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Comparative effect of *Bambusa vulgaris* Schrad. and *Gliricidia sepium*(Jacq.) charcoal powders on the growth of *Parkia biglobosa (*Jacq.) Benth seedlings

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Abstract
The high cost of purchasing inorganic fertilizer and its impacts on the soil and the environment remains a major concern in environmental management. Consequently, there is the need to explore other ways to enhance soil fertility. The study investigated the effects of Bambusa vulgaris Schrad. and Gliricidia sepium (Jacq) charcoal powders on the growth of Parkia biglobosa (Jacq). Benth seedlings. The experiment was laid out in a Completely Randomized Design (CRD) with 13 treatments and 9 replicates each. Seeds were sowed directly into polyethene pots while the various treatments were added a week after sowing seeds. Watering was done daily while weeding was done periodically. Growth parameters of seedling height (cm), stem diameter (mm) and leaf count were assessed weekly for 16weeks. Data collected was subjected to Analysis of Variance (ANOVA) at 5% level of significance while the means were separated using Duncan Multiple Range Test (DMRT). The result obtained showed that 15g of Gliricidia sepium charcoal powder + 2kg of topsoil) performed best in height and leaf production with values of 15.85cm and 20.58 respectively.5g of Bambusa vulgaris charcoal powder + 2kg of topsoil) performed best with the value of 0.41mm for stem diameter.2kg of topsoil had the least performance for all parameter assessed. The ANOVA result showed that there was significant difference at P>0.5 among the treatments at 5% level of probability in terms of plant height, stem diameter, leaf production. The study concludes that the addition of charcoalas soil additive enhanced growth of Parkia biglobosa seedling at nursery stage.

Keywords: Charcoal powder, Inorganic fertilizer, Organic manure, *Parkia biglobosa*, Stem diameter

Introduction
Parkia biglobosa popularly known as African locust bean tree is an indigenous tree species appreciated for its many uses (Teklehaimanot, 2004; Koura *et al.*, 2011; Nyadamu *et al.*, 2017). It is one of the trees with wound-healing properties in South-Western Nigeria (Udobi and Onaolapo, 2009). This is because it is known to influence the proliferation of dermal fibroblasts significantly (Adetutu*et al.*, 2011). *Parkia biglobosa* is one of the highest cited plants used for treating hypertension, malaria and wound (Komolafe*et al.*, 2013; Nadege*et al.*, 2016; Debehou *et al.*, 2016). The bark is used as mouthwash, vapor inhalant for toothache or for ear complaints (Banwo *et al.*, 2004; Kayode, 2008). It is macerated in baths for leprosy and used for bronchitis, pneumonia, skin infections, sores, ulcers, violent colic and vomiting (Soetan *et al.*, 2011; Nadege*et al.*, 2016). Furthermore, it is used to treat sterility, venereal diseases, Guinea worm, Oedema and rickets. The tree is used as poison antidote (Karou*et al.*, 2011).
The leaves are used in lotions for sore eyes burns, hemorrhoids and toothache. The seed is taken for tension and the pulp for fevers. It serves as a diuretic and a mild purgative. The bark leaves and pods husks are rich in tannins, which in general have anti-diarrheal activities (Sacande and Clethero, 2007 in Aja *et al.*, 2015). Despite the socio-economic important, the population of this tree is reducing and it remains semi- or

undomesticated (Teklehaimanot, 2004). This indigenous tree species is exposed to anthropogenic pressure in its natural habitat as a result of population exploitation (Lamien *et al.*, 2011).

Charcoal is a carbon rich solid material produced from the heating of biomass in a closed container in an atmosphere of little or no oxygen (Lehmann and Joseph, 2009). Recently, the use of charcoal on farmlands is considered to be more effective for improving the soil and promoting plant growth. Also, there has been much interest in charcoal as soil additive to improve and maintain soil fertility and increase crop yield (Lehmann *et al.,* 2003). When added to soil or potting mixture, charcoal has been reported to increase available nutrient and prevent their leaching displacement and greatly reduce rate of pesticide on plant (Robert, 2006). Different plants can be used to produce charcoal as soil additive. Charcoal can be an important tool to increase food security and cropland diversity in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertilizer supplies. Charcoal made from *Gliricidia sepium* (Jacq.) when used as soil additive have been known to minimize the usage chemical fertilizer that are very expensive and also environmental unfriendly (Mackenzie, 1986).

Review of literatures have shown that bamboo charcoal as a soil additive is an emerging and highly promising organic material for soil organic-matter maintenance and sustainable soil production (Zheng *et al.,* 2010). Also, Bamboo biomass organic fertilizer made from bamboo charcoal has been used to replace chemical fertilizer as another good organic fertilizer in some countries. It has no chemical residues and can well improve soil organic matter content, which has a great developing prospect (Guo, 2016).

