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EFFECT OF BIOCHAR PRODUCED FROM SELECTED PLANT RESIDUES ON SEEDLINGS GROWTH OF *Mansonia altissima* (A Chev.) FWTA

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Abstract: Biochar is a fine- grained charcoal high in organic carbon and largely resistant to decomposition, it is produced from pyrolysis of plant and waste feedstock. Very little scientific research has been concluded in the area of using different plant residues on the production of biochar in Nigeria. The study was conducted to produce biochar from selected plant residues and assess the effects of its application on the growth of *Mansonia altissima* seedlings. Three plant residues were used to make the biochar, weed, bamboo and cassava peel. They were grinded into powdery form, mixed with topsoil and degraded soil. The experiment was made up of four treatments, (T_0) 2 kg of topsoil (control), (T_1) 50 kg of biochar made from weeds + 2 kg of degraded soil, (T_2) 50 g of biochar from cassava peel + 2 kg of degraded soil, (T_3) 50 g of biochar made from bamboo + 2 kg of degraded soil. The experiment was laid out in a Complete Randomized Design (CRD). The growth parameters assessed included: plant height, stem diameter and leaf production. The data collected were subjected to Analysis of Variance (ANOVA). The result obtained showed that biochar T_2 performed best in height with the values of 23.4 cm, while T_0 had the least performance in height with the value of 13.88 cm. For stem diameter, T_2 performed best (6.8 mm), while T_0 had the least performance (4.8 mm).In terms of leaf production, T_2 performed best (10.2). While T_1 had the least performance of 8.8. The ANOVA result showed that there were no significant difference among the treatments at 5% level of probability in terms of plant height, stem diameter and leaf production. Addition of biochar made from cassava peel as soil amendment to *Mansonia altissima* seedlings at nursery stage, produced healthy and vigorous seedlings in a short period of time, even better than biochar made from weeds and bamboo. Therefore it was recommended that biochar application be adopted for raising seedlings of *Mansonia altissima*.

Keywords: *Mansonia altissima*, seedlings, biochar, plant residues

Introduction

Biochar is a carbon-rich product produced by the slow thermo-chemical pyrolysis of biomass materials under limited supply of oxygen (O_2), and at relatively low temperatures (<700°C). Organic wastes, such as livestock manures, sewage sludge, crop residues and composts are converted to biochars and then applied to soils as an amendment. This process often mirrors the production of charcoal, which is one of the most ancient industrial technologies developed by mankind (Harris, 1999).

The diverse range of biochar applications depends on its physicochemical properties, which are governed by the pyrolysis conditions (heating temperature and duration) and the original feedstock (Enders *et al.*, 2012). Thus, detailed information about the complete production process is a key factor in defining the most suitable application of biochars. The biochar physicochemical properties can cause changes in the soil nutrient and C availability, and provide physical protection to microorganisms against predators and desiccation; this may alter the microbial diversity and taxonomy of the soil (Lehman *et al*., 2011). Soil fertility can be successfully improved using both inorganic and organic fertilizers. The major drawbacks of inorganic fertilizers are high cost, their low accessibility to resource-poor farmers and their low efficiency in highly weathered soils (Baligar and Benenett, 1986) tendency towards environmental pollution. Organic fertilizer improves nutrient use efficiency, mineralizes easily, increases the organic matter but only lasts for few growing seasons. The complimentary use of biochar with organic or inorganic fertilizer has the tendency of improving soil fertility and tree crop productivity. Plants require organic or inorganic fertilizers for their growth and development. However, inorganic fertilizers pose threats to the environment while organic fertilizers are environmentally friendly. Biochar is also an organic fertilizer, it is a form of charcoal which contains high amounts of carbon and is synthesized by the process of pyrolysis

Mansonia altissima A. Chev belongs to the family *Sterculiaceae* (Irvine, 1961). It is a deciduous forest species growing up to 37 m in height and girth of 2.5 m, bearing a dense canopy and deciduous in dry season (Irvine, 1961). *M. altissima* has been described as vulnerable according to the IUCN Red list of threatened species (IUCN, 2014); it therefore requires urgent conservation attention. In an effort to regenerate the exploited stands starting by raising seedlings of *M. altissima*, there is a need to focus on methods that will enhance its sustainable speedy growth.

Conservation effort to promote rapid propagation of this economic species is desirable. This will reverse the current over-exploitation of the species. Inorganic fertilizers have been used by researchers particularly in the nursery to raise seedlings; due to its high cost of procurement, there is a need for alternative source of soil conditioner nutrient for rapid growth and development of seedlings at nursery stage.

The productivities of soil depend upon the supply of organic materials. Wood char can be used to improve the physical, biological and chemical condition of soil as a source of nitrogen and a carrier of fertilizer. The application of charcoal can lower the pH of acidic soils and affect microbial population and their activities in the soil (Davies, 2007). Therefore, information on how biochar affects the growth performance of *M. altissima* seedlings in the nursery can be used as substitute for conventional organic manure.

