**EFFECT OF CATION RICH BIOCHAR AND MICRONUTRIENT BLENDED INORGANIC FERTILIZER ON RICE YIELD IN AN ACIDIC SOIL**

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**Abstract**

Despite the large number of studies on biochar and soil properties, few studies have investigated the effects of biochar in contrasting soils. A study was conducted including three different plots including rice-husk biochar rates, inorganic fertilizer fortified with micronutrients, farmers practice and the control replications to understand the effects on selected soil properties (sand and sandy loam) in Baddegi and Ezhigi, katcha local government, Niger state. Significant changes in soil properties including increases in pH, cation exchange capacity (CEC), organic carbon, water retention at field capacity and saturated hydraulic conductivity, and reduction in bulk density, were observed at higher rates of biochar (0.5% and 1%). Mean-weight-diameter increased only at 1% biochar application rate in sandy soil, whereas it significantly increased across all the rates in sandy loam soil over the control. Electrical conductivity showed no significant increase in either soil, indicating no threat of salinity. Biochar showed a potential for ameliorating acidity, especially in slightly acidic sandy soil. Soil aggregation and water flow improved markedly in sandy loam soil over sandy soil. Further, CEC and water retention of sandy soil had pronounced effects compared with sandy loam soil. Our study highlights the importance of soil type in determining the value of rice-husk biochar as a soil amendment to improve soil aggregation, water retention and flow and CEC.

**Introduction**

Compost is defined as a bio-oxidative process that mineralize organic matter leading to stabilized final product containing humic substances (complex organic molecules) that is free of pathogen and toxics (Bernal *et al*, 2009). The best compost is a mixture of “Green” and “Brown” materials. “Green” are young sappy materials that rot quickly and are high in nitrogen like grass clippings, fish meal, young weeds and plants, fruit and vegetable crops, cut flower and soybean meal etc. they provide nutrients and moisture for the compost workforce. ‘Browns” are organic materials made from tougher materials they are usually dried and are high in carbon like fall leaves, saw dust, woodchips, cardboard, egg cartons, old straw and twigs. They provide energy and are also used or absorbing excess moisture and giving structural strength to pile (Mary Schwarz and Jean Bonhotal 2011)

There is currently an imbalance in the carbon cycle, with growing CO2 emissions to the atmosphere and lower retention of carbon by environmental compartments, making it necessary to develop methods to sequester carbon for a longer time. Agricultural, forestry, and industrial residues, poultry manure, urban waste, and sewage sludge are potential sources of biomass and materials that can be used as renewable energy sources and can contribute to significant environmental benefits through the use of the by-product, charcoal or biochar (BC)(Zhang; *et al.,* 2010). Studies have shown that applications of biochar in compost have led to positive results, especially in regard to physical, chemical, and biological properties (Gray*et al*., 2014; Lehmann *et al*., 2011;Mitchell *et al*.,2015).

Application of biochar has been shown to have a variety of effects on compost which may be associated with its impacts on carbon and nitrogen cycling. Biochar has the capacity to potentially sequester carbon, and also has agronomic benefits such as improving compost quality and nutrient availability (Sohi *et al*., 2010). Biochar amendments can alter compost nitrogen dynamics (Clough and Condron, 2010), increase soil pH, base saturation, available nutrient content, nutrient retention and CEC (Cation Exchange Capacity) ( Mukherjee and Zimmerman, 2013), and decrease Aluminum toxicity (Glaser *et al*., 2002).

Biochar is plant based materials that has been charred by a process called pyrolysis, where there is no or less oxygen. It is rich in carbon elements. Biochar is referred to the plant biomass derived materials that includes chars and charcoal while excluding fossil fuel products (Lehmann and joseph 2009). Biochar (BC) is a carbon-rich material produced by pyrolysis. In recent decade, it is widely described as a soil amendment improving soil quality. The main reason for the positive impact on compost proper­ties, plant and microbial ecosystem is a direct biochar influence on compost physical-chemical properties, nu­trients available contents, and on its ability to sorb nutrients and release them slowly into soil solution (Atkinson *et al*. 2010). Nutrient composition of biochar depends on the feedstock material and conditions of pyrolysis (Mukherjee and Zimmerman 2013).

**Aim and Objective of the Study.** The study aims to determine the effects of biochar on some macro elements municipal compost. The objectives are to determine the effect of biochar amendment and time on the pH, organic carbon and nitrogen content of the composted waste. Compare characteristics of the determined biochar-composted and non-biochar composted

**MATERIALS AND METHODS**

**Description of experimental site**

The experiment was conducted at Crop Production and Soil Science screen house located at Federal University of Technology Minna Teaching and Research Farm Gidan Kwano campus Niger State. Minna lies within Southern Guinea Savanna of Nigeria at latitude 90 31’ 2142 North equator and longitude 60 27’ 6042E. It has a sub-humid climate with means annual rainfall of about 1284mm. the temperature of minna rarely falls below 220c and the peaks are 400c (February and march) 360c (November and December) (Adeboye et al., 2011).