The high cost of purchasing inorganic fertilizer and its impacts on the soil and the environment remains a major concern to all environmental management stakeholders. This has given rise to increasing popularity of organic manure to enhance soil fertility. The most common being animal and decomposed plant manure. Thus, the need to look for other ways of increasing plant yield, maintain and preserve the soil fertility while maintaining the sustainability of the environment.

Consequently, the production and the uses of charcoals as soil additive so as to reduce the use of chemical fertilizer while benefiting from the numerous benefits their addition offer to the soil and the environment. The aim of this study is to examine the effect of *Bambusa vulgaris* and *Gliricidia sepium* charcoal powder on the growth of *Parkia biglobosa* seedlings. This is to aid its growth in the nursery and subsequent domestication through establishment of *Parkia biglobosa* plantation using a common weed; *Gliricidia sepium* and cosmopolitan plant with very rapid growth; *Bambusa vulgaris*.

Origin and Geographical distribution

The plant belongs to the Fabaceae family. Robert Brown described the genus Parkia in 1826.

Parkia biglobosa is a perennial deciduous tree that is fairly widely distributed all over the natural grassland of Northern Nigeria (Ojewumi, 2016). The tree can be found mainly in Africa, especially in the following countries; Benin, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Democratic Republic of Congo, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Senegal, Sierra Leone, Sudan, Togo, and Uganda (Hall *et al.,* 1997)

Description of Parkia biglobosa

Parkia biglobosa is a perennial deciduous tree with a height ranging from 7 to 20 m, although it can reach 30 m under exceptional conditions, with a wide spreading umbrella-shaped crown spreading wide with branches low down on a stout bole (Teklehaimanot, 2004, Ojewumi, 2016). The bark is usually thick, dark grey-brown in color. Amber gum comes out of the bark in drops when wounded. The leaves are alternate and dark green in color. They interchange repeatedly and regularly with one another to form bipinnate of about 30 cm long with pinnae of up to 8-16 pairs with 13-60 pairs of leaflets of 8-30 mm x 1.5-8 mm, of distinctive shape and venation. Leaflets are held on a long rachis (Agroforestry database, 2014).

The flowers are hermaphrodite and orange or red in color. Calyx is 10-13 mm long and exceptional one reaching 16 mm. Corolla is between 10-14 mm long with very short lobe of 1-3 mm long. The seeds are contained in branches of pods that make up the most valuable part of the plant. The pods are flat and large irregular cluster of up to 30 seeds embedded in a yellow pericarp (Omafuvbe *et al.,* 2004). Pods are pinkish brown to dark brown in color when matured. They are about 45 cm long and 2 cm wide. Seeds have a hard Testa, are large (mean weight 0.26 g/seed) with large cotyledons forming about 70% of their weight (Database.prota.org, 2014).

Ecology of Parkia biglobosa

Parkia biglobosa occurs in a diversity of zones, ranging from tropical forests with high and well-distributed rainfall to arid zones where mean annual rainfall may be less than 400 mm (Agroforestry database, 2014). The tree requires an altitude of about 300 m with an average rainfall of 400–700 mm per annum and an average mean annual temperature of 28^{o}C. It prefers well-drained, deep, cultivated soils, but can also be found on shallow, skeletal soils (Database.prota.org, 2014). The tree can also grow on rocky slopes, stony ridges or sandstone hills. Due to its deep taproot system and an ability to restrict transpiration it has a capacity to withstand drought conditions. It is a fire-resistant helophyte (Oyebamiji *et al.,* 2019).

Growth and development

The seedling shows semi-hypogeal germination, the Testa slitting but remaining associated with the freshly, pale green cotyledons. The first leaf is a cataphyll, and subsequent juvenile leaves are bipinnate with usually 3-pairs of pinnate. The whitish to yellowish taproot develops first germination and gives rise to lateral roots. Growth is comparatively fast as seedling may reach a height of 1m in 1 year. Young trees of superior provenance can reach 7m in 6years. Tree development is in accordance with Champagnat's architectural model: The trunk is formed by supervision of renewal shoots from lateral buds: the new shoots is initially orthotropic but later becomes plagiotropic. The phyllotaxy is spiral (Oyebamiji *et al.,* 2019).

Socio-economic importance of Parkia biglobosa

The various importance of *Parkia biglobosa* made it an ideal plant to promote across Africa, as it combines in a single species two of Africa's greatest needs which are; food security and tree cover alongside the health benefits. All trees of the *Parkia*s species are carefully and usually kept safe by the people in the particular area where they grow because of their valuable sources as a reliable source of food, especially the seeds which serves as source of useful ingredients for consumption. The pods and husks have also been discovered to be good food for livestock. *Parkia biglobosa* is beneficial to the soil situated beneath, which is made useful and valuable by the dung and urine of animals that shelter under the tree's shade. It can also be used as timber for making pestles, mortars, bows, and seats (Ntui *et al.,* 2012).

