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# Effect of Maize Crop Residue Biochar on Pepper Performance in Minna, Nigeria

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## Abstract
*The experiment was conducted at the Horticultural Nursery of Federal University of Technology Minna, Nigeria, to determine effect of maize crop residue biochar on pepper performance in Minna. The treatments were five rates of maize crop residue biochar application (0, 5, 10, 15 and 20 tons ha⁻¹), laid down in a Completely Randomized Design (CRD) with four replications. Data collected were plant height, number of leaves, number of days to flowering, fresh and dry biomass and fruit yield. The results showed that the textural class of the soil was sandy loam, soil reaction was slightly acidic (pH 6.7), low in organic carbon (3.60 g kg⁻¹), medium in total nitrogen (0.14 g kg⁻¹) and relatively high in available P (20.72 mg kg⁻¹). Application of 10 ton ha⁻¹ of maize crop residue biochar produced the highest number of leaves, fresh and dry biomass weight, fruit yield and organic content of the soil. 10 ton ha⁻¹ of maize crop residue biochar can be considered useful for the cultivation of pepper in a pot experiment.*
***Keywords: Biochar, maize crop residue, and Minna***

## Introduction
Pepper (*Capsicum frutescence*) is an important fruit vegetable which belongs to the night shade family Solanaceae, and is related to eggplant, potato and tobacco. It is the second most important vegetable after tomatoes, it now commonly cultivated in all parts of the world. The bulk production of pepper is found in the Savanna zone and derived Savanna areas of the south western Nigeria. Nigeria produced 0.63 million metric tonnes (MT) pepper fruits in 1980 (FAO, 1980) which increased to 1.793 million MT in 2009 (FMARD, 2010). Nevertheless, pepper yield is still low, at average of 3.85 MT.ha-1, and with much lower values obtained in the southern states due to many constraints. Pepper has increased in popularity, value and importance over a long period, thus making it an indispensable part of the daily diet of millions of Nigerian. It is an important source of vitamin A and C, which protects the body against disease attack. These vitamins in pepper help in maintenances of bones, tissues and blood and in the efficient utilization of iron. Pepper is normally used as a spice in the preparation of soup and stew when cooked with tomatoes and onions. It can also be used as a condiment and extensively in flavouring of processed meat, colouring certain food preparation and also used for medicinal purposes (Chauhan, 1972). Biochar therefore can possibly help alleviate environmental change by means of carbon sequestration. Freely, biochar can expand soil ripeness of acidic soils (low pH soils), increment rural efficiency, and give security against some foliar and soil-borne maladies. Recently, it has been observed that inadequacy in soil fertility and deficiency in important mineral nutrient has possessed serious constraints to high yield of pepper production (Fagwalawa and Yahaya, 2016). This is because fertilizer has become a scarce commodity, even when available; it is beyond the reach of the poor resource farmers due to its high cost (Fagwalawa and Yahaya, 2016). In moist tropical environment, sustainable agriculture faces large constraints due to low nutrient content and accelerated mineralization of soil organic matter (Yeboah *et.al.*, 2013). The natural issue is typically mineralized quickly and just a little

extent of the connected natural issue is settled in the dirt in the long haul, however progressively discharged to the climate as CO2 (Yeboah *et.al.,* 2013). The way that various feedstuff, for example, plant deposits, maize crop residues etc. are accessible and are considered as contaminations, these waste materials can be burned and used valuably in farming. Consolidation of biochar to the dirt is advantageous in catching water to build soil dampness maintenance and accessible nitrogen hence the objectives of the study is to determine the effect of maize crop residue biochar on pepper performance and some soil chemical parameters like soil organic carbon, total nitrogen and available phosphorus.

