Vol 5 | Issue 1 | Pages 149-160

Journal of Botany Research
ISSN: 2643-6027

Research Article

DOI: 10.36959/771/573

Effects of Biochar Soil Amendment on the Rooting and Early Growth of African Mahogany Species: *Khaya Ivorensis* And *Khaya Grandifoliola*

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Abstract

Biochar application as growing medium is being recognized globally in forest and crop restoration. Biochar soil amendment was proposed to improve rooting media characteristics for effective rooting of mahogany stem cuttings in vegetative propagation system. A study was undertaken at Forestry Research Institute of Ghana to assess effects of different biochar (20v/v and 50v/v) amendment to riversand, loamy soil (80v and 50v), and mixtures of riversand + loam (40v/v and 25v/v) on rooting performance of *K. ivorensis* and *K. grandifoliola* cuttings in non-mist propagators. Thirty single node cuttings of both mahogany species were distributed per treatment in completely randomized block design with 3 replicates. Mean number roots per rooted cutting, root length and survival rate were assessed ten weeks after propagation. Species specific responses to biochar soil amendment was observed as *K. ivorensis* recorded maximum mean survival rate (80.08%) and root length (6.9 cm) whiles *K. grandifoliola* had maximum roots per cuttings (7.6). The 50v biochar + 25 v/v riversand + loam significantly yielded maximum number of roots formed per cutting (6.8), root length (7.03) and survival (75.08%) for both *K. ivorensis* and *K. grandifoliola.* Riversand recorded lowest roots per cutting for both species (3.48) and survival (45%) while loamy soil yielded lowest root length (4.02cm). Increasing biochar (50v/v) and lower mixtures of riversand and loam (25v/v) had profound impact on rooting *K. ivorensis* and *K. grandifoliola* cuttings. 50v biochar + 25 v/v riversand + loam is recommended as suitable medium for producing mahogany stock-plants for effective restoration and conservation.

Keyword

African mahogany, Biochar-soil amendment, Rooting, Stock-plants, Restoration

Introduction

African mahogany is highly desirable and important export commodity in the global timber business and Sub-Saharan Africa respectively [1-5]. The prime mahoganies include species in the genera Khaya, Entandrophragma, Toona, Guarea and others in the family Meliaceae which are widely distributed in Cameroun, Niger, Cote D'Ivoire, Uganda, Gabon and found in Ghana within the semi deciduous, moist and wet evergreen, transitional forest zones [2,6]. Globally, African mahogany are well recognized for their versatile uses for construction of furniture, veneer, and good medicinal value of the bark extracts [6-10]. The rapid declining of many economically important indigenous species in the main land tropics have been emphasized in many studies [11-13]. The African mahogany species in Ghana have faced overexploitation pressures from their natural population in the quest to meet the ever-increasing demand for their hardwood which has triggered scarcity of the resource base, diminishing tree species diversity and loss of valuable germplasm which are needed for restoration [14-17]. Consequently, the rate of their extraction exceeds their

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Accepted: June 28, 2022

Published online: June 30, 2022

Citation: Opoku ME, Opuni-Frimpong E, Sarfo Y (2022) Effects of Biochar Soil Amendment on the Rooting and Early Growth of African Mahogany Species: *Khaya Ivorensis* And *Khaya Grandifoliola*. J Bot Res 5(1):149-160

natural regenerative capacity. Matured seeds harvested from the tree after fruiting may have good germination potential (90%), however the viable seeds that fall on the natural forest floor reduces its viability and are also preyed on by some insects and seed feeding mammals [16,18,19]. These problems in turn impedes successful natural regeneration of mahogany species. Several reports indicate that conservation of biodiversity components including genes, ecologically resilient species and ecosystems enhances sustainability of prime species which genetic resources are eroding from their natural ranges in the tropical forest [11,20]. Plantation culture is promoted as the viable way to restore the declining economic species; however, plantation establishment of African mahogany species are often thwarted by the devastating pest *Hysipyla robusta* [2,21]. The pest attacks actively growing dominant shoots, causing multiple lateral branching which deforms the tree and eventually reduces the quality of tree stem [8,22]. Strategies to propagate the mahoganies through selection and breeding of quality tolerant varieties which could facilitate integrated pest management in plantations are advocated for sustainability of the species [1,8,17,23,24]. Efforts of developing cultivars that are genetically and ecologically adapted to the adverse environments and *Hypsipyla* pest incidence are important to conserving valuable germplasm and sustainable mahogany plantation culture [1,15,24]. Previous studies assessed the influence of cutting length, IBA, age of stock plant, species, and position of cuttings on shoots on the rooting efficiency of *Khaya* and *Entandrophagma* species in the vegetative propagation system [4,5,10,16,19,25-27].

