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Production of Biochar from Selected Plant Residues and the Effects
of its Application on the Growth of *Mansonia altissima* (A. Chev.) A.
Chev-FWTA Seedlings

¹Ojo, M.O., ²Aghimien, E.V.,

¹Forestry Research Institute of Nigeria (FRIN), Ibadan, Nigeria

²Federal College of Forest Resources Management, Sakponba, Benin City, Edo State, Nigeria

Corresponding Author's Email & Phone No.: aghimien4@yahoo.com; +2347031238830

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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. The study is aimed at producing biochars from selected plant residues and to assess the effects of its application on the growth of *Mansonia altissima* seedlings. Three plants residues were used to make biochar, which were bamboo, cassava peel and weeds, and they were grounded into powdery form, mixed with topsoil and degraded soil. The experiment was made up of four treatments, 2kg of topsoil (T₀, control), 50g of biochar made of weeds + 2kg of degraded soil (T₁), 50g of biochar from cassava peel + 2kg of degraded soil (T₂), 50g of biochar made of bamboo + 2kg of degraded soil (T₃). The data collected was subjected to analysis of variance (ANOVA). The result obtained showed that T₂ performed best in height with a value of 23.4cm, while T₀ had the least performance in height with a value of 13.88cm. T₂ performed best with a value of 6.8mm, while T₀ had the least performance in stem diameter with a value of 4.8mm. T₂ also performed best in terms of leaf production with a value of 10.2 while T₁ had the least performance with a value of 8.8. The ANOVA result showed that there were no significant differences among the treatments at 5% level of probability. It can be concluded that biochar made from cassava peel, produce healthy seedlings in a short period of time.

Keywords: cassava; biochars; residues; treatments; pyrolysis; *Mansonia altissima*;

1.0 INTRODUCTION

Biochar is a solid material obtained from the carbonization of biomass. Biochar is a carbon-rich product that results from the low temperature, oxygen-starved combustion (also known as pyrolysis) of carbonaceous biomass such as crop residues, stall bedding, cull timber and sawmill wastes. Reliable scientific sources (Lehmann and Joseph, 2009) also suggested that the application of biochar (inoculated with favorable soil organisms – easily introduced with a small amount of healthy forest soil – coupled with small amounts of nitrogen, and a carbonaceous material such as sawdust) can increase yields on formerly abused soils by as much as 300 percent or more.

Biochar may be added to soils with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases. Biochar also has appreciable carbon sequestration value. These properties are measurable and verifiable in a characterization scheme, or in a carbon emission offset protocol. Like most charcoal, biochar is created by pyrolysis of biomass. Biochar is under investigation as an approach to carbon sequestration to produce negative carbon dioxide emissions (Silber *et al.*, 2010). Biochar has the potential to help mitigate climate change, via carbon sequestration (Badger, 2006). Independently, biochar can increase soil fertility

of acidic soils (low soil pH), increase agricultural productivity, and provide protection against some foliar and soil-borne diseases (Davies, 2007). Furthermore, the term “Biochar” was coined by Peter Read to describe charcoal used as a soil improvement (Dias *et al.*, 2010). One of the side-benefit of biochar is that, it can be dug into soil to increase agricultural yields and to improve soil fertility (Cheng *et al.*, 2006, Lehmann, 2007, Ponge *et al.*, 2006). The importance of *Mansonia altissima* as one of the indigenous hardwood species has resulted in its serious exploitation in the natural forest (Oni, 1999). Unfortunately, not much effort has been made to replace what has

been exploited, while the rate of natural regeneration of the tropical high forest had been rather too slow (Adesina, 2001) and this has made it unreliable as a method of re-stocking the natural forest. However, biochar has not been used in the propagation of *Mansonia altissima* but inorganic fertilizers have been used tremendously by researchers particularly at the nursery stage to raise tree seedlings, due to its high cost of procurement. There is an urgent need for alternative source of nutrient for rapid growth and development of tree seedlings at nursery stage which is also ecosystem friendly.

2.0 MATERIALS AND METHOD

2.1 Experimental Site

The experiment was carried out within the premises of Federal College of Forestry, Jericho, Ibadan. The college is located at Ibadan North-west Local Government Area of Oyo State at Latitude 7°23'N and Longitude 3°36'E. It has annual rainfall of about 1400mm – 1500mm and average relative humidity of about 65%. The average temperature is 32°C with two distinct seasons, which are dry and rainy season (FRIN Meteorological Report, 2014). Some of the tree species inherent in this area are: *Tectona grandis*, *Gmelina arborea*, *Mangifera indica*, *Artocarpus cummunis*, *Terminalia catappa*, *Ceiba pentandra*, *Persia americana*. The soil is sandy-loamy and the topography is slop.

