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Influence of Rice Husk Ash in the Amendment of Automobile Polluted Soil in Owerri South-Eastern Nigeria

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ABSTRACT

The influence of rice husk ash on the growth performance of beans and pumpkin grown on automobile polluted soil was carried out at the school of Agriculture and Agricultural Technology (SAAT), Federal University of Technology Owerri. The experiment was a Completely Randomized Design (CRD).Before the seeds were planted, 8 kg of automobile polluted soil were measured into twelve polyethylene bags (five for Pumpkin and five for bean seeds). Rice husk ash was added in varying quantities 50, 100, 150, 200 and 250 g representing TF1 to TF5 and TB1 to TB5. Two bags of the soil samples served as control. Agro-morphological parameters of the plants were recorded for one month after planting. The result showed that treatment five (T_5) for both beans and pumpkin seeds (planted in polluted soil with addition of 250g of rice husk ash) performed significantly better than T4, T3 and T2. Treatment one (T_1)had the least performance at $P \leq 0.05$. The chemical analysis of rice husk ash revealed that rice husk ash contain important nutrients such as Calcium, Potassium, Nitrogen, Iron and Magnesium in large quantity and these nutrients are needed by plants to grow and perform well.This study recommends that rice husk ash should be used by farmers to improve the performance of crop especially those grown on polluted soil.

Keywords: Rice Husk Ash, Amelioration, Pollution, Soil

INTRODUCTION

Anthropogenic and other natural activities can lead to pollution of soil which in turn can cause harmful effects on organisms living in the soil. Soil is the layer of organic and inorganic materials covering the surface of the earth [1, 2, 3]. The organic portion of the soil is derived from dead and decayed remains of plants and animals, and they are normally concentrated in the top soil; while the rock fragments formed by weathering of rocks make up the inorganic portion of the soil [4, 5, 6]. Artisans working in automobile workshops generate a lot of waste which include scraps of metals, used batteries, spent engine oils and worn out parts, to mention but a few. These waste materials contain pollutants such as heavy metals [7, 8, 9, 10]. Often, these activities are not monitored nor regulated in our country Nigeria and this leads to increased levels of heavy metals and hydrocarbons in the environment. The soil is at the receiving end, hence large amounts of these metals and hydrocarbons are deposited in the soil at concentrations which are dependent on the source of contamination [11, 12, 13, 14]. Heavy metals are chemical elements with relatively high density that is five times the specific gravity of water [15, 16, 17]. The sorption properties of the soil which includes soil texture, pH, moisture content and cathion exchange capacity affects the ability of soil to inhibit the movement of chemicals introduced to it. Most often, runoffs carry and transport metals on the surface of the soil to the ground water [18, 19, 20]. Research works have been carried out in order to develop strategies for the management of agricultural ecosystem as well as remediation of industrial sites which have been exposed to pollutants in the past. This is in response to increased public awareness and concerns about environmental and soil pollution [21, 22, 23, 24]. Several researches have studied the positive effects of organic wastes on soil productivity [25]. Rice husk is an agricultural waste which is readily available in Nigeria and other rice producing countries. Rice husk is composed of cellulose, lignin etc.; and someminerals such as silica, alkali, and trace elements [26]. Rice husk has high content of silicon dioxide which makes it inadequate for use in the formulation of animals or human feeds. It finds use in improving soil fertility, as a substitute for inorganic fertilizer and in improving soil characteristics [27]. Rice husk when burnt can be used in the generation of power [28]. Rice husk ash is classified as a non-hazardous and non-inert residue. However, the large volume of residue littered in the production areas poses a serious risk of environmental pollution. Intense researches have been conducted at the laboratory level on the use of rice husk ash in various economic activities. Unfortunately, the resulting scientific knowledge were not translated into appropriate technologies for commercial production, hence rice husk ash have not been fully utilizedon industrial scale therefore limiting its use to agricultural soils only [29]. Many rice producers use rice husk ash on their fields but only a few studies on this subject have been documented. This has led to an indiscriminate use of rice husk ash in the amendment of polluted soil. Agronomists have demonstrated the beneficial effects of rice husk ash on the development of crops in the field. The question that readily comes to mind is the threshold dose that can be applied without causing harmful effects to plants and/or soil. This threshold dose is dependent on the effects of the rice husk ash on the soil properties [30]. Applications of rice husk ash can increase the pH and nutrient availability. It can affect the hydro-physical properties also. The magnitude of these effects will depend on the characteristics of the rice husk ask and soil, the dosage of rice husk ash, and the interaction between the soil and rice husk ash [31].Rice husk is removed during the refining of rice and becomes a waste which is either burnt by rice farmers or disposed carelessly in the environment thereby becoming a threat to the environment [32]. Hence the use of rice husk in ameliorating polluted soil will go a long way in reducing the problem of disposal of rice husk waste. This study is therefore aimed at investigating the effect of rice husk ash in the amendment of automobile polluted soil in Owerri, South-Eastern Nigeria.