Among other factors, the rooting medium is particularly significant to any vegetative propagation techniques developed as it influences root initiation, growth, and survival of stock-plants for effective regeneration [16,27,28]. Production of quality seedlings of the African mahogany species correlates to increasing stock potential of the established plantations. The choice of a specific technique in regeneration efforts may depend on availability of materials and personnel, cost and the easiness to adopt especially by local people [19,27]. Simple low-cost propagation strategies that maximize growth in the tropical forest tree improvement is preferable to the highly costly techniques [24,29]. Different growing substrate such as sand, topsoil, sawdust, peat moss, vermiculite, and gravel are well documented in the propagation of mahogany with variable responses [16,19,24]. Usually, the suitable medium mixtures are added to soil medium to improve the soil nutrient content for increased vigor of rooting and quality seedlings production.

Currently, biochar is primarily being promoted as soil amendment for forest restoration due to frequent nutrient depletion of many tropical soils [30-32]. The use of biochar as potting and growing substrate are linked to improvement of soil conditions which includes nutrient, soil cation exchange capacity and organic carbon in poorer soils with considerable positive impacts on crop growth [32-35]. Biochar used as soil amendment has potential for carbon sequestration, soil water retention, enhanced mycorrhizal fungi activities and organic matter in soils [36-39]. Compared to other soil amendments, combining different levels of biochar in mixtures of soil needs to be experimented as few evidences on their performance on tropical trees seedling growth are known. Biochar soil mixtures as substrate is likely to improve the rooting efficiency and survival of mahogany leafy cuttings at their early growth stages in the vegetative propagation however ideal rates of biochar application are unclear. Some studies found increased plant uptake of available nutrients with biochar incorporation ranging from lower rates in volume of 4%, 30% and a maximum of 70% [40-42]. The insignificant impact of biochar application rates on growth and yield of crops has also been reported in other studies [43]. Biochar additions to soil media for propagation may differ across species and their environmental ranges, presenting interesting advances for research. Our study was commissioned to assess the effects of different biochar soil amendment on the rooting ability of African mahogany species *K. ivorensis* and *K. grandifoliola*.

Materials and Methods

Propagation set up and stem cuttings production

Simple non mist propagators modified by Leakey, et al. 1990 (31), was utilized for the trial. It was made up of a constructed wooden frame of about 200cm length, width;100cm and height; 5 m. A transparent polythene was used to tighten the base of the propagator and filled with sequential layers of large stones diameter (6-10cm) to a depth (10-15cm), small stones (3cm level), and gravels of diameter (0.1-1cm) to a depth (about 5cm). The set up was watered uniformly. The tightly covered base was to prevent penetration by other roots from the ground and the layers of successive stones and gravels enhanced water retention necessary for adventitious root formation by the leafy stem cuttings.

There was a slight variation in the rooting media application as two separate experiments were involved in the study. However, in all experiments, the rooting media were pasteurized by heating over an open cast metal plate [28]. The media were evenly distributed on the propagator based on the measured quantities and covered with a 0.5mm thick polythene sheet. Non-mist propagators used in the green house were constructed under *Tectona grandis* stand covered with shaded net which ensured light irradiance of 82% - 85% to prevent excessive temperatures. Stock plants were obtained from approximately 15-year-old trees severed to coppicing for about 6 weeks to develop epicormic shoots. Leafy stem cuttings of length (10-30cm) of *K. ivorensis* and *K. grandifoliola* were collected in the morning hours (between 7-8 am) from shoots of the coppiced trees of both species and then enclosed in polythene bags to maintain a humid condition. Single node cuttings of length (6cm) were made from each spp. stems maintaining at most two (2) leaves, and the leaf area was trimmed to 30cm^2 using a graphed paper template. The apical succulent portion of shoots (approximately 5cm) were discarded as they were prone to rot within a short time in the propagator. The experiment was conducted at the nursery site of CSIR-Forestry Research Institute of Ghana (6°44´N, 1°30´W and relief 280 m above sea level). The site is within the moist semi-deciduous forest zone of Ghana with annual precipitation of 1200-1800mm.

Techniques used in the rooting of the stem cuttings

Leafy stem cuttings of *K. ivorensis* and *K. grandifoliola* were inserted to a depth of 1-2cm in each rooting medium. The rooting media consisted of 20v biochar and 50v biochar addition to riversand, mixtures of riversand and loam, and loamy soil to evaluate their rooting abilities for the mahogany species. The biochar was derived from pyrolysis of wood and agricultural residues including poultry litter feedstock and pieces of woody biomass at about 150-250^{0}C for 60 minutes. The cuttings were watered daily using a fine mist knapsack sprayer to maintain adequate moisture needed for rooting. Filling point of the media was monitored to prevent excessive water retention and possible leaves dehydration. The temperature within the propagators was 28-30°C and the humidity was about 70-80% after watering.