2.2 Broadcasting of *Mansonia Altissima* Seeds

The wings of *Mansonia altissima* seeds were detached, and then pre-treated by soaking it in water for 6 hours to facilitate early germination. The seeds were sown in a germination box containing river sand to a depth of 4mm. It was properly watered and lightly covered with soil. The germination box was then put under shade to protect it from direct sunlight after which it was covered with propagator to maintain high humidity and also enhance quick germination. The

seedlings emerged from the soil after 13 days (Blackwell, 2009).

2.3 Production of Biochar

A steeldrum of 34.5 x 22.5 inches in dimension was used as the retort. Cover of the drum was punctured with a nail in three places to allow ventilation, in order to allow the gases that were produced during the pyrolysis to escape. It was then loaded with the feedstock (Plant residues) and then sealed. The bamboo was subjected first 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 inches. Fire was set underneath the retort and kept burning. After 37 minutes, the content inside started to outgas, the gases emerged from the retort through the holes in the drum's cover. The content stopped out-gassing after 4 hours 47 minutes of heating for the bamboo process, 4 hours 28 minutes for the cassava peels and 5 hours 13 minutes for the weeds, thereafter, biochar was produced. The drum was removed from the fire and allowed to cool for 1 hour (Blackwell, 2009).

2.4 Application of the Biochars

The biochars were grinded into powdery form. Fifty grams each of weeds, bamboo and cassava peel. Biochar were mixed with 2kg 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 application of the biochars. Each of the treatment was replicated five (5) times with a total of twenty (20) replicates altogether. The initial reading was taken

immediately, while the subsequent reading was taken after 2 weeks, then on a weekly basis for a period of twelve (12) weeks. Silvicultural practices such as watering and weeding were carried out on the treatments and replicates equally.

2.5 Experimental Design and Layout

T ₁ R ₅	T ₀ R ₃	T ₃ R ₃	T ₂ R ₁	T ₀ R ₄
T ₂ R ₃	T ₃ R ₂	T ₁ R ₂	T ₀ R ₅	T ₃ R ₁
T ₃ R ₄	T ₂ R ₅	T ₀ R ₁	T ₁ R ₄	T ₂ R ₄
T ₀ R ₂	T ₁ R ₁	T ₂ R ₂	T ₃ R ₅	T ₁ R ₃

Treatment A (T₀):- control (topsoil)

Treatment B (T₁):- 50g of biochar made from weed + 2kg of degraded soil

Treatment C (T₂):- 50g of biochar made from cassava peel + 2kg of degraded soil

Treatment D (T₃):- 50g of biochar made from bamboo + 2kg of degraded soil

This experiment was laid out in a Completely Randomized Design (CRD) with each of the treatments being replicated five (5) times. The linear model is expressed as follows;

$$Y_{ij} = \mu + t_i + \varepsilon_{ij} \quad (1)$$

Where,

Y_{ij}: Individual observation, μ : General mean, τ_i : Effects of biochars, ε_{ij} : Experimental error

2.6 Laboratory Analysis

Chemical analysis was carried out on the degraded soil and the three (3) biochar made from plant residues. The laboratory tests were carried out at

Rotas Soil lab. Limited, Mobil, Ringroad, Ibadan, Oyo State. Assessment of growth parameters commenced 2 weeks after transplanting and subsequently on a weekly basis. The parameters assessed were: plant height (cm), stem diameter (mm) and leaf production.

2.7 Data analysis

The data collected was subjected to analysis of variance (One way - ANOVA). The means found to differ from each other were subjected to follow-up test using Least Significant Difference (LSD).