## Materials and Methods

This experiment was conducted at Horticultural Nursery, Federal University of Technology, Gidan Kwano Minna. In the Southern Guinea Savanna of Nigeria. The pots were filled 10 kg soil. There were 5 treatment which are; 0 t $ha^{-1}$, 5 t ha $^{-1}$,10 t $ha^{-1}$, 15t$ha^{-1}$, 20 t $ha^{-1}$. The experiment was laid on a completely design (CRD) with four replications. The maize crop residue biochar was mixed thoroughly two week before sowing. Pepper seed was sown by broadcasting method on nursery bed; three seedlings were transplanted into the pot at two week after emergence. The seedling was later thinned to one seedling per pot. Water was applied on daily basis. Weeding was done on regular basis by hand pulling. Soil samples were collected randomly from the Teaching and Research Farm. The soil samples were collected from each pot at the end of the experiment to determined soil chemical analysis. Sampling was done within depth of 0 – 15cm using shovel. The samples was bulked together to form a composite sample which was air-dried and analysed for particle size and some chemical properties using the standard procedures. Soil particle size distribution was determined by the hydrometer method . Soil pH was determined in a 1:2.5 soil to water with a pH meter, while the soil organic carbon was determined using the Walkley and Black wet oxidation method , total nitrogen by the micro- Kjeldhal method. Exchangeable bases were extracted with neutral 1 N $NH_4OAC$ extraction. Na and K in the extract was determined using Flame photometry while the Ca and Mg was determined by Na-EDTA titration. Exchangeable acidity was extracted and then determined by titrimetric method and phosphorus was extracted and phosphorus was extracted using Bray P-1 method and the concentration was determined colorimetrically using atomic absorption spectrophotometer. The height of pepper was measured from the base of the plant to the tip of the plant using meter rule at 2, 4, 6, 8 10, 12 week after transplanting (WAT). The number of leaves was determined by counting of leaves on the plant at 2,4 6,8, 10,12 WAT. The days to flowering was done by visual assessment on the pepper. The number of days was calculated from the day of sowing to the date when first flower appear on each treatment pot. The number of flower was determined by counting the number of flower on each treatment pot. All the fruit harvested from the pot of each of the treatment pot was weight and recorded as fruit yield and the biomass was harvested and weighted as fresh biomass and weighed after drying as dry biomass. Data collected was subjected to analysis of variance (ANOVA) treatment means was compared using the Duncan Multiple Range Test (DMRT) at 5% level of probability.

## Results and Discussion

### Some Soil Physical and Chemical Properties

The soil physical and chemical properties before sowing are shown in Table 1. The textural class of the soil was sandy loam. The soil was slightly acidic in water (pH 6.7) and the organic carbon (3.62 g $kg^{-1}$) was low, medium in total nitrogen (0.14 g $kg^{-1}$) with relatively high available phosphorus (20.72 mg $kg^{-1}$) (Esu, 1991)

### Effect of maize crop residue biochar on growth and yield of pepper

The effect of maize crop residue biochar on plant height of pepper at different growth stage is shown in Table 2. At 2 WAT, 20 ton $ha^{-1}$ were significantly taller ($p<0.05$) than other treatments. At 6 WAT, 20 ton $ha^{-1}$ were significantly taller ($p<0.05$) than 0, 5 and 10 ton $ha^{-1}$ but similar to 15 ton $ha^{-1}$. At 8 WAT, 20 ton $ha^{-1}$ were significantly taller ($p<0.05$) than 0, and 5 ton $ha^{-1}$ but similar to 10 and 15 ton $ha^{-1}$. Similar trends were observed at 10 and 12 WAT. There was however no significantly difference among the treatment at 4 WAT. The effect of maize crop residue biochar on number of leaves of pepper at different growth stage is shown in Table 3. At 2 WAT, 15 and 20 ton $ha^{-1}$ had the higher number of leaves which was significantly higher ($p<0.05$) than 5 ton $ha^{-1}$. There was no significantly difference among the treatment at 4 WAT. At 10 WAT 15 and 20 ton ha$^{-1}$ had the higher number of leaves which was significantly different ($p<0.05$) from 5 ton ha$^{-1}$ and control, similar trends was observed at 12 WAT.