Materials and Methods

Study area

The experiment was carried out at the screen house of Federal College of Forestry, Ibadan. The College is located at Jericho area of Ibadan North West Local Government area of Oyo State, The area is on latitude 7°26’N and longitude 3°54'E of the Greenwich meridian. The climate is tropical and the area is dominated by two seasons rainy season (April to October) and dry season (November to March). Its annual rainfall is about 1400 – 1500 mm while the average temperature is 31.8°C. The average relative humidity is 65% (FRIN, 2014).

Procurement of materials

Methods

Samples of different sources A steel drum of 34.5'' x 22.5'' in dimension was used as the retort. The cover of the drum was punctured with nail in three places to allow aeration, in order to allow the gases that were produced during the pyrolysis (the process of baking biomass without air is called pyrolysis) to escape. It was then loaded with the different plant residues and sealed. The bamboo was subjected to pyrolysis before the cassava peel and later the weeds. The retort was placed on top of four concrete blocks measuring 6'' x 8'' x 16''. Fire was set underneath the retort and kept burning. After 37 min, the content inside started to outgas. The content stopped out-gassing after 4 h 47 min of heating for the complete heating process while the heating process for cassava peels lasted 4 h 28 min and 5 h 13 min for the weeds. The drum was removed from the fire and allowed to cool. The biochar were removed 1 h after the cooling process.

The biochars were grounded into powdery form. Fifty grams each of weed, bamboo and cassava peel were mixed with 2 kg each of degraded soil before potting and then watered. Healthy *Mansonia altissima* seedlings were transplanted from the germination box into the potted mixture after three days of introducing the biochar. Each of the treatment was replicated five (5) times making a total of twenty (20) replicates all together. The initial reading was taken immediately, while the subsequent reading was taken 2 weeks after, then on a weekly basis for a period of a thirteen (13) weeks. Silvicultural practice such as watering and weeding were carried out.

Experimental design and layout

Treatment A (T_0) = Control (Topsoil)

Treatment B (T_1) = 50 g of biochar made from weed + 2 kg of degraded soil

Treatment C (T_2) = 50 g of biochar made from cassava peel + 2 kg of degraded soil

Treatment D (T_3) = 50 g of biochar made from bamboo + 2 kg of degraded soil

$Y_{ijk} = \mu + T_j + E_{ijk}$

Where: Y_{ijk}= Individual observation; μ = General mean;
T_j = Effect of Treatment; E_{ijk}= Experimental error

Laboratory analysis

Proximate analysis was carried out on the degraded soil and the three (3) biochars made from plant residues. The laboratory tests were carried out at Rotas Soilab limited, Ringroad, Ibadan.

Parameters assessed

Theassessment of parameters commenced 2 weeks after transplanting and the experiment was monitored for thirteen (13) weeks. The following parameters were taken: Plant height (cm) with the aid of a graduated ruler, Stem diameter (mm) with the aid of venier calliper and Number of leaves were taken by counting the leaves on each stand. There are nine treatments replicated seven times making a total of sixty four polythene pots. The experiment was laid down in a Completely Randomized Design (CRD).

Data Collection and Analysis. The data were then subjected to one-way analysis of variance to compare the effect of the different treatments on the early growth characteristics of *Mansonia altissima* seedlings.While the treatment means were separated using Least Significant Difference (LSD) at 5% probability level.

Results and Discussion

Soil analysis

Laboratory analysis of the topsoil, degraded soil and biochars

Table 1 showed that the topsoil acidic with a pH value of 6.36, the concentrations of essential nutrients are minimal, and the quantity of Carbon is low, which is very suitable for the optimum growth of plants.

It also showed that the degraded soil is highly acidic with a pH of 3.72. This pH is too acidic for plants. It is high in Iron (Fe), usually they exist as Iron sulphide, and the Sulphides react with Oxygen to form sulfiric acid. Release of this sulphuric acid from the soil can be in turn release Iron, Aluminium, and other heavy metal (particularly arsenic) within the soil. Once mobilized in this way, the acid and metals can create a variety of adverse impacts such as killing vegetation. Reduction in agricultural productivity through contamination of soil (Mosley *et al.,* 2014).