3.0 RESULTS

Table 1: Top Soil Chemical Analysis Mean Value

pH	Cmol/kg	Cmol/kg	Cmol/kg	Cmol/kg	%	%	Mg/Kg	Mg/Kg	Mg/Kg	Mg/Kg	Mg/Kg
	Ca	Mg	Na	K	C	N	P	Mn	Fe	Zn	Cu
6.36	1.04	1.15	0.83	0.75	2.98	0.33	1.679	1.98	3.15	2.04	1.89

Table 2: Degraded Soil Chemical Analysis

pH	Cmol/kg Ca	Cmol/kg Mg	Cmol/kg Na	Cmol/kg K	% C	Mg/K g P	Mg/K g Mn	Mg/Kg Fe	Mg/K g Zn	Mg/K g Cu
4.63	0.97	0.83	0.27	0.38	1.67	1.28	13.64	17.06	1.92	1.85

Table 3: Biochars Chemical Analysis

	pH	% N	Mg/Kg P	Cmol/kg K	Mg/Kg Zn	Cmol/kg Mg	% C	Cmol/kg Na
Cassava peel	10.35	1.43	51.73	35.97	62.25	2.38	51.27	0.164
Bamboo	8.25	1.37	46.18	24.73	27.40	2.56	39.57	0.168
Weeds	7.01	0.47	47.99	31.46	25.20	1.31	43.06	0.183

3.1 Plant Height (cm)

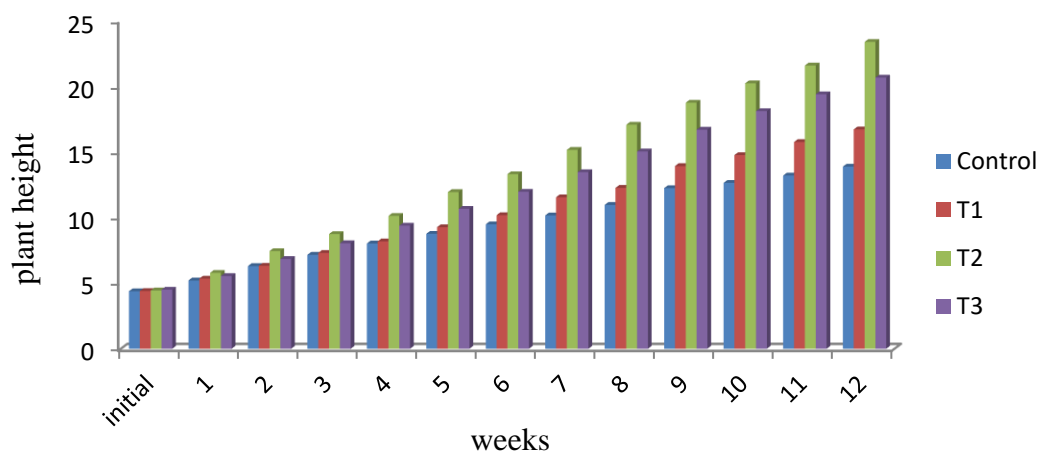


Figure 1: Plant Height Distributions of *Mansonia altissima* after 12 Weeks

Table 4: ANOVA Result for Plant Height of *Mansonia altissima*

Source of Variation	SS	DF	MS	F	P-value	F crit.
Treatment	142.1713846	3	47.39046	2.01287	0.124641	2.798061
Error	1130.098646	48	23.54372			
Total	1272.270031	51				