Experimental design

Fifteen coppiced trees (stock plants) were selected for each of the two species. The slender tips of the leafy cuttings were discarded as they were prone to rotting within a short time. Single nodes about (6cm) were made from the remaining stems and the leaf area was trimmed to 50cm^2 using a graphed paper template. Twenty cuttings of each of the two species were collected and distributed uniformly into the treatment with three replicates. Each treatment with replicate consisted of 60 cuttings (1plants x 1trtmts x 3replicates x 20cuttings) hence a total of 720 cuttings were utilized in the experiment. The cuttings were inserted in the 20v and 50v biochar treatments added to riversand, loamy soil, and the mixture of riversand and loam media, and their controls in a randomized completely block design.

Two experiments were conducted in a complete randomized block design with variation in the media mixtures. The treatments consisted of 20v biochar and 50v biochar additions to riversand, mixture of riversand and loam, and loamy soil. The first experiment consisted of 20v biochar + 80vriversand, 20v biochar + 40v/v riversand + Loam, 20v biochar + 80v loamy soil. The second experiment consisted of 50v biochar + riversand, 50v biochar + 25v/v riversand and loam, and 50v biochar + 50v loamy soil. In both experiments, control treatments consisting of riversand, 50v/v riversand and loam, and loamy soil was set up for comparison. Adequate water necessary for rooting was ensured. The cuttings were considered rooted when at least 1 primary root (≤ 2cm) was formed (Figure 1). However, observations on dead cuttings and callus formation were made daily after watering.

Data collection and Analysis

Data on number of roots formed root length and percentage survival of the cuttings were taken 8 weeks after insertion into the rooting media. However, observance of dead cuttings, callus formation was made daily after watering. Data collected were subjected to one-way analysis of variance at $P < 0.05$. Where differences between means were significant, they were further separated with the Tukey's range test of statistiXL version 15.

Results

Experiment 1

Effects of 20v/v biochar on rooting performance of the African mahogany cuttings

K. ivorensis recorded maximum mean number of roots formed (5.73) and root length (5.28cm) in the 20v biochar +

Figure 1: African mahogany leafy stem cuttings with roots formed, length of roots and shoot development in the biochar mixed media.

Table 1: Mean number of roots formed per cutting, root length and Percentage Survival of *K. ivorensis* and *K. grandifoliola* cuttings 10 weeks after propagation in 20v/v biochar soil amendment and their control.

	Rooting media					
Rooting ability	Riversand	50v/v Riversand + Loam	Loamy soil	20v Biochar + 80v Riversand	20v Biochar + 40v/v Riversand + Loam	20v Biochar + 80v Loamy soil
Number of roots per cuttings						
K. ivorensis (Ki)	3.61 ± 0.21a	4.14 ± 0.41a	4.52 ± 0.19a	43.87 ± 0.55a	5.33 ± 0.44b	4.0 ± 0.42b
K. grandifoliola (Kg)	4.11 ± 0.43a	5.38 ± 0.12a	4.83 ± 0.38a	5.4 ± 0.58a	5.73 ± 0.18b	4.83 ± 0.38b
Root length per rooted cuttings						
Ki	4.43 ± 0.10a	5.08 ± 0.19a	3.91 ± 0.31a	4.90 ± 0.17a	5.55 ± 0.08b	5.28 ± 0.42a
Kg	4.17 ± 0.21a	4.96 ± 0.19a	3.82 ± 0.61a	4.25 ± 0.13a	5.51 ± 0.17b	5.19 ± 0.30a
Cuttings Survival (%)						
Ki	49.20 ± 1.92a	52.80 ± 4.55a	46.92 ± 8.68a	51.67 ± 4.41a	58.5 ± 4.58 b*	54.42 ± 4.66a*
Kg	48.33 ± 1.67a	52.5 ± 3.82a	45.83 ± 5.46a	54.25 ± 4.99a*	67.5 ± 1.44b*	56.20 ± 5.90b*

Values are means ± standard errors, values followed by the same letters in the column are not significantly different (P < 0.05). Values marked with * are not significant

80v loamy soil (Table 1). There were no marked differences among the media with biochar additions for number of roots formed and root length growth of *K. ivorensis* cuttings (P > 0.05) but remarkable differences existed between the 20v biochar combined with either 80v riversand or 80v loamy soil. Riversand medium yielded the lowest number of roots formed (3.68) by *K. ivorensis* whereas the lowest root length was recorded for loamy soil (3.91cm). *K. grandifoliola* recorded maximum mean number of roots formed per rooted cuttings (5.40) and root length (5.51cm) in the 20v biochar + 40v/v riversand + loam which differed significantly from all the control media and the 20v bio + 80v riversand treatment. No significant interaction existed between 20v biochar + 40v/v riversand + loam and the 20v biochar + 80v loamy soil for number of roots formed per cutting and root length growth of *K. grandifoliola* (Table 1).