The most valuable parts of the locust bean, and possibly the entire tree, are the seeds themselves which are high in lipid (29%), protein (35%), carbohydrate (16%), and is a good source of fat and calcium for rural dwellers (Lamien *et al.,* 1996). The yellow pulp, which contains the seeds, is naturally sweet and can be consumed directly as is a valuable source of carbohydrate food. The fermented seeds popularly known as 'dawadawa' amongst the Hausas; 'Iru' by the Yorubas serve primarily as condiment for seasoning sauces and soups. Roasted seeds are used as a coffee or café nerge. The ground seeds are mixed with *Moringa oleifera* (Lam.) leaves to prepare sauce, and are also used to make doughnuts. The Leaves are sometimes eaten as vegetable. Usually after boiling and then mixed with other foods such as cereals flour. Young flower buds are added to make mixed salads (Ojewumi, 2016).

Indigenous healer in Africa use difference parts of the locust bean tree for health benefits. In a survey conducted on healer in Togo; *Parkia biglobosa* was one of the highest cited plants used for treating hypertension (Teklehaimanot, 2004). The tree was also one two plants listed as having real wound- healing properties in South – Western Nigeria, influencing the proliferation of dermal fibroblasts significantly (Karou *et al.,* 2011).

Parkia biglobosa is beneficial to the soil situated beneath, which is made useful and valuable by the dung and urine of animals that shelter under the tree's shade. It can also be used as timber for making pestles, mortars, bows, and seats (Ntui *et al.*, 2012).

Materials and Methods

Experimental site

The experiment was carried out within the screen house of Federal College of Forestry, Jericho Ibadan, Oyo state. The college lies on Latitude 7°23'N and Latitude 3°51' E. Climatically, the area is characterized by annual average rainfall of between 1200 mm- 1250 mm. The annual average temperature is about 32°C; with average relative humidity of about 80%. There are two distinct seasons in the area, dry season usually from November- March and rainy season usually from April- October (FRIN, 2019).

Procurement of materials

Parkia biglobosa seeds were gotten from Agoro area of Iwo town in Osun state and were extracted from its pod. *Gliricidia sepium* branches for the charcoal were gotten from Nursery C of Forestry Technology Department. *Bambusa vulgaris* tree for charcoal were collected from stream beside Nursery A of Forestry Department. Polythene pots of 2 kg and identification tags were gotten from Dugbe market in Ibadan. Materials for both charcoals were cut into smaller size, burned, grinded and sieved to get fine powder.

Seed preparation

Seed viability was tested using the soaking method. The seeds were soaked in water and the seeds that sunk down were collected as viable seeds for planting while those that floated were discarded. To break seed dormancy and enhance seed germination, the method used by Aliero (2004) and adopted by Dauda *et. al*. (2019) was used. The seeds to be planted were pretreated using Concentrated H_2S0_4 (10%). Seeds to be pre-treated were put on wire gauze of 2 mm size and immersed into the concentrated H_2SO_4. The seeds were withdrawn immediately after five minutes. The seeds were then soaked in water for 10 minutes and air dried for three hours. Seeds were sowed directly inside the polythene pot filled with 2 kg topsoil and various treatments. The seeds were raised for one week and the already prepared *Bambusa vulgaris* and *Gliricidia sepium* charcoal powder were applied accordingly after one week. Silvicultural practice of watering was done daily while weeding was done periodically on each polyethene pot. Thorough observation, monitoring and assessment of growth parameters were carried out.

Charcoal production and Application

Two small holes of about 30 cm were dug in Nursery C of the Forestry Technology Department. Materials for both charcoals were cut into smaller size. The materials were put into the hole appropriately. Small fire was set to each hole. When the materials for the charcoal had become pulverized, the fire was completely put out using water. The resulting charcoal from each material was air. After being completely dried, the charcoal was put in clean heavy sack and beaten to powder using pestle. The resulting powders were sieved to fine powder using fine mesh cocktail strainer (Barbano, 2012). The grinded charcoals were weighed using sensitive scale into the different quantity required; 5g, 10g, 15g, and 20g. It was then thoroughly mixed with water and applied to the transplanted plant each replicate with different mass quantity (Artiola *et al.*, 2017).