3.2 Stem Diameter (mm)

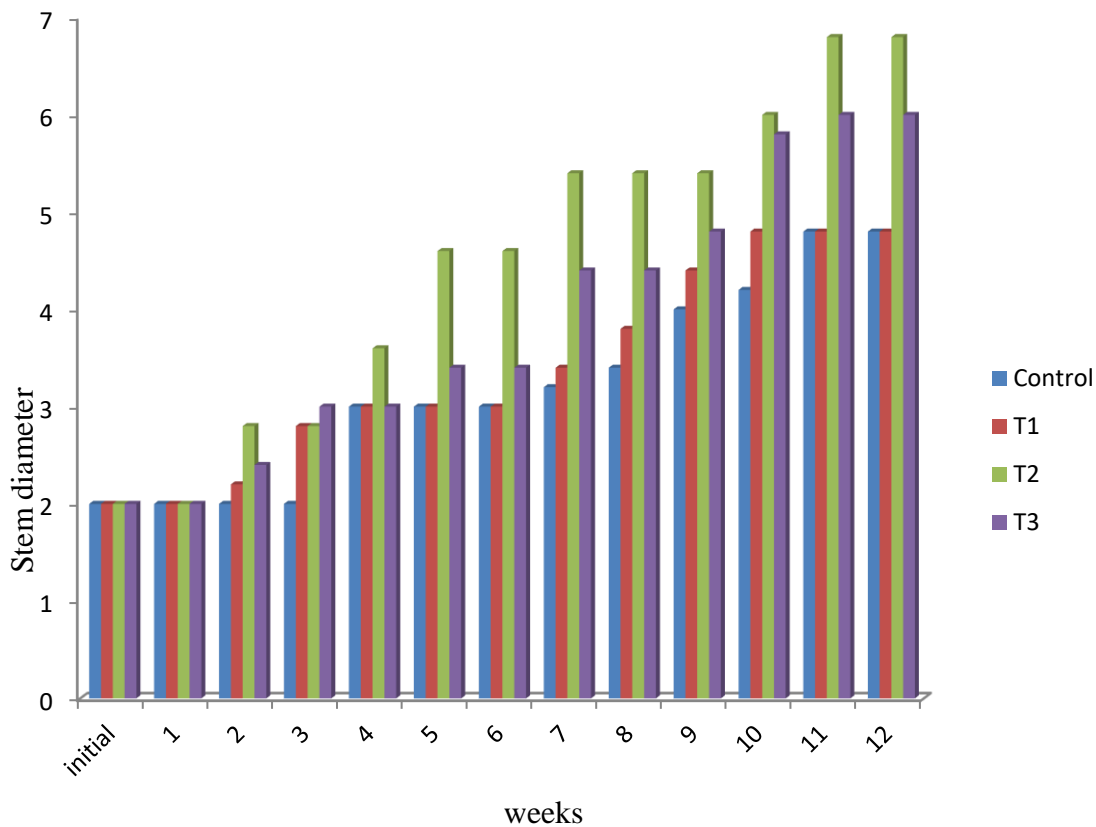


Figure 2: Stem Diameter Distributions of *Mansonia altissima* after 12 Weeks

Table 5: ANOVA Result for Stem Diameter of *Mansonia altissima*

Source of Variation	SS	DF	MS	F	P-value	F crit.
Treatment	13.01154	3	4.337179	2.431888	0.076463	2.798061
Error	85.60615	48	1.783462			
Total	98.61769	51				