The 20v biochar + 40v/v riversand + loamy soil recorded the highest survival for both *K. ivorensis* and *K grandifoliola* at values of 58.5% and 67.5% respectively. Major differences were recorded in rooting performance among the media between the 20vbiochar + 40v/v riversand and loam, and the other companion biochar media as well as the media without biochar except the 20v biochar + 80v loamy soil. The lowest survival rate for both *K. ivorensis* (about 47%) and *K. grandifoliola* (45.8%) was recorded in loamy soil. Comparison of species rooting ability shows that with respect to 20v biochar treatments and their controls, loamy soil recorded highest number of dead cuttings (over 50%) for both *K. ivorensis and K. grandifoliola.*

Experiment 2

Effects of 50v/v biochar soil amendment on roots formed per cutting, root length growth and survival rate of the African mahogany cuttings

The rooting media influenced the rooting response of cuttings of both *Khaya grandifoliola* and *Khaya ivorensis*. Results from our study shows variation in species performances and rooting ability to the biochar soil mixtures and their control treatments assessed in our study. *K. grandifoliola* yielded significantly higher mean roots formed per cutting than *K. ivorensis* leafy stem cuttings within the same propagation environment. *K. grandifoliola* yielded maximum mean number of roots formed (7.6), root length (6.11cm) and percentage survival (70%) in the 50v biochar + 25v/v riversand and loamy soil (Figure 2, Figure 3, Figure 4). There was significant variation among the rooting performance of *K. grandifoliola* in the various media with the 50v biochar + 25v/v riversand and loamy soil differing markedly from the other media rooting ability (P < 0.05). Comparison between the media performance showed highly significant differences between the 50v/v biochar + 25v/v riversand and loam, and the relative biochar media 50v/v bichar + loam (P ≤ 0.001), and 50v/v biochar + riversand (P ≤ 0.001). Major differences did not occur for number of roots formed by *K. grandifoliola* cuttings in riversand and loam media (P > 0.05, Figure 2). A similar trend was recorded for root length growth of *K. grandifoliola* leafy cuttings (Figure 3). Riversand control medium yielded the lowest number of roots formed for *K. grandifoliola* (3.27), and survival (40%) whereas loamy soil recorded the least mean root length (4.03cm) per cutting (Figure 2, Figure 3, Figure 4). There was however no considerable variation (P > 0.05) among the media performances for average number of roots formed per cutting and survival rate of the spp. in the control treatment (Figure 2, Figure 4).

K. ivorensis leafy cuttings recorded highest mean values of roots formed per cutting (6.0), root length (6.9cm) and survival (80.20%) in the 50v biochar + 25v/v riversand and loamy soil (Figure 5, Figure 6, Figure 7). The highest rooting ability in the *K. ivorensis* cuttings for number of roots formed and survival in the 50v biochar + 25v/v riversand and loamy medium differed remarkably (P < 0.05) from the relative values of parameters recorded for the spp. in the companion biochar media and their control treatment. Comparison of