Experimental design

The experiment was arranged in a Completely Randomized Design (CRD) with thirteen treatments, replicated nine times.
The CRD treatment is given as

T_1- 2kg of topsoil (Control)
T_2- 5g of *Bambusa vulgaris* charcoal powder+ 2kg of topsoil
T_3- 10g of *Bambusa vulgaris* charcoal powder + 2kg of topsoil
T_4 -15g of *Bambusa vulgaris* charcoal powder + 2kg of topsoil
T_5 – 20g of *Bambusa vulgaris* charcoal powder + 2kg of topsoil
T_6 – 5g of *Gliricidia sepium* charcoal powder + 2kg of topsoil
T_7 – 10g of *Gliricidia sepium* charcoal powder + 2kg of topsoil
T_8- 15g of *Gliricidia sepium* charcoal powder +2kg of topsoil
T_9- 20g of *Gliricidia sepium* charcoal powder +2kg of topsoil
T_{10}- 2.5g of mixture of *Bambusa vulgaris* charcoal powder and 2.5g *Gliricidia sepium* charcoal powder + 2kg topsoil
T_{11}- 5g of mixture of *Bambusa vulgaris* charcoal powder and 5g *Gliricidia sepium* charcoal powder + 2kg of topsoil
T_{12}- 7.5g of mixture of *Bambusa vulgaris* charcoal powder and 7.5g *Gliricidia sepium* charcoal powder + 2kg of topsoil
T_{13} – 10g of mixture of *Bambusa vulgaris* charcoal powder and 10g *Gliricidia sepium* charcoal powder + 2kg of topsoil

Experimental Layout

T_1R_1	$T_{10}R_8$	T_6R_7	T_2R_6	$T_{11}R_4$	T_7R_3	T_3R_6	$T_{12}R_5$	T_7R_7	T_2R_8	$T_{11}R_7$	T_7R_6	T_5R_4
T_2R_9	$T_{11}R_1$	T_7R_5	T_3R_1	$T_{12}R_1$	T_8R_5	T_4R_1	$T_{13}R_9$	$T_{13}R_3$	T_5R_2	T_5R_7	T_8R_9	$T_{10}R_9$
T_3R_4	$T_{12}R_7$	T_8R_1	T_4R_4	$T_{13}R_6$	T_9R_2	T_5R_8	T_2R_2	T_9R_1	T_8R_4	T_2R_4	$T_{11}R_2$	T_6R_8
T_4R_7	$T_{13}R_4$	T_9R_9	T_5R_6	T_1R_9	$T_{10}R_7$	T_6R_5	T_1R_1	$T_{11}R_3$	T_6R_3	T_4R_5	$T_{13}R_5$	T_7R_8
T_5R_3	T_1R_5	$T_{10}R_2$	T_6R_4	T_2R_1	$T_{11}R_9$	T_7R_4	T_4R_6	$T_{10}R_4$	T_9R_5	T_1R_2	$T_{12}R_8$	T_9R_8
T_6R_2	T_2R_3	$T_{11}R_8$	T_7R_9	T_3R_3	$T_{12}R_2$	T_8R_2	T_3R_2	$T_{12}R_9$	T_7R_2	T_3R_9	T_1R_7	T_8R_6
T_7R_1	T_3R_8	$T_{12}R_4$	T_8R_8	T_4R_9	$T_{13}R_7$	T_9R_7	T_5R_5	T_3R_7	$T_{10}R_3$	$T_{10}R_6$	T_3R_5	$T_{13}R_2$
T_8R_3	T_4R_2	$T_{13}R_8$	T_9R_4	T_5R_1	T_1R_3	$T_{10}R_1$	T_6R_9	T_1R_4	$T_{13}R_1$	T_6R_6	T_2R_7	$T_{12}R_6$
T_9R_6	T_5R_9	T_1R_6	$T_{10}R_5$	T_6R_1	T_2R_5	$T_{11}R_6$	T_8R_7	T_4R_3	$T_{12}R_3$	T_9R_3	T_4R_8	$T_{11}R_7$

Data Collection

The following growth parameters were assessed weekly during the experiment.

i. Plant height (cm): measurements were taken from the base to the apex of the plant using ruler;
ii. Stem Diameter (mm): measurements were taken at the base of the plant using Venier caliper;
iii. Leaf production: by counting the number of leaves of the seedlings;
iv. Biomass accumulation – biomass production will be carried out at the end of the experiment.

Data Analysis

Analysis of variance (ANOVA) was used to analyzed the data collected and the means was separated by using Duncan multiple range test (DMRT).

