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Soil Chemical Properties and Yield of Cucumber as Affected by Rice Husk Dust, Biochar and Woodash Applications in Abakaliki, Southeastern Nigeria

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Abstract: *This study was conducted at the Teaching and Research Farm, Faculty of Agriculture and Natural Resources Management of Ebonyi State University, Abakaliki, Nigeria in 2016 to determine soil chemical properties and yield of cucumber as affected by biochar, wood ash and rice husk dust application in Abakaliki Southeastern Nigeria. Four treatments were laid out in a Randomized Complete Block Design (RCBD) with five replicates. Treatments were 5 tha^{-1} each of T_1 (Rice husk dust), T_2 (Biochar) and T_3 (Woodash) while T_0 is plot with no application of amendment was used as control. Soil samples were collected from the soil depth of 0 – 20cm before and after treatments application for the determination of soil pH, available P, total N, organic C, organic matter, exchangeable bases, exchangeable acidity, total exchangeable bases, effective cation exchange capacity and base saturation. The results indicated that the application of amendment improved soil properties and agronomic parameters studied. Since the aim of a farmer is to have high crop yield, the study suggests the use of rice husk dust, biochar and woodash at 5 tha^{-1} as soil amendment with preference given to woodash the recorded the highest cucumber yield.*

Keywords*: Amendment, cultivation, fertility, wastes, yield*

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I. Introduction

According to Brandy and Weil (2002) organic wastes are a complex and heterogeneous mixture of carbon that contains residues generated as a result of human, plant and animal activities. Lal and Kang (1982) stated that Organic wastes play a key role in sustaining soil productivity especially in the tropics where soil fertility undergoes a rapid decline when land is cleared and cultivated. Essentially, these organic wastes when added to the soil usually have residual effects since they decay and remain in the soil (Lickas and Penny, 2000), although become reduced in amount as crops are continuously grown on it. Furthermore, the organic wastes are normally converted from their organic forms to inorganic forms that could be assimilated by crops and hence remain in stable forms in the soil (Brady and Weil, 2002). According to Pain and Philips (2000), effect of organic wastes remains in the soil maintain its fertility through positive impacts on soil properties. Decomposed organic wastes improve and supply N, P, S, organic carbon, exchangeable cations of Ca, Mg and K to the soil (Allison, 2001).

According to Khanna *et al*. (1994) wood ash is characterized by high alkalinity and high Ca, Mg, K and, to a lesser extent, P contents; in contrast, it is generally poor in N. Bramryd and Fransman (1995); Eriksson (1998); Khanna *et al*. (1994); Ludwig *et al*. (2002) reported that wood ash application to soils can lead to an increment in soil pH and base cations saturation. Demeyer *et al*., (2001); Ozolinčius *et al.*, (2007) observed that wood ash induces a strong alkaline reaction (liming effect) when used as a soil ameliorant and has the ability to correct nutrient deficiencies induced by base cation leaching and soil acidification .The effect of wood ash is affected by soil properties and application rate, it can potentially replace almost all nutrients (with the exception of N) (Pitman, 2006; László *et al*., 2009). In addition, wood ash contains no sulphur and though not classified as a nutrient, it does not contribute to the carbon supply. Rice husk are the coating for the seeds, or grains, of the rice plant, to protect the seed during the growing season. These are removed from the grain during a milling process as the husk is indigestible to humans.

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Modern agriculture generates large quantities of waste during processing. Njoku *et al.*, (2011) reported that rice husk dust 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. Organic carbon in agricultural soils contributes positively to soil fertility, soil tilth, crop production and overall soil sustainability.