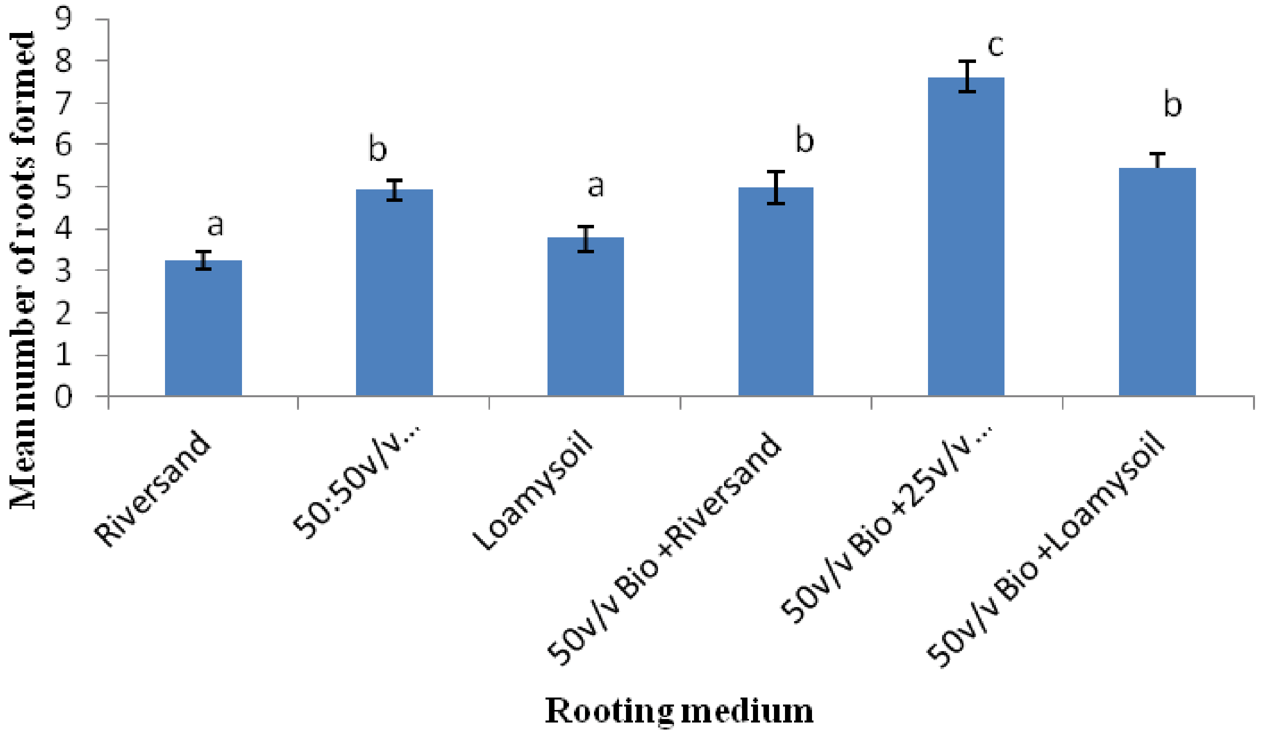

Figure 2: Mean number of roots formed by *K.grandifoliola* cuttings per rooting media.

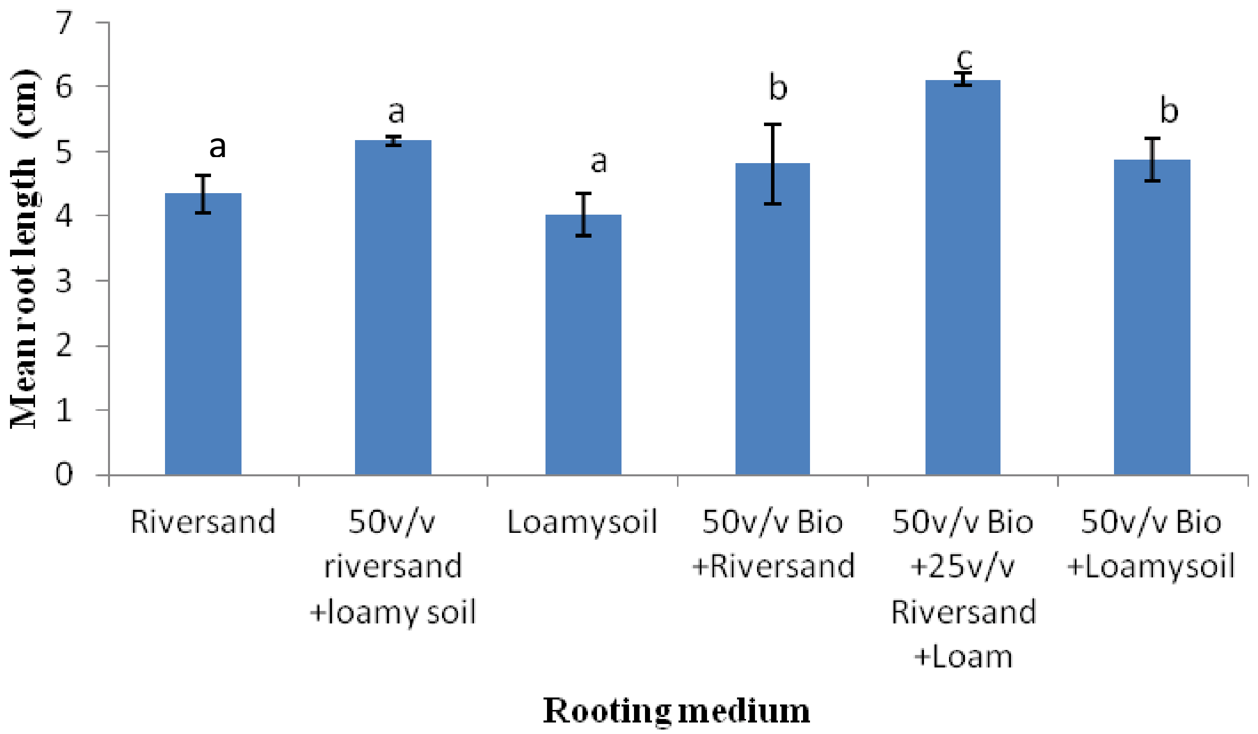

Figure 3: Mean Root length of *K. grandifoliola* leafy cuttings per rooting media.