Pre-sowing analysis of soil and charcoals used for the experiment

Soil pH measures the acidity or alkalinity of soil water. This soil property influences the chemical and physiological process in the soil including nutrient availability to plants. It also determines the overall health of a soil (Horneck *et al.*, 2011). A high or low soil pH locks up nutrients in the soil and thus, making nutrient unavailable to plants. Table 1 show that the topsoil used for the experiment has a neutral pH with a value of 6.6. The soil has a86.5% of sandy particles and 8.5% silt particles. The result also indicates 0.66% of Organic Carbon (O.C), 1.13% of Organic Manure (O.M) and 0.06% of Nitrogen (N). Also contained in the topsoil are; 48.9cmol/kg of Phosphorus (P), 29.1cmol/kg of Calcium (Ca), 3.62cmol/kg of Magnesium (Mg), 0.019cmol/kg of Sodium (Na), 0.06cmol/kg of Potassium (K), 8.9cmol/kg of Copper (Cu), 68cmol/kg of Manganese (Mn), 26.8cmol/kg of Zinc (Zn) and 15.4cmol/kg of Iron (Fe).

Table 1: Chemical analysis of topsoil used

Element	Properties
P^H	6.66
O.C %	0.66
O.M %	1.13
P mg/kg	0.06
Ca Cmol/kg	48.9
Mg Cmol/kg	29.1
Na Cmol/kg	3.62
K Cmol/kg	0.019
Cu Cmol/kg	0.06
Mn Cmol/kg	8.9
Zn mg/kg	68
Fe mg/kg	26.8
Silt (%)	8.5
Clay (%)	17
Sand (%)	86.5

Source: Department of Bioscience, Forestry Research Institute of Nigeria, Ibadan

The organic matter content of soil influences its fertility. The amount of organic matter in a soil depends on rainfall, air and soil temperatures, type of plants grown or growing in the soil, management practices to mention a few. Soil frequently tilled will be low in organic matter asa result of increased decomposition as tilling reduce soil particle size and amount of air in soil (Crouse, 2018). Most productive soils in agriculture have organic matter of 3-6% (Mahler, 2004). The organic matter of the soil used is low with a value of 1.13% as against the standard for most productive soil. In addition, the soil is low in Nitrogen and Carbon content with a value of 0.0.6% and 6-6% compared to the minimum of 1.5% and 45% respectively required by most plants (Crouse, 2018). The nutrient level of the soil shows that it still good enough for planting as it contains the necessary nutrients needed for plant growth.

Table 2 shows chemical analysis of *Bambusa Vulgaris* charcoal used in the experiment. The result shows the charcoal is made of nutrients both in large and small quantity. The result shows that the charcoal contains 5.99% of Organic Carbon (O.C), 10.3% of Organic manure (O.M), 0.5% of Nitrogen (N), 0.03% of Phosphorus (P), 0.011% of Manganese (Mn) and 0.0052% of Iron (Fe). Other nutrients contained in the charcoal are; 0.58% Zinc (Zn), 0.05% Sodium (Na), 0.02% of Potassium (K), 0.22% of Magnesium and 0.34% of Calcium (Ca). This charcoal has a percentage of Organic manure with values of 10.3% compared to the 3-6% in productive soil (Mahler, 2004). The Carbon 5.99% is low as against the 45% needed by most plants for health growth (Crouse, 2018). The Nitrogen of this charcoal is also low with a value of 0.5% as against the general standard value of 1.5% (Mahler, 2004; Crouse, 2018).

Table 2: Chemical analysis of *Bambusa vulgaris* charcoal used for the experiment

Element (%)	*Bambusa vulgaris* charcoal powder
O.C	5.99
O.M	10.3
N	0.5
P	0.03
Mn	0.011
Fe	0.58
Cu	0.002
Zn	0.58
Na	0.05
K	0.02
Mg	0.22
Ca	0.34

Source: Department of bioscience, Forestry research institute of Nigeria, Ibadan

These elements; organic manure, organic carbon and Nitrogen are known to enhance plant growth and productivity when present in high quantity in soil (Crouse, 2018). The secondary nutrient of Magnesium content of the charcoal is a little higher (0.22%) that the optimum (0.2%) required by most plant while Calcium content (0.34%) is not far from the optimum requirements (0.5%) of most plants (Crouse, 2018). Micronutrients of Zinc and Iron with value 0.58% for both are far too high compared to optimum (0.002 and 0.01) required by most plants (Hornbeck *et al.,* 2017; Crouse, 2018). The overall nutrient content of the charcoal shows that it contains all the nutrients needed by plants for growth

Table 3 shows chemical analysis of *Gliricidia sepium* charcoal used in the experiment. The result shows the percentage of all nutrients contained in the charcoal. The result indicates 4.99% of organic Carbon (O.C), 8.99% of Organic Manure (O.M), 0.14% of Nitrogen (N), 0.4% of Calcium (Ca), 0.2% 0f Magnesium (Mg), 0.05% of Sodium (Na), 0.1% of Potassium (K), 0.325% of Iron (Fe), 0.0016% of copper. Also, observed in the charcoal are: 0.0037% of Zinc (Zn), 0.006% of Manganese (Mn) and 0.06% of Phosphorus.