Biochar is a relatively new term, yet it is not a new substance. Soils throughout the world contain biochar deposited through natural events, such as forest and grassland fires (Skjemstad *et al.* 2002). Lehmann and Joseph (2009) defined biochar as a carbon-rich product obtained when biomass, such as wood, manure, or plant residues are heated in a closed system with little or no air. Biochar is a carbonaceous solid material produced by heating biomass in an oxygen limited environment through a pyrolysis process. It is intended to be added to soils as a means to sequester carbon (C) and maintain or improve soil functions. Biochar addition to soil can produce changes in the soil's chemical and physical properties including nutrient availability, CEC, pH, soil strength, and moisture holding capacity. Chan *et al.* (2008) concluded that the chemical changes in soil after biochar application reflects the properties of the biochar being applied. Several research studies have found that biochar addition to soil increases total C (Van Zwieten *et al* 2010), total N, pH, CEC, available P, and exchangeable cations (e.g. Ca, Mg, Na, and K) in soil (Chan *et al* 2008). Similarly, Major *et al.* (2010) found that biochar addition increases available Ca, Mg, and pH in soil.

Frequent use of inorganic fertilizers for a prolonged period deteriorates the surface soil characteristics and affects the availability and uptake of nutrients by the plants (Kerenhap *et al* 2007). To minimize these hazards, naturally occurring materials such as rice husk dust, biochar and woodash are better alternate to commercially available inorganic manures. The objective of the study is to determine soil chemical properties and cucumber yield as affected by rice husk dust, biochar and woodash applications**.**

II. Materials And Methods

2.1 The Study Area

This study was conducted at the Teaching and Research Farm; Faculty of Agriculture and Natural Resources Management of Ebonyi State University, Abakaliki. The area lies on longitude 6.33674^0N – 6.01177^0N and latitude 8.11267^0E –8.14136^0E in the derived savannah zone of south East Nigeria. It is characterized by high temperatures and high rain fall. The mean monthly temperature is 27^0. Rainfall starts appreciably in April and stops in October. The rainfall regime is bimodal (April – July) and (September – November), with peaks in the months of July and September. The total annual rainfall in the area ranges between 1500 to 2000mm, with a mean of 1,800mm. Humidity is high (80%) with lowest (60%) levels occurring during the dry season in April, before the raining season begins. The soil is hydromorphic and belongs to the order, Ultisol, within the Ezzamgbo soil association, derived from shale and classified as typic Haplustult (Federal Department of Agriculture and Land Resources, 1985).

2.2 Sources of materials

Rice mill wastes were collected from the rice mill factory, Abakaliki. The woodash was sourced from local Rice parboiling factory in college of Agriculture, Ebonyi State University, Abakaliki. The biochar was sourced from Golden Star Bread bakery factory in Abakaliki and the biochar was grinded into fine nature. Cucumber seed (Point Set variety) was bought from Hosanna Park in Abakaliki, Ebonyi state.

2.3 Experimental Design and land preparation

The experiment was established in a Randomized Complete Block Design (RCBD) with four treatments and five replications. The land was cleared manually using cutlass, debris was removed manually as well and each bed was cultivated using hoes. The area of land that was used for this study is 15m X 17 m (0.0255 ha). Each bed size was 3m X 3 m the distance between replications and plots were 1m and 0.5m, respectively. 5tha^{-1} each of biochar, woodash and rice husk dust were weighed and uniformly spread on the plots and then incorporated into the soil using traditional hoe while two cucumber seeds were planted per hole in a spacing 50 cm by 50 cm. Plots were made weed-free manually using hoes, cutlass, and hand pulling and harvesting was done as soon as plants reached its physiological maturity (8 weeks after planting).

2.4 Treatment detail

The treatment combinations were as follows:

$T_{0\,=}$ control (No amendment application)

$T_{1\,=}$ 5 tonnes of rice husk dust per ha

$T_{2\,=}$ 5 tonnes of biochar per ha

$T_{3\,=}$ 5 tonnes of woodash per ha.

2.5 Soil Sampling:

Initial soil samples was collected from the site before the application of the treatments at the depth of 0-20cm using soil auger, sieved in a 2mm sieved and was taken to the laboratory to determine the pre-planting soil properties. Soil samples were also collected at the depth of 0-20cm after crop harvest to determine post harvesting analysis. These soil samples were sieved in a 2mm sieve and were taken to the laboratory for the analysis of the following parameters.