Table 1: Laboratory analysis of the topsoil, degraded soil and biochars used for the experiment

Parameter	Topsoil	Degraded Soil	Biochar of cassava peel	Biochar of Bamboo	Biochar of Weed
PH (H_2O)	6.36	4.63	10.35	8.25	7.01
C%	2.98	1.67	51.27	39.57	43.06
N%	0.33	0.341	1.43	1.37	0.47
P mg/kg	1.68	1.28	51.73	46.18	47.99
Ca(mol/kg)	1.04	0.97	–	–	–
Mg(mol/kg)	1.15	0.83	2.38	2.56	1.31
Na(mol/kg)	0.83	0.27	0.16	0.17	0.18
Cu mg/kg	1.89	1.85	–	–	–
Zn	2.04	1.92	62.25	27.73	25.20
K	0.75	0.38	35.97	24.73	31.46
Mn	1.98	13.64	–	–	–
Fe	3.15	1.92	–	–	–

Finally, it showed that the biochars are bases, the cassava biochar is highly alkaline, the bamboo biochar is moderately alkaline and the weed biochar is slightly acidic. The test showed that the cassava biochar had the highest amount of Nitrogen, Phosphorus, Potassium, Zinc, Carbon and the weed biochar had the highest amount of Sodium. With the bamboo having the highest amount of magnesium. The presence of Nitrogen, Potassium and Phosphorus in high quantities will positively contribute to the growth of plant because they are the primary nutrients needed for optimum growth.

Effect of biochar on seedlings growth of Mansonia altissima seedlings

Figure 1 showed that biochar made from cassava peel had the highest mean height (23.4 cm) followed bybiochar made from bamboo (20.68), this was closely followed by biochar made from weeds (16.72 cm) while the least mean value was the control (13.88 cm). This is in consonance with Fagbenro (2000), who reported positive effect of sawdust biochar on plant height. In addition, Batool *et al*. (2015) observed positive effects of application of various combinations of biochar on plant heights of *Abelmoschusesculentus.*

Table 2 presented that the analysis of variance for the effect of biochar on the height growth of *Mansonia altissima* and there were no significant differences among the treatments at 5% level of probability.

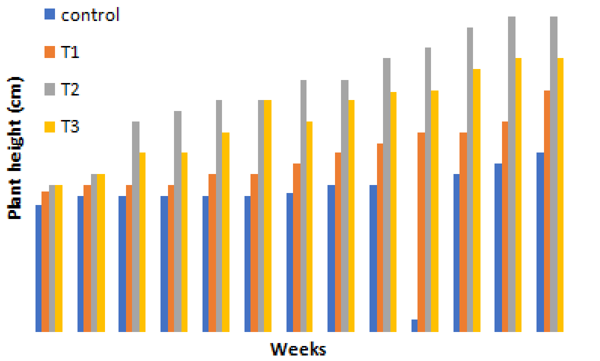

Fig. 1: Plant Height (cm) of *Mansonia altissima* after 13 weeks

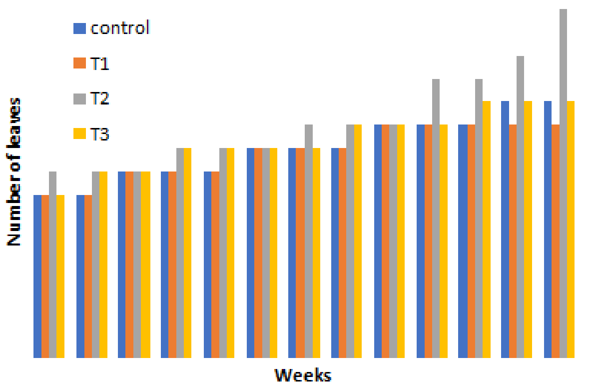

Fig. 3: Leaf production of *Mansonia altissima* after 13 weeks

Table 2: ANOVA for plant height

Sources of Variation	SS	DF	MS	F	P–Value	F–crit.
Treatment	142.17	3	47.39	2.01	0.12	2.80
Error	1130.10	48	23.54			
Total	1272.27	51				

Not significant at 5% level of probability

Table 4: ANOVA for leaf production

Sources of Variation	SS	DF	MS	F	P–Value	F crit.
Treatment	1.14	3	0.38	0.13	0.94	2.80
Error	136.02	48	2.83			
Total	137.16	51				

Not significant at 5% level of probability

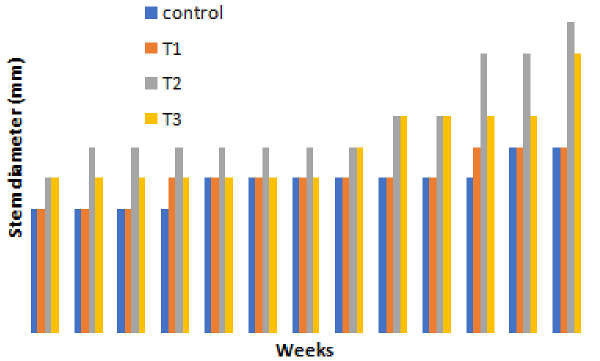

Fig. 2: Stem diameter (mm) of *Mansonia altissima* after 13 weeks

Figure 2 indicated that T_2 which is biochar made from cassava peel (6.8 mm) also had the highest mean valuein terms of the stem diameter followed by T_3 which is biochar made from bamboo (6 mm), while the least mean value is T_0 which is the control (4.8 mm). The result again showed that biochar made from cassava peel is most appropriate for silviculturists and tree growers interested in the size of the trees. This is in accordance with findings of Blackwell (2009) that biochar has the ability to enhance growth and nutrient content when applied to a variety of soils. Adejoh *et al.* (2016) equally stated that biocharprovides optimum support for both height and stem growths of *Theobroma cacao* and *Entandrophragma utile* at seedlings stage.