The organic manure of the charcoal (8.99%) is higher than the range of the standard (3-6%) required by most plants (Crouse, 2018). The Carbon content of (5.9%) is lower than the optimum required for most plants. The charcoal is also low in Nitrogen and Potassium (0.14% and 0.06%) respectively compared to 1.5% and 0.2% of the nutrients required by most plants for growth. The secondary nutrient of Magnesium in the charcoal is equal to that required by most plants while Calcium content (0.5%) is very close to the optimum required by most plants (Crouse, 2018). The overall nutrients contained in the charcoal prove that it contains nutrients needed for plant growth.

The nutrient content of the two charcoals shows they could be good amendment to improve soil fertility. The high carbon content of both charcoals could be a result of carbon storage in the plant parts especially the stem. This is an indication that charcoal can be used in climate change mitigation (Rome, 2017).

Table 3: Chemical analysis of *Gliricidia sepium* charcoal used for the experiment

Element (%)	*Gliricidia sepium* charcoal powder
O.C	4.99
O.M	8.99
N	0.14
Ca	0.4
Mg	0.2
Na	0.05
K	0.1
Fe	0.325
Cu	0.0016
Zn	0.0037
Mn	0.006
P	0.06

Source: Department of Bioscience, Forestry Research Institute of Nigeria, Ibadan

Results and Discussion

Plant height is an essential morphological and developmental phenotype that shows the overall plant growth. It is defined as the shortest distance between the upper boundary of the main photosynthetic tissues on a plant and the ground level, expressed in centimeter (Wang *et al.*, 2018).

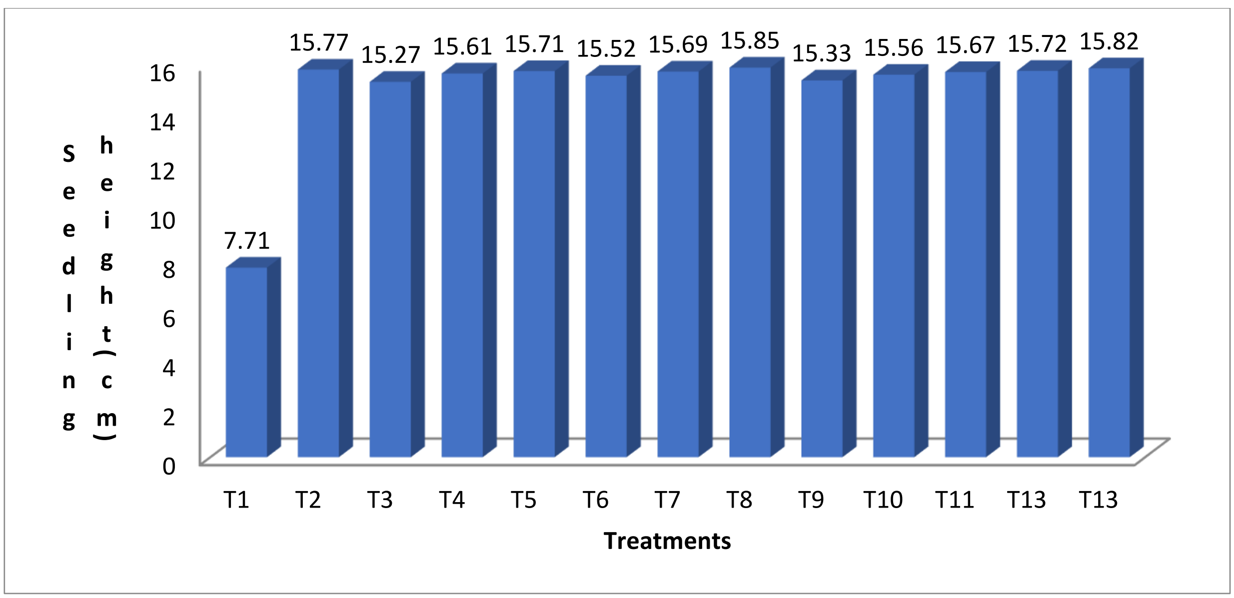

Figure 1: Seedling height (cm) of *Parkia biglobosa* after 16 weeks

Figure 1 shows T_8; with 15g of *Gliricidia sepium* charcoal +2kg of topsoil had the highest mean plant height value of 15.85cm. This is followed by T_{13}; with 10g of both charcoals (*Bambusa vulgaris* and *Gliricidia sepium*) + 2 kg of topsoil with a mean value of 15.82 cm. This is closely followed by T_2; treatment with 5g of bamboo charcoal + 2 kg of topsoil having mean value of 15.77 cm. The least mean value is the control T_1 (2 kg of topsoil) with a mean value of 7.71 cm. It can be deduced from the result that the seedling performed well for plant height with the two types of charcoal used. However, the highest result was observed when *G. sepium* charcoal alone was used. This was closely followed by the 10g of both charcoals. Study by Hoshi (2001) that revealed a 40% increase in height of trees when bamboo charcoal was used as soil additive. Treatment with bamboo charcoal ranked third in seedling height for this study. This might be a function of the plant types used.