**Table 1: Some physical and chemical properties of soil prior to sowing**

| Parameters | Value |
|---|---|
| Sand (g kg$^{-1}$) | 764 |
| Silt (g kg$^{-1}$) | 130 |
| Clay (g kg$^{-1}$) | 106 |
| Textural class | Sandy loam |
| pH water | 6.7 |
| Organic carbon (g kg$^{-1}$) | 3.60 |
| Available phosphorus (mg kg$^{-1}$) | 20.72 |
| Total nitrogen (g kg$^{-1}$) | 0.14 |
| Exchangeable bases (cmol kg$^{-1}$) | |
| $Ca^{2+}$ | 4.60 |
| $Mg^{2+}$ | 2.70 |
| $K^{+}$ | 0.23 |
| $Na^{+}$ | 0.08 |
| Exchangeable acidity (cmol kg$^{-1}$) | 0.12 |
| ECEC | 7.73 |

**Table 2: Effect of maize crop residue biochar on plant height of pepper**

| | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| Treatment | 2WAT | 4WAT | 6WAT | 8WAT | 10WAT | 12WAT |
| Control | 5.50$^{b}$ | 7.33$^{a}$ | 9.17$^{b}$ | 9.67$^{c}$ | 10.00$^{c}$ | 12.00c |
| 5 ton ha$^{-1}$ | 5.17$^{b}$ | 6.50$^{a}$ | 8.67$^{b}$ | 11.33$^{bc}$ | 12.67$^{bc}$ | 14.00$^{bc}$ |
| 10 ton ha$^{-1}$ | 5.33$^{b}$ | 7.33$^{a}$ | 10.00$^{b}$ | 13.00$^{bc}$ | 14.67$^{b}$ | 16.50$^{bc}$ |
| 15 ton ha$^{-1}$ | 6.33$^{b}$ | 9.50$^{a}$ | 11.33$^{ab}$ | 15.17$^{ab}$ | 16.00$^{ab}$ | 18.00$^{ab}$ |
| 20 ton ha$^{-1}$ | 9.00$^{a}$ | 11.33$^{a}$ | 11.33$^{a}$ | 19.00$^{a}$ | 20.00$^{a}$ | 21.17$^{a}$ |
| SE± | 0.49 | 0.72 | 0.95 | 1.00 | 1.03 | 1.00 |

Means with the same letter(s) in a column are not significantly different at 5% level of probability
WAT: week after transplanting.

**Table 3: Effect of maize crop residue biochar on number of leaves of peeper**

| | Number of leaves | | | | | |
|---|---|---|---|---|---|---|
| Treatment | 2WAT | 4WAT | 6WAT | 8WAT | 10WAT | 12WAT |
| Control | 6$^{ab}$ | 9$^{a}$ | 11$^{bc}$ | 15$^{b}$ | 18$^{b}$ | 23$^{c}$ |
| 5 ton ha$^{-1}$ | 4$^{b}$ | 6$^{a}$ | 9$^{c}$ | 13$^{b}$ | 18$^{b}$ | 24$^{bc}$ |
| 10 ton ha$^{-1}$ | 6$^{ab}$ | 8$^{a}$ | 11$^{bc}$ | 20$^{a}$ | 24$^{a}$ | 28$^{abc}$ |
| 15ton ha$^{-1}$ | 7$^{a}$ | 10$^{a}$ | 13$^{ab}$ | 20$^{a}$ | 27$^{a}$ | 33$^{a}$ |
| 20 ton ha$^{-1}$ | 7$^{a}$ | 51$^{a}$ | 14a | 21$^{a}$ | 27$^{a}$ | 31$^{a}$ |
| SE± | 0.45 | 8.25 | 0.61 | 0.93 | 1.25 | 1.30 |

Mean with the same letter(s) in a column are not significantly different at 5% level of probability.
WAT: week after transplanting

The control flower earlier which was significantly different from 20 ton ha$^{-1}$ that flower at the later days (Table 4). 10 and 20 ton ha$^{-1}$ had the highest fruit yield which was significantly different ($p<0.05$) from other treatments (Table 4). Effect of maize crop residue biochar on fresh and dry biomass of pepper was shown in Figure 1. The treatment 15 ton ha$^{-1}$ recorded the highest fresh biomass and the lowest was observed in control. Similar results were observed on dry biomass of pepper. The application of organic fertilizer like biochar have shown to enhance crop and soil quality (Olowokere 2004). Remain of organic based fertilizer have shown to increase the growth of crop such as pepper (Berova *et al.,* 2010). The application of biochar to soil improves the physical and chemical environment in soil providing microbes with a more favourable habitat. This consequence aid the transformation of nitrogen held in organic form to form available for uptake by plant roots potentially improving its availability to plant (Sandip and Harsha 2013). ). Biochar provide a suitable habitat for many micro-organisms by shielding them from predation and desiccation and also provide diverse carbon energy mineral nutrient needed to plant (Warnock *et al.,* 2007). The effect of maize crop residue biochar on total nitrogen, organic carbon and available phosphorous is shown in Table 5. Treatment 10 ton $ha^{-1}$ significantly increased organic carbon content while 15 ton $ha^{-1}$ increased the available phosphorous but there was no significantly different from total nitrogen of the soil (Table 5). Positive change in soil chemical properties been recorded for different soil as result of application of biochar. These include increase in cation exchange capacity and pH of the soil (Liang *et al*; 2006; Cheng *et al*; 2008). Biochar also show as an increase in the availability of major cation phosphorus as well as total nitrogen concentration (Glaser *et al.,* 2002; Lehmann *et al.,* (2003). The volatilization of crop residue to biochar and introduction into small holder vegetable cropping system is suggested for restoring soil nitrogen in the vegetable farm as well as modifying the environmental for bioavailability and efficiency of nutrient in soil (Tagoe *et al; 2008*).