Table 3 showed the analysis of variance for the effect of biochar on the stem diameter of *Mansonia altissima* and there were no significant differences among the treatments at 5% level of probability.

Table 3: ANOVA for stem diameter

Sources of Variation	SS	DF	MS	F	P–Value	F crit.
Treatment	13.01	3	4.34	2.43	0.08	2.80
Error	85.61	48	1.78			
Total	68.62	51				

Not significant at 5% level of probability

Figure 3 showed that biochar made from cassava peel (T_2) had the highest mean (10.2), followed by T_3 which is biochar made from bamboo (9.4), then T_0 which is the control (9), while treatment with the least mean value is T_1 which is biochar made from weeds (8.8). This implies that biochar made from cassava peel produced the highest number of leaves while biochar made from bamboo (T_3) is not suitable in termsof leaves production (value). This is in accordance with findings Lehmann and Joseph (2009), that the application of biochar can increase yields on formerly abused soils by as much as 300 percent or more.

In Table 4, the analysis of variance for the effect of biochar on the leaf production of *Mansonia altissima* indicated that there were no significant difference among the treatments at 5% level of probability. Biochar made from cassava peel (T_2) had the best performance in terms of stem height, stem diameter and leaf production. This implies that T_2 is the most effective amongst all the treatments.

Conclusion

The study revealed that biochar can positively influence the growth and development of *Mansonia altissima* seedlings at nursery stage. This has shown the potentials of biochar in contrast to topsoil (control), especially biochar made from cassava peel in increasing the growth of *Mansonia altissima* seedlings. It can be concluded that addition of biocharmade from cassava peel as soil amendment to *Mansonia altissima* seedlings in the nursery will better produce healthy and vigorous seedlings in a short period of time, even better than biochar made from weeds and bamboo.

Conflict of Interest

Authors declare that there is no conflict of interest reported in this work.

References

Adejoh OP, William OA, Yakubu FB & Afolabi JO 2016. Prospects of Biochar in Improving Forest Soil Fertility and Tree Crop Productivity

Baligar VC & Bennett OL 1986. NPK-fertilzer efficiency – A situation analysis for the tropics. *Fertilizer Research*, 10: 147 – 164.

Batool A, Taj S, Rashid A, Khalid A, Qadeer S, Saleem AR & Ghufran MA 2015. Potential of soil amendments (Biochar and Gypsum) in increasing water use efficiency of *Abelmoschusesculentus* L. Moench. Front. *Plant Science*, 6: 733.

Blackwell P 2009. Biochar for application to soil. Biochar for Environmental Management (Eds J Lehmann and S Joseph), pp. 207-226.

Davies EO 2007. Molina enough nutrient needed for plant. *Amer. J. Soil Sci.* 10(16): 137 – 158.

Enders A, Hanley K, Whitman T, Joseph S & Lehmann J 2012.: Characterization of biochars to evaluate recalcitrance and agro- nomic performance, *Bioresou. Techn*., 114: 644–653.

Fagbenro 2000. Analysis and use of organic materials. Invited lead paper. In: Babalola, Olaolu (c.ed.) *Proceeding 26 Annual Conf. Soil Sci. Soc. Nig*. Ibadan, p. 141-154.

FRIN 2015. Forestry Research Institute of Nigeria, Annual Meteorological Report.

Harris P 1999. On charcoal. *Interdisciplinary Science Reviews*, 24: 301–306.

Irvine FAR 1961. Woody Plants of Ghana with Special Reference to their Uses. Oxford Univ. Press London, p. 146.

IUCN 2014. Red List of Threatened Species. The International Union Conservation Nature (IUCN).

Lehmann J & Joseph S 2009. *Biochar for Enviromental Menagaement: Science and Technology.* Earthscan London and Sterling, VA, 416p.

Lehmann J, Rillig MC, Thies J, Masiello CA, Hockaday WC & Crowley D 2011. Biochar effects on soil biota: a review. *Soil Biol. Biochem*., 43: 1812-1836.

Mosley LM, Palmer D, Leyden E, Fitzpartrick R & Shand P 2014. Changes in acidicity and metal metal geochemistry in soil, groundwater, drain and river water in the Lower Murray River after a severe drought. *Science of the total Environment,* 486: 281-291.