2.6 Laboratory Analysis:

The following properties were analyzed before the application of the plant wastes and after the incorporation of the plant wastes to the soil.

Soil pH: Soil pH was determined by using a suspension of soil and distilled water in the ratio of 2:5 – soil: water (Mclean, 1982).

Total Organic Carbon: This was determined using procedure described by Nelson and Sommer (1982)

Total Nitrogen: Total nitrogen was determined using modified kjeldahl digestion procedure (Bremmer and Mulvaney 1982).

Phosphorus: This was determined using procedure described by Tel and Rao (1984)

Exchangeable Bases: This was determined using procedure described by Tel and Hagarty (1983).

Exchangeable acidity (EA): Exchangeable base was determined by the titration method (Jou, 1979).

Total exchangeable bases (TEB): This was calculated as the sum of the exchangeable bases.

Effective Cation Exchange Capacity (ECEC): This is the sum of EA and TEB.

2.7 Agronomic Parameters:

Five plants were picked at random from each plot and tagged and assessments of the following crop parameters were carried out on the tagged plants. After harvest, pods collected from the tagged plants were counted to determine the yield. Pod length was determined by measuring the pod with a meter rule also the plant height was taken from the soil surface to the apical tip of the plant using meter rule. The length and breadth of the plant leaf was measured to obtain the leaf area index which was estimated as its length multiplied by its maximum width and number of leaves determined by counting the number of leaves on each of the tagged plant.

2.8 Data Analysis

The data obtained in this work was subjected to analysis of variance (ANOVA). Treatment means were tested for significant difference using Fishers least significant difference (SAS, Institute Inc., 1999).

III. Result And Discussion

3.1 Initial Soil properties

Table 1 shows the initial properties of the soil before the application of the amendment.

Table 1: Initial Soil Properties

Soil properties	**Values**
Sand	408 gkg^{-1}
Silt	414gkg^{-1}
Clay	178 gkg^{-1}
Textural Class	Sandy Loam
pH	5.20 gkg^{-1}
Phosphorus	154$mgkg^{-1}$
Nitrogen	1.40gkg^{-1}
Organic Carbon	4.8gkg^{-1}
Organic Matter	8.4gkg^{-1}
Calcium	2.40 Cmol(+)kg^{-1}
Magnesium	0.070 Cmol(+)kg^{-1}
Sodium	0.180 Cmol(+)kg^{-1}
Exchange acidity	0.88 Cmol(+)kg^{-1}
Effective Cation Exchange Capacity	4.730 Cmol(+)kg^{-1}
Base Saturation	81%

3.2 Soil pH, Available P, Total N, Organic C, C: N ratio and Organic Matter As Affected by Rice Husk Dust, Biochar, Wood Ash and Applications

Soil pH, available P, total N, organic C, C: N ratio and organic matter as affected by biochar, woodash and rice husk dust applications are as shown in Table 2. There was a significant ($p<0.05$) changes among the treatments studied with respect to these parameters. Control and woodash amended plot recorded the lowest and highest pH of 5.10 and 6.30, respectively. Munecheru-Muna *et al* (2007); Mbah and Onweremadu (2009); Njoku *et al.* (2011) and Njoku and Mbah (2012) observed that the used of either rice husk dust, biochar or woodash as amended increase in soil pH level in the soil. This increase in soil pH might be attributed to increase in the exchangeable bases from the amendments. The order of increase in available P was control < rice husk dust plot < biochar plot < woodash plot. Higher content of available P in amended plots when compared to control is credited to high phosphorus content of the different amendments. This is in line with the findings of Erich (1991); Erich and Ohno (1992) that the addition of woodash amendment in the soil increases available phosphorus. Similarly, Njoku and Mbah (2012) found out that application of burnt or unburnt rice husk dust significantly increased phosphorus. In the same vein, Chan *et al* (2007) reported that the addition of biochar to the soil resulted in increased phosphorus. Control had the lowest total nitrogen of 0.14%. This observed total N in control was lower than rice husk dust plot, biochar plot and woodash plot by 91, 10 and 11%, respectively. Njoku and Ibekwe (2017) while studying response of selected soil chemical properties and maize yields (*zea mays*) as affected by animal wastes application in Abakaliki, southeastern Nigeria observed that animal wastes amended plots recorded higher total N than unamended plot. The order of increase in organic C was control < woodash plot < rice hust dust plot < biochar plot. The lowest C: N ratio was obtained in rice husk dust plot whereas the highest C: N ratio was obtained biochar plot. The lowest organic C in woodash plot might be attributed from the fact that organic carbon in the wood ash had been burnt away thus remaining only the inorganic mineral in ash residues.