Stem diameter is a growth factor that determines the yield, development and production of any plant. Figure 2 indicates T_2, treatment with 5g of bamboo+ 2 kg of topsoil had the highest mean stem diameter value of 0.41 mm. This is followed by mean stem diameter value of 0.40 mm for treatments; T_{10} and T_{11} (2.5g each of Bamboo and *G.sepium* charcoals + 2 kg of topsoil) respectively. T_1 which is the control (2 kg of topsoil) had the least mean stem diameter value of 0.24 mm. The result showed that charcoal of bamboo alone produced the greatest value for stem diameter. This might be due to its content which favours stem diameter growth. This is followed by charcoals Bamboo and *G.sepium* used together as treatment. Thus, if what is needed from the plant is large stem, charcoal of bamboo alone is appropriate. This agrees with the findings of Blackwell (2009) that postulate charcoal has the greatest ability to improve plant growth and nutrient content when applied to variety of soil.

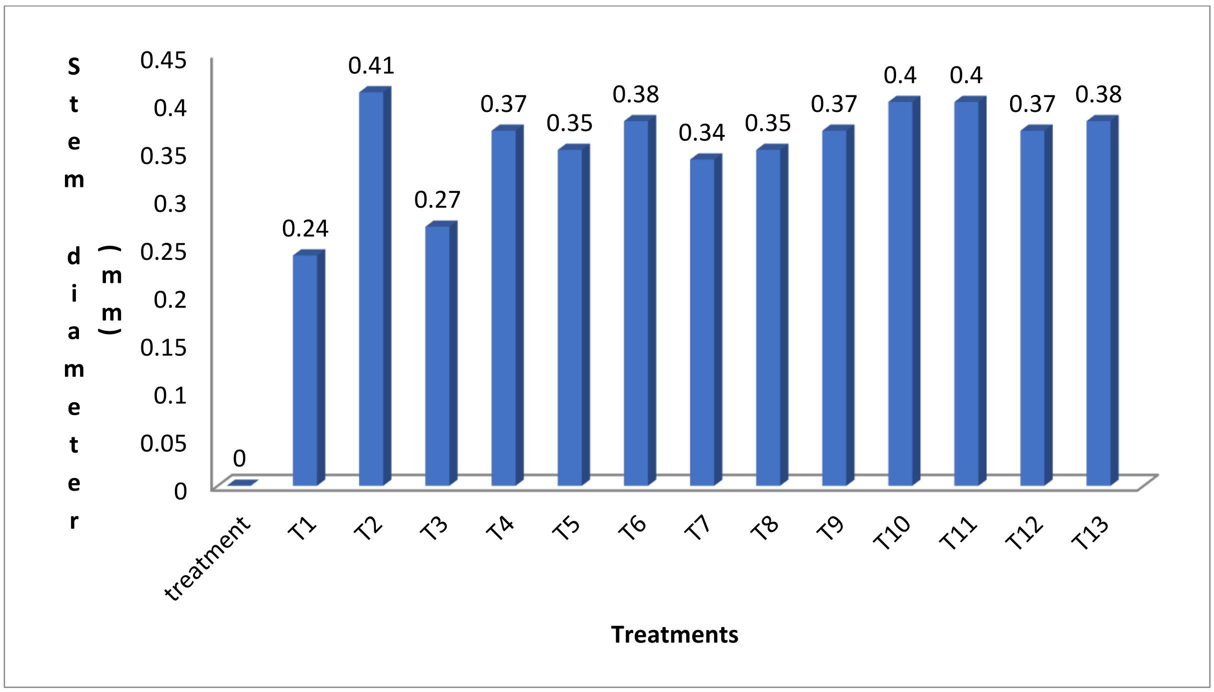

Figure 2. Stem diameter (mm) of *Parkia biglobosa* after 16 weeks

Leaf production is an indispensable function in the process of photosynthesis in any plant. Figure 3 showed that treatment with 15g *Gliricidia sepium* charcoal + 2 kg of topsoil (T_8); had the highest mean value of 20.58 for leaf production. This is closely followed by T_{10} which is treatment with 2.5g each of Bamboo and *Gliricidia sepium* charcoals + 2 kg of topsoilwith mean value of 20.46. The control (T_1) had the least leaf production value of 12.75. All treatments with the exception of the control (T_1) had a high value for leaf production.

