent lubricant oil.

Treatment	Sampling periods (weeks after planting, WAP)			
	2	4	6	8
SD	26.29	54.49	118.01	183.54
UBRHD	30.4	58.52	119.01	188.05
BRHD	28.17	53.05	114.89	182.90
CO	25.38	50.63	114.15	172.69
LSD 0.05	NS	NS	NS	NS

SD = Sawdust, UBRHD = Unburnt Rice Husk Dust, BRHD = Burnt Rice Husk Dust, CO = Control

Table 6: Residual effect of organic wastes on leaf area index of soil contaminated with spent lubricant oil

Treatment	Sampling periods (weeks after planting, WAP)			
	2	4	6	8
SD	24.70	39.00	65.90	73.34
UBRHD	26.50	39.90	67.90	74.17
BRHD	25.00	39.00	66.00	73.35
CO	24.60	37.70	65.80	71.17
LSD 0.05	NS	NS	NS	NS

SD = Sawdust, UBRHD = Unburnt Rice Husk Dust, BRHD = Burnt Rice Husk Dust, CO = Control

Table 7: Effect of soil amendments on mean yield of shelled maize grain (t/ha)

Treatment	Yield (tha^{-1})
SD	1.00
UBRHD	1.40
BRHD	1.10
CO	0.60
LSD (0.05)	0.01

SD = Sawdust, UBRHD = Unburnt Rice Husk Dust, BRHD = Burnt Rice Husk Dust, Co = Control