**Collection of municipal solid waste (MSW) separation**

The municipal solid waste was collected from a dumpsite behind the boy’s hostel (block B) at the Federal University of Technology Minna, main campus (Gidan kwano) Niger State. The dumpsite consist mainly consist of home and kitchen waste. Shovel was used to turn over the waste pile so as to open up the inner materials that are considered biodegradable. The municipal waste was collected in to two (2) bucket size of 14 Liters which was transported to the experimental site.

**Municipal solid waste separation**

The municipal solid waste was separated using manual separation method. This method was employed because the municipal solid waste consists of materials of uniform sizes therefore, materials like polythene, paper tins and contaminants (batteries) were picked by hand.

**Composting material proportion**

The compost material used include the following materials with their corresponding weight equivalent: municipal waste 4kg, rice husk biochar 1kg, eucalyptus green leave 0.2kg and rice straw 0.2kg.

**The compost mix**

A total of six(6) compost pile was made; the first pile (P1) contain rice straw, eucalyptus leave, municipal compost waste and rice husk biochar with three replication (PB1,PB2 and PB3) while the other pile contains all the various ingredients with the exception of biochar with three replication (PNB1, PNB2 and PNB3). This variance in biochar addition is to determine the effect of biochar on P1 relative to macro element content and compare with the result that will be obtained from P2 that is without biochar.

**Laboratory analysis**

**Determination of organic carbon (Wet oxidation)**

One gram of air dried 0.5 mm sieved soil was weighed in to a 259 ml conical flask and 5ml of potassium dichromate (K2Cr2O7) was added and the flask was gently swindled to disperse the soil in solution. 10 ml of concentrated sulphuric acid was added and solution was mixed thoroughly then allows to stand on asbestos pad for 30minutes to cool down, 100 ml od distilled water and 4 drops of ferroin indicator was added and the solution was titrated against 0.5 N ammonium ferrous sulphate ((NH4) FeSo4). The color changes from greenish grey to green then finally to a brown color which is the end point ( Walkey and Black, 1934).

**Determination of Total Nitrogen**

Total nitrogen was determined by Kjeldahl technique. It involves 3 processes; Digestion, distillation and titration.

In digestion, one grams of sample passed throughout a 0.5 mm sieve was put into the kejldahl digestion tube, 20 ml of conc. H2So4 and kjeldahl tank to accelerate the reaction. The tube was heated at 360°C to produce a colorless digest which was transferred to a standard flask and distilled water was added to the 100 ml.

In distillation, the digest and 10 ml NaOH was introduced to a purification chamber a flask containing 100 ml of boric acid was placed to collect purified digest.

The digest was titrated against 0.1N, H2SO4 by micro berrete. A blank without soil was prepared also.

**Statistical Analysis**

The data collected was subjected to analysis of variance (ANOVA) at 5% level of probability where significant difference between means were observed, Duncan’s multiple range test was used for mean separation.

**RESULTS**

Table 4.1.1 the effect of biochar amendment and time on the pH of compost derived from municipal waste. The result as presented in table 4.1.1 showed that biochar and no biochar had a significant effect on pH in both water and KCl. The result also showed that time had a significant effect in water but had no significant effect in KCl. However, biochar recorded high pH value in water and KCl than with no biochar. The pH for biochar and no biochar were neutral.

**Table 4.1 Effect of biochar amendment and time on the pH (1:2.5) of the compost derived from the municipal waste**

|  |  |  |
| --- | --- | --- |
|  | **pH in water** | **pH in KCl** |
| **Treatment** |  |  |
| **Biochar amendment** |  |  |
| Biochar | 7.22a | 6.83a |
| No biochar | 6.93b | 6.79b |
| **SE±(0.05)** | 0.04 | 0.01 |
| **Time (weeks)** |  |  |
| 2 | 7.00b | 6.81a |
| 4 | 7.04b | 6.81a |
| 6 | 7.09ab | 6.82a |
| 8 | 7.17a | 6.82a |
| **SE±(0.05)** | 0.06 | 0.01 |

Means in the same column with the same letter as superscript are not significantly different at 0.05 level of probability

Table 4.2 Interaction between biochar amendment and time on pH of compost derived from municipal compost waste. The result showed that pile with biochar had a significant effect in both water and KCl. However, pile with biochar at 8th week was slightly alkaline (7.43) while 6th, 4th, and 2nd were neutral.

