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Research paper

Effects of potting mixture on the growth of seedlings of *Entandrophragma cylindricum* (SPRAGUE) and *Tamarindus indica* L

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Abstract - The study describes the effects of biochar and NPK fertilizer on *Entandrophragma cylindricum* and *Tamarindus indica* seedlings in the nursery of the Department of Forestry and Wildlife, University of Benin, with a view to evaluating the seedling growth response to the quantity of potting mixture. The potting mixtures used were soil only which is the control, mixture of soil and biochar, mixture of soil, biochar and fertilizer, mixture of soil and fertilizer. The seeds of *Entandrophragma cylindricum* and *Tamarindus indica* were sourced for and planted. Transplanting was carried out for germinated seeds until the required weeks number of seedlings needed for the experiment was obtained. Measurements were taken at one week interval for ten weeks plant height, stem height, collar diameter and leaf number. The experiment was a completely randomized design. Data were analyzed using ANOVA. Result indicates that there was no significant difference in the growth variables except for stem height of *Entandrophragma cylindricum* at 5% level. Control i.e. forest top soil had the highest height of stem of 5.90 cm and 8.49 cm for *Entandrophragma cylindricum* and T*amarindus indica*, respectively. Marginal differences in the growth variables were observed. Other silvicultural practices that would promote the growth of the species should be considered.

Keywords - Biochar; seedlings, fertilizer; *Entadrophragma cylindricum*; *Tamarindus indica*

Introduction

Most tropical trees have natural durability and fruit edibility; they are preferred for use as materials for housing, construction, building erection, food and medicine. The majority of these timber and non timber trees possess extractives that are of biological and economic values. The peculiar nature of tropical climate and soils predisposes the soils to heavy leaching due to their acidic nature (Isikhuemen 1995). The need to buffer and augment the soil nutrients supply by artificial means becomes important. Aluko (1982) reported that in developed countries, forest fertilization is an accepted tool for increasing wood production.

The use of biochar as soil amendment is modeled on the carbon rich anthropogenic soils known as "Indian black earth" (Glaser 2007). Recently, efforts to duplicate the "Indian black earth" techniques using biochars produced from modern pyrolysis prove that charcoal additions can have an ameliorating effect on excessive weathered, infertile tropical soils by increasing cation exchange capacity (CEC) and plant nutrient supply, reducing soil acidity and aluminum toxicity, and improving fertilizer efficiency due to reduced nutrient leaching (Glaser et al. 2007; Lehmann et al 2003). Studies have reported that plant growth responses are largest when charcoal and fertilizers are combined (Lehmann et al. 2003; Steiner et al 2007; Chan et al. 2008; Mete et al. 2015).

Today, the need to carry out research on the protection, conservation as well as biology of indigenous tree species is increasing in Nigeria because of their importance (Isikhuemen 1995). *Entandrophragma cylindricum* and *Tamarindus indica* are two important species in Nigeria. *Entandrophragma cylindricum* and *Tamarindus indica* belong to the family of Meliaceae and Caesalpinioideae, respectively. *Entandrophragma cylindricum*, also called Sapelli, is a long-living timber tree species of high commercial value found from Sierra Leone East to the Democratic Republic of Congo and to Uganda, in tropical evergreen and semi deciduous forests (Lehmann et al 2003). *Tamarindus indica*, commonly known as Tamarind tree is one of the most important multipurpose tropical fruit tree species in the Indian subcontinent. It is a large evergreen tree up to 30 m tall, bole usually 1-2 m, up to 2 m diameter, crown is dense, widely spreading, rounded; bark rough, fissured, grayish- brown (Santosh et al. 2011). *Tamarindus indica* has a hard and heavy wood for general carpentry, boat build-

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ing, firewood, charcoal, the tree is used for shade, amenity, bee forage and windbreak.

To effectively harness the potentials of these two species, emphasis must be made for improving their demand as plantation trees, and also their early growth, and speed up their full development rate. In this regard, the use of biochar application and fertilization into forest soil management practice becomes essential. Miller (1981) reported that during the early stages of growth, trees are very well dependent on soil nutrient supply. At this point, the forest manager, by judicious application of biochar and or fertilizer, can influence the subsequent development of stand, perhaps saving many years in rotation length.