MATERIALS AND METHODS

SAMPLE COLLECTION

The soil samples were collected from mechanic village workshop Amawire Okigwe road in Orji Owerri West Local government Area of Imo State. The rice husk was collected from Stine industries Ltd, Km 1 Okigwe Express way, Amachi Nnewi South LGA, Anambra State. Stine industries Ltd has been in operation since 2005. The rice husk was collected into polythene bags and taken to the laboratory, air-dried and burnt to ash. The weight of the rice husk before burning was 20kg, after burning to ash the weight of the ash was 9kg.

Treatment of the Soil with Rice Husk Ash

Twelve polyethylene bags were used. In each of the bags 8 kg of soil was added. Two of the bags served as control and contained fresh unpolluted garden soil. The bags were labeled in the following order. T1U, T2U, T3U, T4U and T5U representing 50, 100, 150, 200 and 250 g of rice husk ash in 8 kg of soil with fluted pumpkin planted in them. While T1B, T2B, T3B, T4B and T5B represents the same mixture of soil and rice husk ash but with beans planted in them. The control bags were labeled CU and CB.

Table 1: Treatment of soil with Rice Husk Ash

	Treatment	**Quantity of Rice husk ash**
1.	T_1U & T_1B	50g of rice husk ash in 8kg of soil
2.	T_2U & T_2B	100g of rice husk ash in 8kg of soil
3.	T_3U & T_3B	150g of rice husk ash in 8kg of soil
4.	T_4U & T_4B	200g of rice husk ash in 8kg of soil
5.	T_5U & T_5B	250g of rice husk ash in 8kg of soil

The sample was mixed thoroughly, watered and allowed for 7 days before planting seeds on it.

SAMPLE TREATMENT

Standard operating procedures were used to test soil properties: pH (Maxted *et al.,* 2007), bulk density (Matini, Ongoka & Tathy, 2011), particle size distribution by the hydrometer method (Bouyoucos, 2002), organic matter by the Walkley-Black rapid acid dichromate oxidation (Schumacher, 2002), cation exchange capacity by the summation of Na, K, Ca and Mg(Walkley and Black, 1934), soil total metals by aqua regia digestion (ISO, 1995).

Determination of exchangeable bases capacity**:** Exchangeable bases were determined from Ammonium Acetates (NH_4OA_c) Leachate of the soil. Exchangeable calcium and magnesium were determined by the EDTA (Ethylene Diamine Tetra-acetic Acid) versenate titration method while exchangeable sodium and potassium were determined by the flame photometer method (Chapman, 1965)

Determination of heavy metals in soil: The heavy metals copper (Cu), Zinc (Zn), lead (Pb) and Cadmium (Cd) were determined as follows; 1g of the soil sample was digested and made up to 50ml volumetric flask. The sample was further analyzed using the atomic absorption spectrophotometer (AAS). Each element had a cathode lamp. Heavy metal concentration was calculated as follows:

Heavy metal concentration = $Mg^{-1} be\ X$

1000 ml digest contains X mg element therefore 50ml digest would contain 50 X mg / 1000 element since this is from 1g soiltherefore 1000g will contain 50x/1000x100mg/l therefore heavy metal $mgkg^{-1} = 50X$ where X = concentration ($mgkg^{-1}$)

ANALYSIS OF PHYSICAL PROPERTIES OF SOIL

Determination of Moisture Content

The soil moisture content was analyzed using gravimetric method. It was done by weighing the soil samples in a weighing balance before and after drying it, and calculating its original moisture content Moisture content was calculated using the formula:

$$\% \text{ Moisture Content (MC)} = \frac{w_2 - w_3}{e_s} X 100$$

$w_3 - w_1 = 1$

where W_1 = Weight of moisture can

W2 = weight of the air-dried soil plus moisture can

W3 = weight of oven dry soil plus moisture

PLANTING METHOD

Three (3) seeds of pumpkin each were planted in the five bags (T1U – T5U) same was done for the bean seeds and the control bags (UC and BC). The plants were watered twice a day (morning and evening) Agro-morphological parameters of the plants such as leaf length, plant height, petiole length, leaf width were measured every week.