Table 2: Soil pH, Available P, Total N, Organic C, C: N ratio and Organic Matter As Affected by Biochar, Wood Ash and Rice Husk Dust Applications

Treatment	**pH**	**Available P ($Mgkg^{-1}$)**	**Total N (%)**	**Organic C (%)**	**C:N**	
T_0	5.10	46.40	0.140	0.97	6.9	
T_1	5.20	56.10	0.268	1.05	3.9	
T_2	5.30	57.20	0.154	1.29	8.4	
T_3	6.30	82.00	0.156	0.98	6.3	
FLSD < 0.05	0.131	2.909	0.030	0.035	0.540	

Where T_0 = (Control – No application of Amendment), T_1 = (Rice husk dust at $5tha^{-1}$), $T_{2=}$ (Biochar at $5tha^{-1}$) and T_3 = (Woodash at $5tha^{-1}$)

3.3 Soil Exchangeable Bases, Exchangable Acidity, Effective Cation Exchange Capacity and Base Saturation As Affected By Biochar, Wood Ash and Rice Husk Dust Applications

Table 3 shows soil exchangeable bases, exchangable acidity, effective cation exchange capacity and base saturation as affected by biochar, wood ash and rice husk dust applications. There was also a significant ($p < 0.05$) differences among the treatments studied with respect to the above parameters. The lowest Ca value was observed in control. This observed calcium value in control was lower than that of rice husk dust amended plot, biochar amended plot and woodash amended plot by 20, 60 and and 10%, respectively. The order of increase of Mg was control < woodash plot < rice husk dust plot < biochar plot. Control and woodash amended plot recorded the lowest and highest K values of 0.11 and 0.15 $Cmol_{(+)}kg^{-1}$, respectively. The lowest Na value of 0.12 $Cmol_{(+)}kg^{-1}$ was recorded in control while Na in amended plots ranged between 0.13 – 0.16 $Cmol_{(+)}kg^{-1}$. The order of exchangeable acidity increase was biochar plot < rice husk dust plot = woodash plot < control.

Table 3: Soil Exchangeable Bases, Exchangable Acidity, Effective Cation Exchange Capacity and Base Saturation As Affected By Biochar, Wood Ash and Rice Husk Dust Applications

Treatment	Ca	Mg	K	Na $Cmol_{(+)}kg^{-1}$	EA TEB	ECEC	BS (%)
T_0	4.00	2.00	0.11	0.12	0.46 6.23	6.69	93.12
T_1	4.80	2.80	0.13	0.14	0.40 7.87	8.27	95.16
T_2	6.40	3.20	0.14	0.13	0.32 9.98	10.62	93.97
T_3	4.40	2.40	0.15	0.16	0.40 7.11	7.51	94.67
FLSD < 0.05	0.29	0.44	0.137	0.012	0.109	0.168	2.724

Where T_0 = (Control – No application of Amendment), T_1 = (Rice husk dust at $5tha^{-1}$), $T_{2=}$ (Biochar at $5tha^{-1}$) and T_3 = (Woodash at $5tha^{-1}$)