Materials and methods

Experimental site

The study was carried out in the nursery of the Department of Forestry and Wildlife, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The University is located in the southern part of Edo State and lies on Latitude 5°34'N and Longitude 6°24'E with an elevation of 134 m above sea level. The mean annual temperature is about 27°C and receives an annual rainfall of 1500mm to 2000mm. The mean relative humidity ranges from about 75% at 12:00 a.m. to over 95% at 6:00 a.m. The topography of the study area is gentle slope (University of Benin Master Plan, 1993)

Seed procurement and sowing

150 Seeds of *Entandrophragma cylindricum* were purchased from Okomu National Park, Udo, Edo State, on 6th February, 2016; and kept in a cool dry place. While 495 seeds of *Tamarindus indica* were purchased from Forestry Research Institute, Otagba, Benin City, Edo State, on 15th March, 2016. The seeds were soaked overnight. This was done for faster and easier germination of the seeds. The seeds of *E. cylindricum* and *T. indica* were sown in germination bed and germination trays, respectively. The germination tray was filled with top soil to three-quarter its size to prevent water run-off during watering. Watering was carried out regularly every other day.

Soil collection and preparation

Top soil was collected from the forest floor in the nursery and was properly mixed (See Fig. 1). The polythene pots were filled with top soil and each given a uniform weight of 6 kg for the pots without biochar. The pots containing biochar were filled in a ratio four to half, that is, four head pans of top soil to half head pan of biochar for every eighteen poly pots (See Fig. 2). The treatments were:

1. Top soil only i.e. control (T1)
2. Soil + Biochar (T2)
3. Soil + Biochar + Fertilizer (T3)
4. Soil + Fertilizer (T4)

Figure 1 - Top soil from the nursery.

Figure 2 - Biochar before pounding.

Seedling transplant

112 seedlings of *Entandrophragma cylindricum* were transplanted to the prepared poly pots, one seedling per poly pot. 80 seedlings of *Tamarindus indica*, were transplanted to 6 kg poly pots. Fertilizer was applied six days after the transplant of all the species in linear form and 3 cm deep for T3 and T4 i.e. treatments involving fertilizer as aforementioned. The level of fertilizer used was 400kg/ha. That is, 1.2 g of NPK per 6 kg of poly pot.

Experimental design

The experiment was laid in a Completely Randomized Design (CRD) with seven replications for both species independently. Data collection

started ten days after transplanting with the following parameters measured at one week interval per plant, per treatment, for ten weeks. The parameters were height, leaf number, collar diameter. Data were analyzed using one-way analysis of variance (ANOVA); least significant difference (LSD) was used to separate means that were significant at 5%.

Results

Characterisation of the Soil Mixture

We carried out laboratory analysis on the soil samples prior to the experiment so as to ascertain the nutrient status of the samples. The preceding biochar, top soil and soil mixtures analysis presented in Table 1 show their nutrient status and pH. The nutrient status of top soil alone appears to have the lowest Nitrogen (0.82g/kg), while the mixture of soil+ biochar+ fertilizer has the highest amount of Nitrogen (3.80g/kg), Phosphorus (22.06mg/kg) and Potassium (5.35cmol/kg). The pH level for biochar is 7.8, fairly neutral and that of the mixture of soil+ fertilizer is 4.8, fairly acidic.

Table 1 - Physio-chemical properties of the treatments.

Parameters	Biochar	Soil	Soil+ biochar	Soil+ biochar+ fertilizer	Soil+ fertilizer
pH	7.8	5.8	6.8	6.9	4.8
Org. C. (g/kg)	31.92	17.2	33.73	35.44	25.40
Total N (g/kg)	1.60	0.82	1.69	3.80	3.27
P. (mg/kg)	10.22	6.54	12.36	22.06	20.40
K (cmol/kg)	3.65	0.35	3.87	5.35	5.11
Ca (cmol/kg)	3.00	0.67	2.15	2.25	0.52
Mg (cmol/kg)	1.21	0.28	0.63	0.92	0.21
Na (cmol/kg)	0.64	0.21	0.33	0.36	0.18
H (cmol/kg)	0.20	0.40	0.22	0.21	1.6
Al^{3} (cmol/kg)	0.04	0.04	0.05	0.05	0.56
Sand (g/kg)	0	886.4	868	866	864
Silt (g/kg)	0	56.2	100	93	86
Clay (g/kg)	0	57.4	32	41	50