DATA ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) and results presented as mean ± standard deviation

RESULTS AND DISCUSSION

Soil pollution is a major factor which affects crop productivity, and this has necessitated studies geared towards finding out ways of remediating polluted soil in order to increase crop production and subsequently food supply. Rice husk is a waste product from rice production which can be converted to beneficial use and in so doing reduce pollution from rice husk. The nutrient composition of rice husk ash is presented in table 1. It was observed that rice husk ash is rich in potassium (3.94 mg/1000 g), phosphorus (1.14 mg/1000 g), calcium (2.04 mg/1000 g) and other nutrients needed for plant growth. Aliyu (2001); Mbah and Onweremadu (2009) also studied the importance of rice husk in soil improvement and got similar results.

Table 1: Nutrient composition of Rice Husk Ash

Parameters	Values
Ph	7.30
Organic carbon (%)	0.22
Organic matter (%)	0.38
Nitrogen (%)	0.03
Phosphorus (mg/100g)	1.14
Calcium (mg/100g)	2.04
Magnesium (mg/100g)	0.78
Sodium (mg/100g)	2.11
Potassium (mg/100g)	3.94
Iron (mg/100g)	0.20
Lead (mg/100g)	0.04
Nickel (mg/100g)	0.04
Chromium (mg/100g)	0.02

Table 2 presents the germination percentage of plants grown in varying quantities of rice husk ash. The percentage germination of both beans and fluted pumpkin was observed in this study to be high in the treatments with 150, 200 and 250 g rice husk ask added to the soil. This shows that the rice husk ash added was able to amend the polluted soil, hence the increased germination percentage.

Table 2: Effect of Rice Husk Ash on germination percentage of plants on ameliorated soil

Rice husk ash	Mean Germination		Percentage (%)	
	B	F	B	F
T1 (50g)	1	2	25	50
T2 (100g)	2	2	50	50
T3 (150g)	3	3	75	75
T4 (200g)	3	3	75	75
T5 (250g)	3	3	75	75
Control B	3	3	75	75
Control F	3	3	75	75

Legend: B = Bean, F= fluted pumpkin

Tables 3, 4, 5 and 6 show the effect of rice husk ash on the vine length, number of leaves, leaf area and petiole length of beans and fluted pumpkin grown on soil amended with rice husk ash. It is evident from the result that there was a concentration dependent effect. Better results were recorded as the quantity of rice husk ash added to the soil increased. The treatment with 250g of rice husk ash supported the growth of the exposed crops better than the other treatments, while the treatment with 50 g rice husk ash supported the growth performance the least. Treatments T3, T4 and T5 showed greater plant growth for both beans and fluted pumpkin. Chang and Sipio (2001) in their study reported that rice husk ash caused growth response in plants and that the growth response was dependent on the quantity of rice husk ash added to the soil. This corresponds with the findings in this present study. To this end, this study has shown that rice husk ash can be used as an alternative fertilizer for plant growth in areas with polluted soil, and can be used by poor farmers to improve plant yield.

Table 3: Effect of Rice Husk Ash on vine length of plants grown on ameliorated soil

Rice husk ash	Mean Vine length (cm)							
	1WAP		2WAP		3WAP		4WAP	
	B	F	B	F	B	F	B	F
T1 (50g)	1^a	0^a	15^c	1.3^a	20^c	7^b	25^d	25^d
T2 (100g)	1^a	0^a	8^b	1.5^a	25^d	20^c	30^e	42^f
T3 (150g)	1^a	0^a	10^b	1.5^a	33^e	24^d	34^e	45^f
T4 (200g)	1^a	0^a	10^b	1.8^a	35^e	28^d	37^e	48^f
T5 (250g)	1.2^a	0^a	25^d	2.0^a	38^e	33^e	42^e	54^g
Control B	1^a	0^a	18^c	1.5^a	30^e	30^e	32^e	47^f
Control F	1^a	0^a	15^c	1.5^a	30^e	25^d	31^e	45^f

Legend: WAP = Weeks after planting, B= bean, F fluted pumpkin
Mean along the column having different superscript of letters differ significantly at $P < 0.05$

Table 4: Effect of Rice Husk Ash on Number of Leaves of Plants

Rice husk ash	Mean plant height (cm)							
	1WAP		2WAP		3WAP		4WAP	
	B	F	B	F	B	F	B	F
T1 (50g)	2^a	0^a	4^b	2^a	7^c	4^b	8^c	9^c
T2 (100g)	2^a	0^a	4^b	2^a	7^c	5^b	8^c	11^{bc}
T3 (150g)	2^a	0^a	5^b	3^a	8^c	6^b	9^c	12^{bc}
T4 (200g)	2^a	0^a	5^b	3^a	8^c	7^c	10^c	12^{bc}
T5 (250g)	2^a	0^a	6^b	3^a	8^c	8^c	11^{bc}	14^d
Control	2^a	0^a	5^b	3^a	7^c	7^c	10^c	12^{bc}

Legend: WAP = Weeks after Planting, B= bean F= fluted pumpkin
Mean along the column having different superscript of letters differ significantly at $P < 0.05$

Table 5: Effect of Rice Husk Ash on Leaf Area of Plants.