3.3 Leaf Production

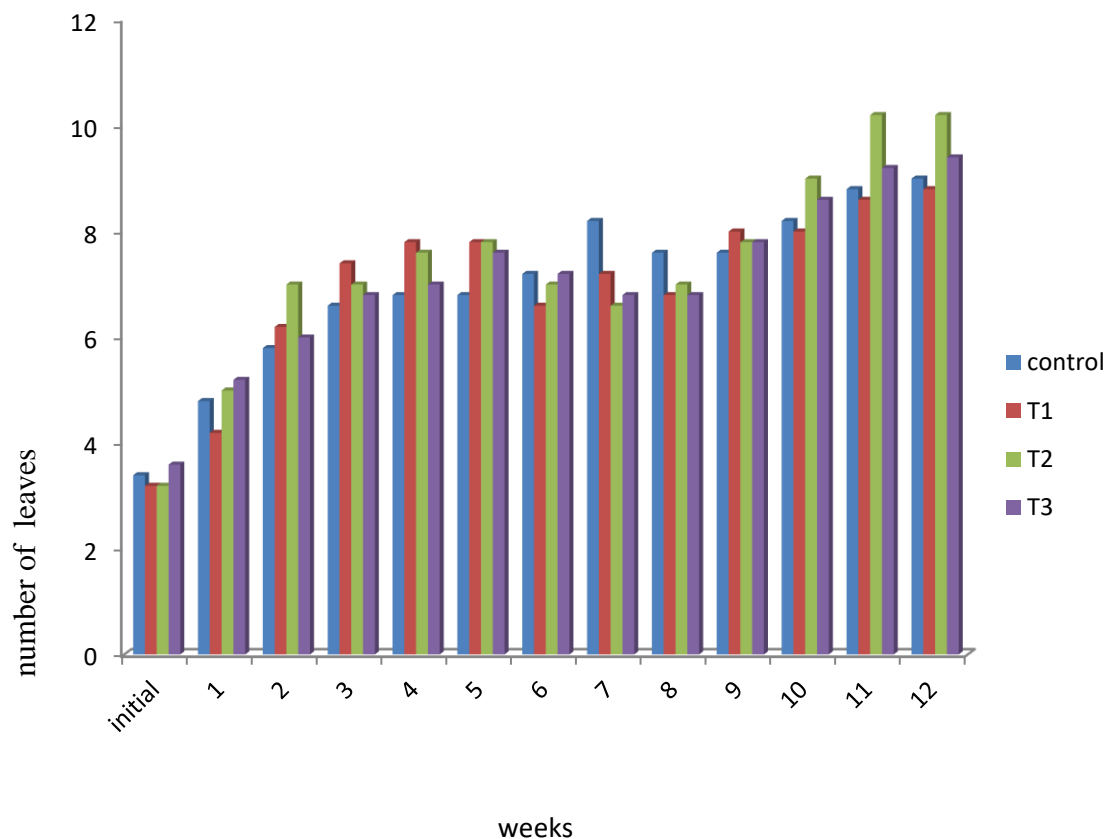


Figure 2: Leaf Production Distributions of *Mansonia altissima* after 12 Weeks

Table 6: ANOVA Result for Leaf Production of *Mansonia altissima*

Source of Variation	SS	DF	MS	F	P-value	F crit.
Treatment	1.138462	3	0.379487	0.133918	0.939371	2.798061
Error	136.0185	48	2.833718			
Total	137.1569	51				

4.0 DISCUSSION

Table 1 showed that the topsoil is slightly acidic with a pH of 6.36, the concentrations of essential nutrients are minimal, and the quantity of carbon (2.98) is low, which is very suitable for the

optimum growth of *Mansonia altissima*. The degraded soil was highly acidic with a pH of 4.63. It was high in iron (17.06), usually they exist as iron sulfide, and the sulfides react with oxygen to form sulfuric acid as presented in Table 2. The

release of this sulfuric acid from the soil can in turn release iron, aluminum, and other heavy metals (particularly arsenic) within the soil. However, the acid and metals can create a variety of adverse impacts such as destruction of the vegetation, reduction in agricultural productivity through metal contamination of soils (Mosley *et al.*, 2014). Table 3 shows that the biochars were basic in nature. The cassava peel biochar was highly alkaline (10.35) while the bamboo biochar was moderately alkaline (8.25) and the weeds biochar was slightly acidic (7.01). The test showed that the cassava biochar had the highest amount of Nitrogen (1.43), Phosphorus (51.73), Potassium (35.97), Zinc (62.25), Carbon (51.27), and the weeds biochar had the highest amount of Sodium (0.183), with the bamboo biochar having the highest amount of Magnesium (2.56). The presence of Nitrogen, Phosphorus and Potassium in high quantities indicates positive contribution to the growth of *Mansonia altissima* because they are the primary nutrients needed for optimum plant growth.

Figure 1 showed that Biochar made from cassava peel had the highest mean value of 23.4cm, while biochar made from bamboo had a mean value of 20.68 cm, and it was closely followed by Biochar made from weeds with a mean value of 16.72cm, followed by the mean value of the control with a mean value of 13.88 cm. This was in accordance with the findings of Hoshi (2001) that there is a 20% increase in volume and 40% increase in height of seedlings with biochar as additive. Table 4 revealed no significant differences among the treatments at 5% level of probability. Figure 2

5.0 CONCLUSION

The study revealed that biochar has positive influence on the growth and development of *Mansonia altissima* seedlings at the nursery stage. The study has shown the potentials of biochar in contrast to topsoil (control), especially biochar made from cassava peel enhanced the growth of *Mansonia altissima* seedlings. It can be concluded

that T_2 had a mean value of 6.8mm and the highest mean value in terms of the stem diameter followed by T_3 which is biochar made from bamboo with a mean value of 6mm. T_0 had the least mean value of 4.8mm. The result again showed that biochar made from cassava peel is most suitable, if the intention is to raise plant with large stem. It corroborates with the findings of Blackwell (2009), that biochar has the greatest ability to enhance plant growth and nutrient content when applied to a variety of soils. The analysis of variance on the effects of biochars on stem diameter of *Mansonia altissima* showed that there was no significant difference among the treatments used at 5% probability level as presented in Table 5. Figure 3 showed that Biochar made from cassava peel (T_2) had the highest mean value of 10.2, while T_3 had a mean value of 9.4, and T_0 had a mean value of 9, followed by the treatment with the least number in terms of mean average value of leaf production. T_1 had a mean value of 8.8. This implies that biochar made from cassava peel produced the highest number of leaves while biochar made from bamboo (T_1) was not suitable in terms of leaves production. This was in line with the findings of Lehmann and Joseph (2009), that the application of biochar can increase yields on formerly abused soils by as much as 300 percent or more. Table 6 indicates that there was no significant difference among the treatments at 5% probability level. Therefore, 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 the treatments.

that addition of biochar made from cassava peel as manure to *Mansonia altissima* seedlings in the nursery will better produce healthy and vigorous seedlings in a short period of time.

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