Growth parameters

Plant height

The results of the effects of the four treatments i.e. Soil + Fertilizer, Soil + Biochar + Fertilizer, Soil + Biochar, and Control (forest top soil) on plant heights are presented in Table 2. We defined plant height as the vertical distance from seedling collar to the tip of the apical bud. The mixture of soil and fertilizer had the highest mean plant height growth of 14.975 cm for *Entandrophragma cylindricum*. Control (forest top soil) had 14.767 cm. While the mixture of soil and biochar had the lowest mean total height growth of 14.096 cm for same species. However, there is no statistical difference among the treatments at 5% level with respect to plant height growth for *Entandrophragma cylindricum*. In the case of *Tamarindus indica*, the mixture of Soil + Biochar + Fertilizer had the highest mean height growth of 15.00 cm. This was followed by forest top soil (control) with 14.75 cm. The mixture of Soil + Fertilizer had the lowest value of 13.944 cm. No significant difference was observed among the treatment at 5% level when the data were analyzed regardless of marginal increase.

Table 2 - Separation of means for plant height.

Species	Treatments	Mean
E. cylindricum	Soil + Fertilizer	14.975[a]
	Control	14.767[a]
	Soil + Biochar + Fertilizer	14.504[a]
	Soil + Biochar	14.096[a]
T. indica	Soil + Biochar + Fertilizer	15.000[a]
	Control	14.750[a]
	Soil + Biochar	14.397[a]
	Soil + Fertilizer	13.944[a]

Mean with the same superscript are not significantly different at 5%

Stem height

The result for stem height is presented in Table 3. Stem height is defined as the vertical distance between the oldest/lowest leaf of the crown and the collar of the seedling. The result showed that *Entandrophragma cylindricum* raised on forest top soil (control) only had the highest average stem height of 5.902 cm. This was followed by mixture of forest soil + fertilizer average stem height of 5.496 cm. The mixture of Soil + Biochar and the mixture of Soil + Biochar + Fertilizer had the lowest average stem height of 3.992 cm and 3.946 cm, respectively for *Entandrophragma*. The analysis of variance revealed a high level of significance at 5% ($P<0.05$). Control i.e. forest top soil was significantly different from other treatment. While the mixture of Soil + Biochar and the mixture of Soil + Biochar + Fertilizer were not statistically different. The result for *Tamarindus indica* showed no significant difference at 5% ($P>0.05$) among the treatment for stem height. However, there were numerical variations; with Control having the heighest average stem height of 8.488 cm. The mixture of Soil + Biochar + Fertilizer had the second height average stem height of 8.375 cm. The mixture of Soil + Fertilizer had the lowest mean stem height (7.309 cm).

Table 3 - Separation of means for stem height.

Species	Treatments	Mean
E. cylindricum	Control	5.902[a]
	Soil + Fertilizer	5.496[b]
	Soil + Biochar	3.992[c]
	Soil + Biochar + Fertilizer	3.964[c]
T. indica	Control	8.488[a]
	Soil + Biochar + Fertilizer	8.375[a]
	Soil + Biochar	7.841[a]
	Soil + Fertilizer	7.309[a]

Mean with the same superscript are not significantly different at 5%

Collar diameter

The result of the effect of the treatment on seedling collar diameter is presented in Table 4. From the Table it can be observed that the four treatments i.e. Control, Soil + Fertilizer, Soil + Biochar and Soil + Biochar + Fertilizer did not significantly affect the collar diameter growth for both *Entandrophragma cylindricum* and *Tamarindus indica*. However, there were numerical variations among the treatments. The mixture of Soil + Fertilizer had the largest collar diameter of 3.177 cm for *Entandrophragma cylindricum*, while the mixture of Soil + Biochar had the largest mean collar diameter of 2.249 cm for *Tamarindus indica*.

Table 4 - Separation of means for collar diameter.