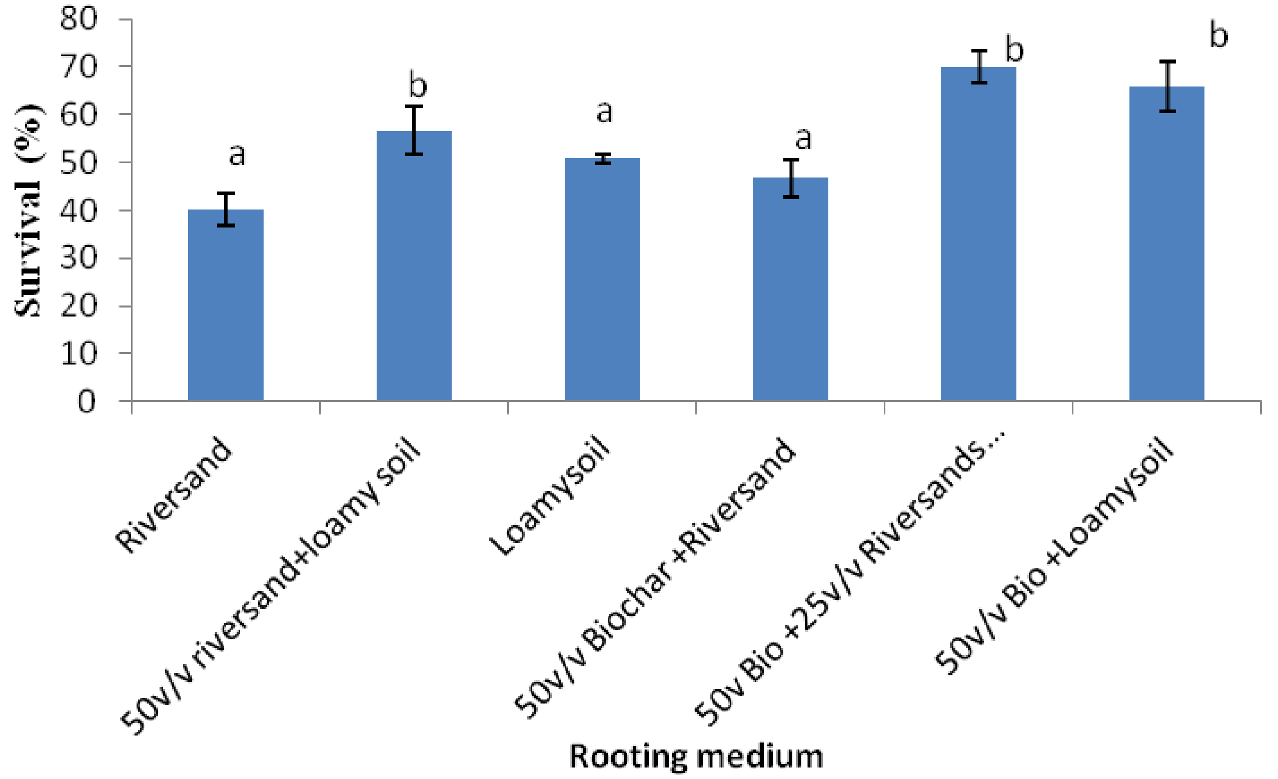

Figure 4: Survival rate (%) of *K. grandifoliola* leafy stem cuttings per rooting media.