Control recorded lowest TEB of 6.23 $Cmol_{(+)}kg^{-1}$ which was lower than TEB in rice husk dust plot, biochar plot and woodash plot by 26, 60 and 16%, respectively. Similarly, control had the lowest ECEC of 6.69 $Cmol_{(+)}kg^{-1}$ while ECEC in the amended plots ranged between 7.51 – 10.62 $Cmol_{(+)}kg^{-1}$. The order of BS increase was control < biochar plot < woodash plot < rice husk dust plot. Njoku and Mbah (2012) observed that the application of rice husk significantly increased exchangeable bases of the soil. Chan *et al* (2007) also observed that the application of biochar to the soil resulted in increased available Na^+ and Ca^+ in the soil. The EA of the soil decreased in all amended plots when compared with control. This could be attributed from the fact that the amendment had more exchanges bases. Mbah (2006), Ayeni *et al* (2008) had shown that increase in cation exchange capacity reduce soil exchangeable acidity. Similarly, Njoku and Mbah (2012), Adeleye *et al* (2010) observed that application of rice husk dust increased soil exchangeable bases and lowered exchangeable acidity.

3.4 Agronomic parameters of Cucumber as Affected by Rice Husk Dust, Biochar and Woodash Applications

Table 4 shows the yield of cucumber as affected by rice husk dust, biochar and woodash applications. The Table also showed that plant length, pod circumference, plant height, leaf area index and yield were significant at ($p<0.05$) among treatments while number of pods and pod diameter were non-significant. The lowest plant length of 15.45 cm was observed in control. This observed plant length in control was lower than plant length in rice husk dust plot, biochar plot and wood ash plot by 7, 43 and 26%, respectively. The order of decrease in pod circumference was woodash > rice husk dust > biochar > control. Control also recorded the lowest plant height of 74.7 cm while that of plant height in amended plots ranged between 80.15 – 98.75 cm. The order of decrease in leaf area index was woodash plot > biochar plot > rice husk dust > control. Lowest number of leaves of 19.00 was observed in control whereas number of leaves in amended plots ranged between 23.00 – 27.00. Control also, recorded lowest cucumber yield value of 5.65 tha^{-1}. This lowest cucumber yield observed in control was lower than that of rice husk dust plot, biochar plot and woodash plot by 9, 4 and 37%. Thus, these results showed that the amendments improved the agronomic parameters of cucumber studied. Naylor and Smith (1989); Demeyer *et al.* (2001) showed that woodash has a positive effect on the growth and yield of agricultural crops. Odiete *et al* (2005), Iremirer (1989) also noticed the increase in crop yield due to incorporation of woodash into the soil. Mbah *et al*. (2017) while studying the amelioration of a degraded ultisol with hardwood biochar: effects on soil physico-chemical properties and yield of cucumber showed that biochar improved agronomic parameters in general and yield of cucumber in particular. On the other hand Njoku *et al*. (2011) and Njoku and Mbah (2012) also showed that rice husk dust improved soil properties and yield of crops.

Table 4: Agronomic parameters of Cucumber as Affected by Rice Husk Dust, Biochar and Woodash Applications

Treatment	Plant Length (cm)	Number of Pods	Pod Circ. (cm)	Pod Diameter (cm)	Plant Height (cm)	Leaf Area Index	Number of Leaves	Yield tha^{-1}
T_0	15.45	3.03	7.38	4.44	74.70	68.23	19.00	5.65
T_1	16.51	3.13	16.08	5.37	96.65	86.25	24.00	6.15
T_2	22.13	3.14	15.40	4.90	80.15	88.95	25.00	5.85
T_3	19.49	3.63	13.95	5.53	98.75	114.08	27.00	7.73
FLSD < 0.05	1.45	NS	1.53	NS	4.46	21.90	5.574	0.59

Where T_0= (control) T_1 = Rice husk dust), $T_{2=}$ (Biochar) and T_3 = (Woodash)

IV. Conclusion

This research showed that using rice husk dust, biochar and woodash as soil amendment improved soil chemical properties and the agronomic parameters studied. The application of woodash recorded the highest cucumber yield when compared to the yield obtained in the application of biochar and rice husk dust. Therefore, this study suggests the use of rice husk dust, biochar and woodash at 5tha^{-1} as soil amendment with preference given to woodash the recorded the highest yield.

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