**Table 4.2 Interaction between biochar amendment and time on pH (1:2.5) of compost derived from municipal waste**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **pH in water** | | | **pH in KCl** | | |
| **Biochar Amendment** | | |  | | |
|  | | |  | | |
| **Time (weeks)** | PB | PNB | | PB | PNB |
| 2 | 7.05d | 6.95e | | 6.82b | 6.80c |
| 4 | 7.13c | 6.95e | | 6.82b | 6.79c |
| 6 | 7.25b | 6.93e | | 6.84ab | 6.79c |
| 8 | 7.43a | 6.91e | | 6.85a | 6.79c |
| **SE±(0.05)** | 0.03 |  | | 0.01 |  |

**PB=**pile with biochar, **PNB=**pile without biochar

Means in the same column with the same letter as superscript are not significantly different at 0.05 level of probability

Table 4.3 the effect of biochar amendment and time on total nitrogen and organic carbon of the compost derived from municipal waste. The result showed that biochar and no biochar had a significant effect on total nitrogen and organic carbon. It also showed that time had a significant effect on nitrogen and organic carbon.

**Table 4.3 Effect of biochar amendment and time on nitrogen and organic carbon of the compost derived from municipal waste**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Total nitrogen(g/kg)** | **Organic carbon(g/kg)** |
|  |  |  |
| **Biochar amendment** |  |  |
| Biochar | 0.84a | 13.22a |
| No biochar | 0.49b | 12.02b |
| **SE±(0.05)** | 0.05 | 0.10 |
| **Time** |  |  |
| Initial | 0.84a | 13.96a |
| Final | 0.49b | 11.28b |
| **SE±(0.05)** | 0.05 | 0.10 |

Means in the same column with the different letter as superscript are significantly different at 0.05 level of probability

Table 4.4 Interaction between biochar amendment and time on nitrogen and organic carbon of compost derived from municipal waste. The result showed that pile with biochar had a significant effect in organic carbon and nitrogen at initial and final. It was also observed that pile with biochar recorded higher nitrogen and carbon than pile with no biochar at initial and final. There was a decrease in organic carbon of both pile with biochar and no biochar at initial too final while that of total nitrogen shows an increase. The total nitrogen of pile with biochar was moderately low (1.17) at final while the pile with biochar was low (0.51)

**Table 4.4 Interaction between organic amendment and time on nitrogen and organic carbon of the compost municipal waste**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Organic carbon (g/kg)** | | **Total nitrogen (g/kg)** | | |
|  |  | |  | | |
| **Biochar amendment** | Initial | Final | | Initial | Final |
| PB | 15.12a | 11.32c | | 0.51b | 1.17a |
| PNB | 12.80b | 11.24c | | 0.47b | 0.51b |
| **SE±(0.05)** | 0.14 |  | | 0.07 |  |

**PB**=Pile with biochar, **PNB**= pile with no biochar

Means in the same column with the same letter as superscript are not significantly different at 0.05 level of probability

**Discussions**

From table 4.1 the result showed that biochar and no biochar had a significant effect on pH in water and KCl. The biochar and no biochar composted were neutral in water and KCl (7.22 and 6.88 respectively) while no biochar composted were neutral in water and KCl respectively (6.93 and 6.79 respectively). Table 4.2 showed that pile with biochar had a significant effect on PH both in water and KCl. It is also observed that pile with biochar increase in pH value from week 2nd 4th 6th and 8th. The increase in pH value overtime is likely due to the adsorption of H+ on to the negatively charged organic material and biochar from solution, thereby decreasing H+ in solution (Ockert .G. Botha 2016).The pH at 8th week was slightly alkaline (7.43)which recorded the highest pH value than 2nd 4th and 6th week**.** This increase in pH is associated with progressive loss of the acid surface of functional group (Reves *et al* 2007)**.** The increase of pH during composting stage was attributed to the production and accumulation of ammonia in the composted material. The material composted with biochar is characterized by higher pH compared to that composted without biochar addition(chen *et al*., 2010).

However, Pile with biochar had a significant effect on the organic carbon content of the compost derived from municipal waste than pile with no biochar. Analyses showed that organic carbon decrease in the final. The pile with biochar had higher organic carbon content than pile with no biochar. The decrease in organic carbon could be as a result of leaching. The application of biochar to compost derived from municipal compost waste increase the total nitrogen (table 4.3). The total nitrogen content increase in the final compost compared with the initial nitrogen value. This result is in agreement with the result obtained by (chen *et al*., 2010 and lopez-cano *et al*., 2016) they stated that, biochar addition to compost increase the content of total nitrogen in the final compost. Nitrogen losses in compost with biochar addition are reduced as a result of adsorption of NH4 or volatile NH3 on biochar surface.

**5.1 Conclusion**

The application of biochar to the compost derived from municipal waste increase the pH, nitrogen and quality of the compost derived from municipal waste.

**5.2 Recommendation**

The pile with biochar should be encouraged among farmers due to the increase in pH of the compost and increase in the release of nitrogen. The pile with biochar should be made available to farmers has it use has tremendous benefit for plant growth.

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