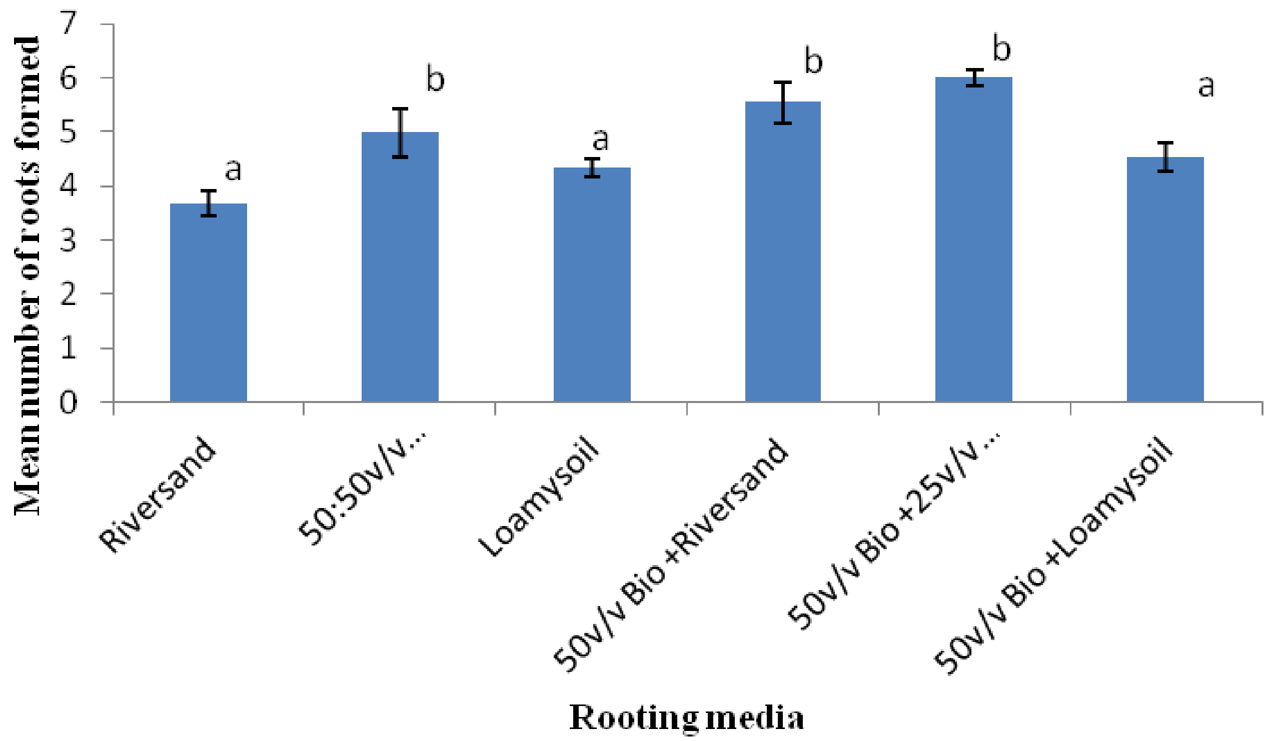

Figure 5: Mean number of roots formed by *K.ivorensis* leafy cuttings per rooting media.