**Table 4: Effect of maize crop residue biochar on days to flowering and fruit yield of pepper**

| Parameters | Day to flowering | Fruit yield (g) |
|---|---|---|
| Control | 57.67c | 1.19c |
| 5tonha$^{-1}$ | 67.3bc | 1.51b |
| 10tonha$^{-1}$ | 67.33bc | 1.83a |
| 15tonha$^{-1}$ | 62.67c | 1.56b |
| 20tonha$^{-1}$ | 82.00a | 1.81a |
| SE± | 2.90 | 0.07 |

Means with the same letter(s) in a column are not significantly different at 5% level of probability.

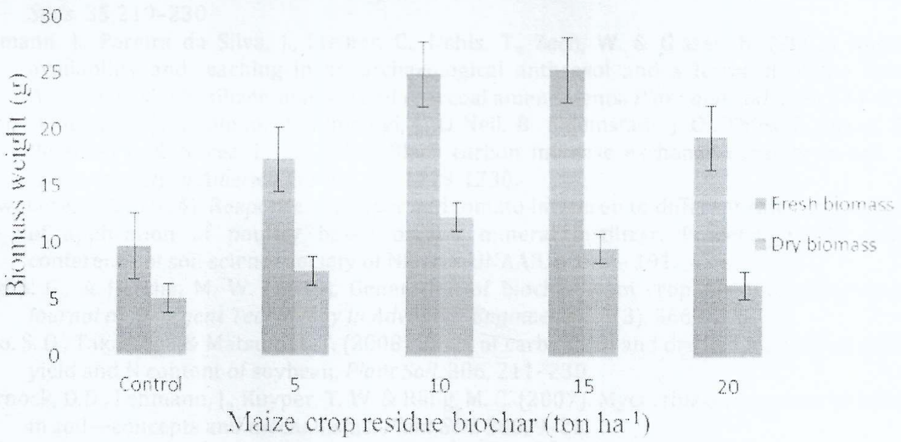


Figure1: Effect of maize crop residue biochar on biomass weight of pepper

**Table 5: Effect of maize crop residue biochar on some selected soil properties**

| Treatment | Total Nitrogen(g $kg^{-1}$) | Organic Carbon (g $kg^{-1}$) | Available Phosphorous (mg$kg^{-1}$) |
|---|---|---|---|
| Control | 0.04$^a$ | 5.64$^b$ | 19.18$^b$ |
| 5tonha$^{-1}$ | 0.04$^a$ | 7.40$^b$ | 22.90$^b$ |
| 10tonha$^{-1}$ | 0.01$^a$ | 13.08a | 22.91$^b$ |
| 15tonha$^{-1}$ | 0.05$^a$ | 6.95$^b$ | 35.79$^a$ |
| 20tonha$^{-1}$ | 0.07$^a$ | 6.40$^b$ | 14.92$^b$ |
| SE± | 0.01 | 0.26 | 2.32 |

Means with the same letter(S) in a column are not significantly different at 5% level of probability

## Conclusion

From the results of this study, 10 ton $ha^{-1}$ of maize crop residue biochar improved the growth, fresh biomass weight, dry biomass weight, fruit yield of pepper and organic content of the soil and therefore it can be considered useful for the cultivation of pepper in a pot experiment.

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