The highest leaf productions were observed in the treatment with *G.sepium* charcoal alone. This was followed by the charcoal produced from both Bamboo and *G.sepium*. This may be due to the high content of organic manure and organic carbon that enhance photosynthesis and subsequent increased productivity. This is in accordance with the findings of Lehmann and Joseph (2009), that the application of charcoal increases yield on formerly abused soils by as much as 300%.

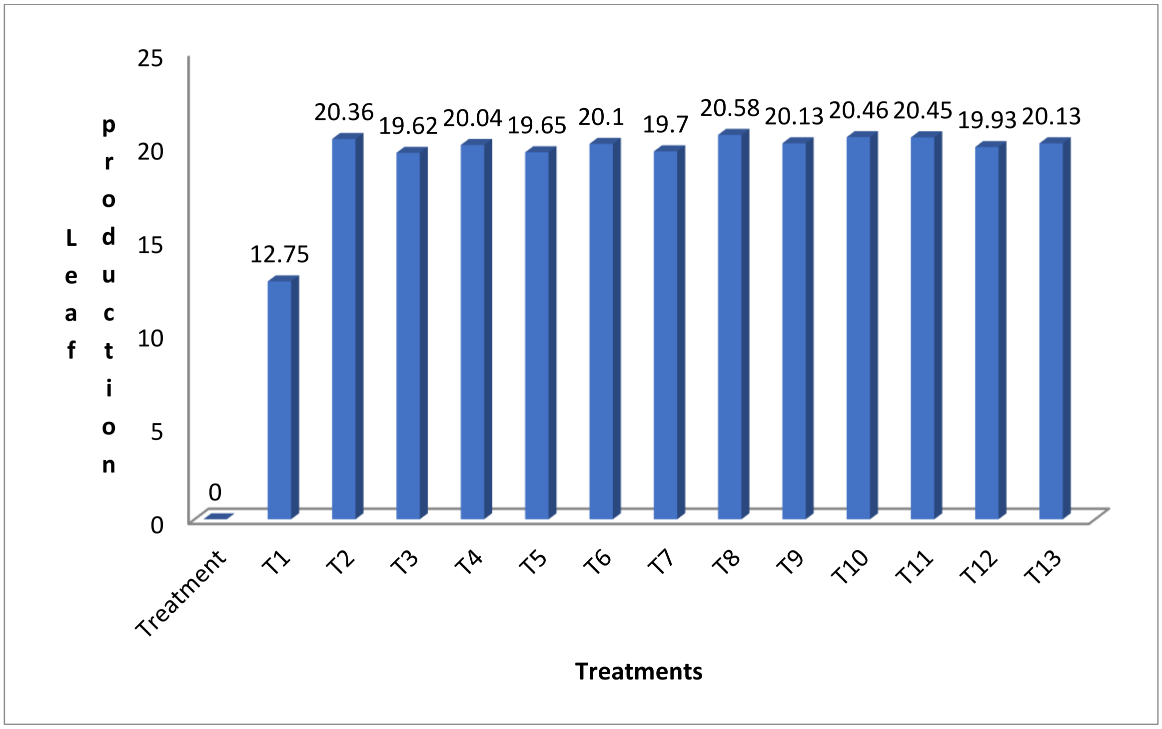

Figure 3. Leaf production of *Parkia biglobosa* after 16 weeks of growth

Conclusions and Recommendations

The study sets out to empirically investigate the influence of *B. vulgaris* and *G.sepium* charcoals as soil addictive on the growth of *Parkia biglobosa* seedlings at the nursery. Based on the findings; the study concluded that:

(i) the addition of charcoal powder to soil as addictive to enhance its fertility influenced the growth and development to *Parkia biglobosa* seedlings at the nursery,

(ii) the charcoals when used individually and in combination with each other produced positive result on the different aspect of the seedling growth assessed,

(iii) the used of these charcoals can therefore help improve soil fertility, enhance productivity while improving their nutrient retention ability.

The study recommends charcoal made from bamboo (*Bambusa vulgaris)* and *Gliricidia sepium* in raising *P. biglobosa* seedlings in the nursery and on the field. This is because materials for producing the charcoal are readily available and are environmentally friendly. Also, little or no cost implication is attached. Further studies should be carried out on the use of charcoal made from other plant source as soil addictive in raising other indigenous tree species in the nursery for better understanding of the use charcoal-based fertilizer in our forest nurseries.

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