Rice husk ash	Mean leaf area (cm^2)							
	1WAP		2WAP		3WAP		4WAP	
	B	F	B	F	B	F	B	F
T1 (50g)	0.4^{a}	0^{a}	0.4^{a}	1.0^{a}	4.2^{c}	3.8^{b}	6.2^{d}	20.0^{cd}
T2 (100g)	0.4^{a}	0^{a}	3.2^{b}	1.3^{a}	9.0^{ab}	6.0^{d}	11.8^{h}	21.1^{cd}
T3 (150g)	0.8^{a}	0^{a}	3.8^{b}	2.7^{d}	9.3^{ab}	9.6^{ab}	7.3^{cf}	31.5^{k}
T4 (200g)	2.5^{aa}	0^{a}	4.1^{c}	3.8^{b}	8.8^{ab}	8.4^{ab}	11.7^{h}	34.0^{k}
T5 (250g)	2.0^{aa}	0^{a}	8.4^{ab}	9.0^{ab}	10.9^{h}	28.0^{j}	13.7^{ah}	49.0^{ak}
Control B	1.5^{a}	0^{a}	4.6^{c}	7.5^{cf}	7.5^{cf}	22.8^{cc}	9.9^{ab}	48.0^{ak}
Control F	1.0^{a}	0^{a}	4.6^{c}	6.7^{d}	7.5^{cf}	21.6^{cd}	9.6^{ab}	48.0^{ak}

Legend: WAP = Weeks after planting, B = bean F= fluted pumpkin
Mean along the column having different superscript of letters differ significantly at $P < 0.05$

Table 6: Effect of Rich husk ash on the petiole length of plants on ameliorated soil

Rice husk ash	Mean petiole length (cm)							
	1WAP		2WAP		3WAP		4WAP	
	B	F	B	F	B	F	B	F
T1 (50g)	0.5^{a}	0^{a}	1.1^{b}	1.5^{b}	2.5^{d}	2.0^{d}	2.8^{e}	5.0^{g}
T2 (100g)	1.0^{b}	0^{a}	1.0^{b}	1.7^{c}	3.1^{e}	3.2^{e}	3.0^{e}	5.0^{g}
T3 (150g)	1.5^{b}	0^{a}	1.9^{c}	1.7^{c}	3.1^{e}	3.5^{e}	3.4^{e}	6.0^{h}
T4 (200g)	1.9^{c}	0^{a}	2.0^{d}	2.0^{d}	3.0^{e}	3.9^{f}	3.2^{e}	7.0^{k}
T5 (250g)	2.0^{d}	0^{a}	3.1^{e}	2.0^{d}	3.6^{e}	4.8^{f}	4.0^{f}	7.0^{k}
Control B	1.8^{c}	0^{a}	2.1^{d}	1.5^{b}	3.0^{b}	4.0^{f}	3.0^{e}	6.0^{h}
Control F	1.0^{b}	0^{a}	2.3^{d}	1.4^{b}	2.8^{e}	4.1^{f}	3.0^{e}	5.0^{g}

Legend: WAP = Weeks after planting, B = bean, F= fluted pumpkin

Mean along the column having different superscript of letters differ significantly at $P < 0.05$

RESULT OF THE SOIL ANALYSIS

Table 7: Physico-chemical Indices of Soil

Parameter	T1	T5	Unpolluted soil
pH in H_2O (1:25)	6.777	7.149	5.24
% organic carbon	1.496	1.436	1.147
% organic matter	2.580	2.476	1.977
% Nitrogen	0.130	0.128	0.186
Phosphorus (ppm/p/g)	8.61	15.61	16.34
Ca (Cmol/kg)	7.80	10.80	12.36
Mg (Cmol/kg)	1.002	3.34	4.32
K (Cmol/kg)	1.306	9.821	0.166
Na (Cmol/kg)	0.321	0.267	0.174
Exchangeable Acidity	0.840	0.560	2.502
% Sand	94.24	94.24	91.24
% Silt	4.00	5.00	2.00
% Clay	1.76	0.76	6.76
Fe (mg/100g)	2.67	2.87	1.42
Pb (mg/100g)	0.411	0.436	0.162
Ni (mg/100g)	0.037	0.030	0.023
Cr (mg/100g)	0.041	0.048	0.016

CONCLUSION

This study has shown that rice husk ash can be used as an alternative to fertilizers for plants in polluted soil and can be used by farmers who cannot afford expensive fertilizers for their crops. Good quantity of rice husk ash (200 – 250 g) is recommended in order to achieve a good performance for plants.

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