Species	Treatments	Mean
E. cylindricum	Soil + Fertilizer	3.177[a]
	Soil + Biochar	3.064[a]
	Soil + Biochar + Fertilizer	3.052[a]
	Control	3.029[a]
T. indica	Soil + Biochar	2.249[a]
	Soil + Biochar + Fertilizer	2.247[a]
	Soil + Fertilizer	2.238[a]
	Control	2.194[a]

Mean with the same superscript are not significantly different at 5%

Mean leaf number

Similarly, the leaf number of *Entandrophragma cylindricum* and *Tamarindus indica* were counted and analyzed (see Table 5). No significant difference was observed at 5% (P>0.05) among the four treatment for the two species. Little or no variation could be seen from the Table. However, the mixture of Soil + Biochar had the highest average leaf number of 6.271 and 13.84 for *Entandrophragma cylindricum* and *Tamarindus indica*, respectively.

Table 5 - Separation of means for leaf number.

Species	Treatments	Mean
E. cylindricum	Soil + Biochar	6.271[a]
	Soil + Biochar + Fertilizer	6.164[a]
	Soil + Fertilizer	5.971[a]
	Control	5.707[a]
T. indica	Soil + Biochar	13.840[a]
	Soil + Fertilizer	13.314[a]
	Soil + Biochar + Fertilizer	13.107[a]
	Control	12.764[a]

Mean with the same superscript are not significantly different at 5%

Discussion

This study has demonstrated the potential of biochar to promote growth in *Entandrophragma cylindricum* and *Tamarindus indica*. The major morphological criteria used to describe seedling quality are shoot height, collar diameter, leaf number, etc. These are the bases for grading seedlings in the nursery. The result of this study reveals that the total height, collar diameter and leaf number were not statistically significant but the stem height was significant for only *Entandrophragma* seedlings. The stem height of *Entandrophragma* was statistically different within the treatments, but *Tamarindus* appeared marginally better than *Entandrophragma* seedlings. The stem height appears to do better in control and soil + fertilizer for *Entandrophragma* and control and soil + biochar + fertilizer for *Tamarindus*. The stem height of *Tamarindus* was consistently better than *Entandrophragma* seedlings all through the experiment for all the treatments.

This study is not in line with Mete et al. (2015) who studied the synergistic effects of biochar and NPK on soybean yield in an alkaline soil. The authors reported a significant increase in soybean yield when biochar and NPK was combined compared to control. The low yield in the control was attributed to a high soil pH of 8.8. The pH of control in the current study was 5.8 which may have favoured the growth of the seedlings. Similar observation was reported by Liang et al. (2014), Oram et al. (2014), Smider and Singh (2014) and Tammeorg et al. (2014).

The total height of *Tamarindus* was marginally better than that of the *Entandrophragma* seedlings throughout the experiment. Though there was no statistical significant difference among the treatments, but it appears that *Tamarindus* seedlings did better in all the treatments than *Entandrophragma* seedlings. Although all the means of collar diameters were not statistically significant, the collar diameter of *Entandrophragma* appears to be better than that of *Tamarindus* marginally. *Tamarindus* seedlings appear marginally better than *Entandrophragma* seedlings among the treatments for leaf number. Also, we observed pest attack on the leaf of *Entandrophragma cylindricum* which could have affected the growth of this plant. As the pest was sighted feeding on the leaf of the plant; thereby reducing the leaf surface area available for photosynthesis.

The results obtained from pot trials cannot be estimated for the field due to differences in soil volume, presence of impeding horizons or moisture stress Onuwaje and Uzu (1982). The pot trials should rather serve as a guide for field application or further field studies into the effect of biochar and NPK fertilizer on seedlings growth.

Conclusions

The result of the study showed that application of biochar and NPK fertilizer at four ratio half head pans and 400kg/ha respectively did not significantly affect most of the growth parameters measured; although there was improvement and

marginal increase. Therefore, the use of biochar and NPK fertilizer in raising *Entandrophragma* and *Tamarindus* seedlings may not be necessary. We recommend that other silvicultural practices that would promote the growth of *Entandrophragma* and *Tamarindus* should be considered. And whenever an experiment like this is being carried out in the nursery¸ arrangements should be made to eradicate pest and insect attack.

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