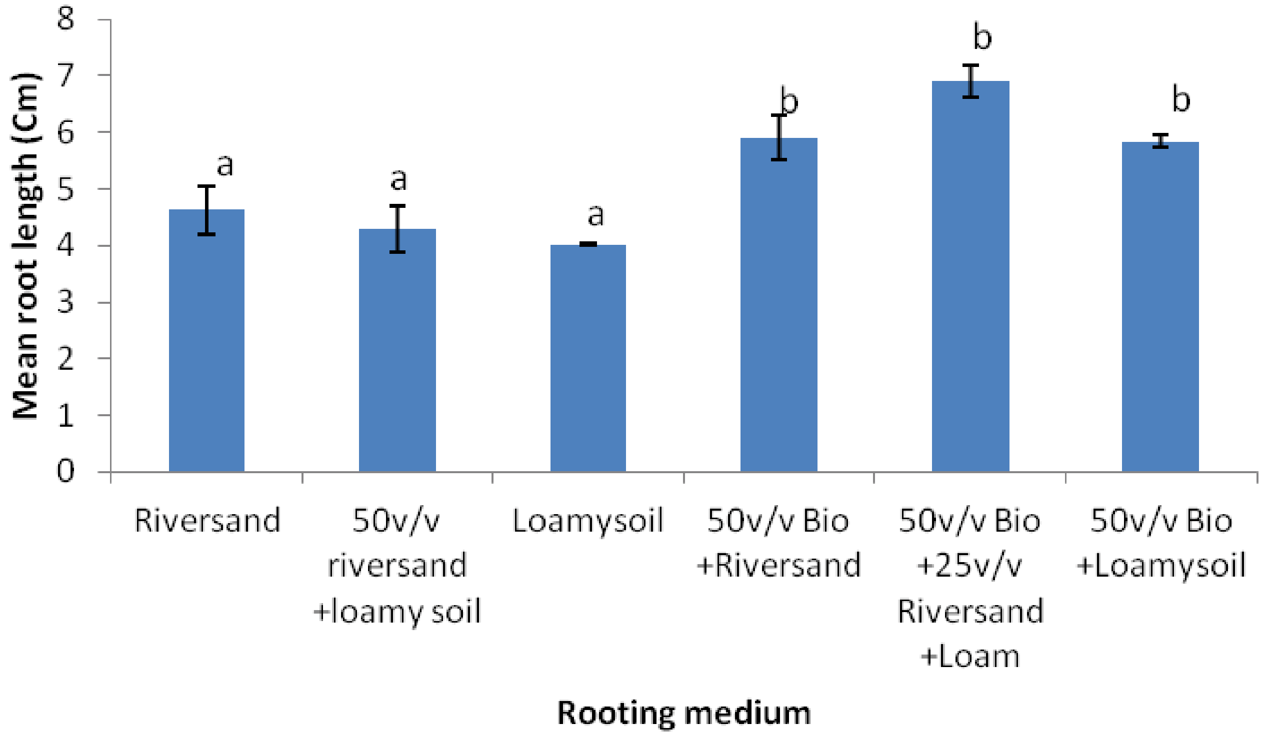

Figure 6: Mean root length of *K.ivorensis* leafy stem cuttings per rooting media.

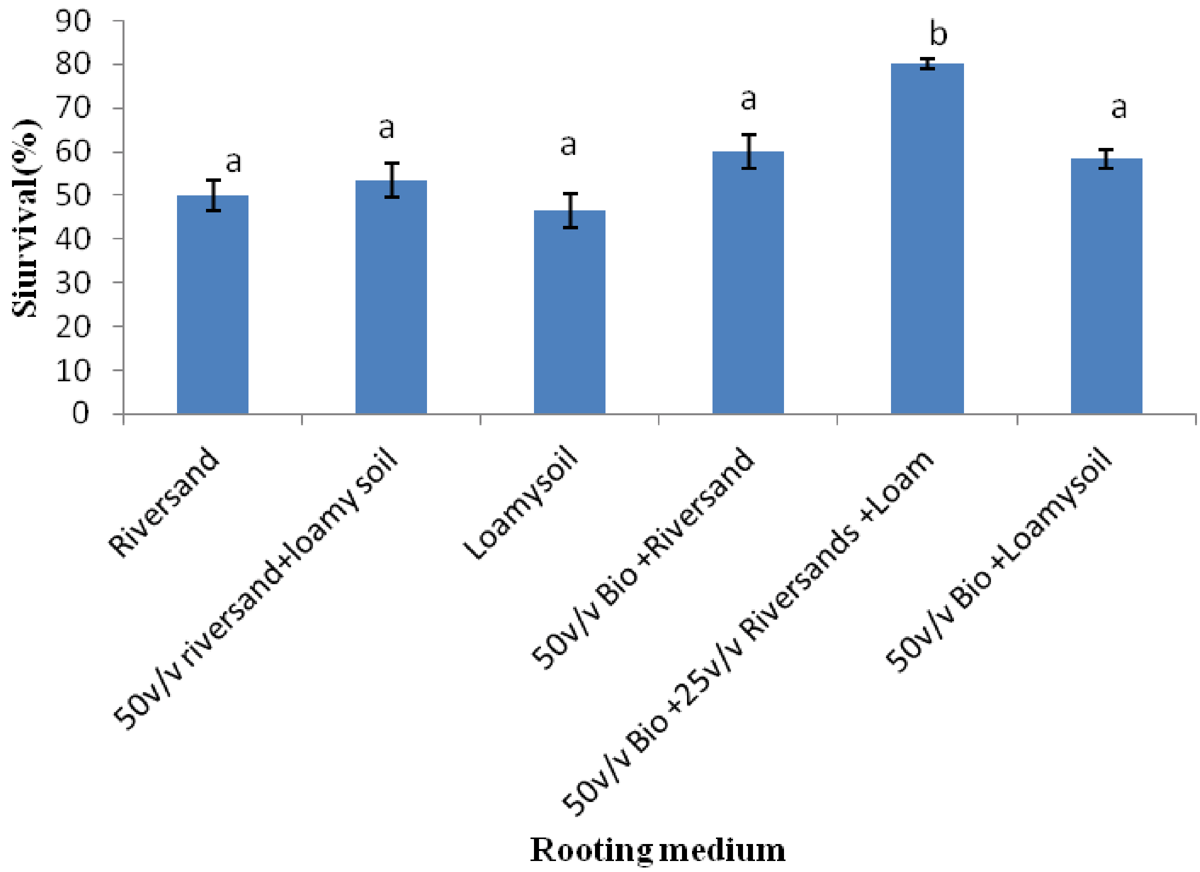

Figure 7: Survival rate (%) of *K. ivorensis* leafy stem cuttings per rooting media.

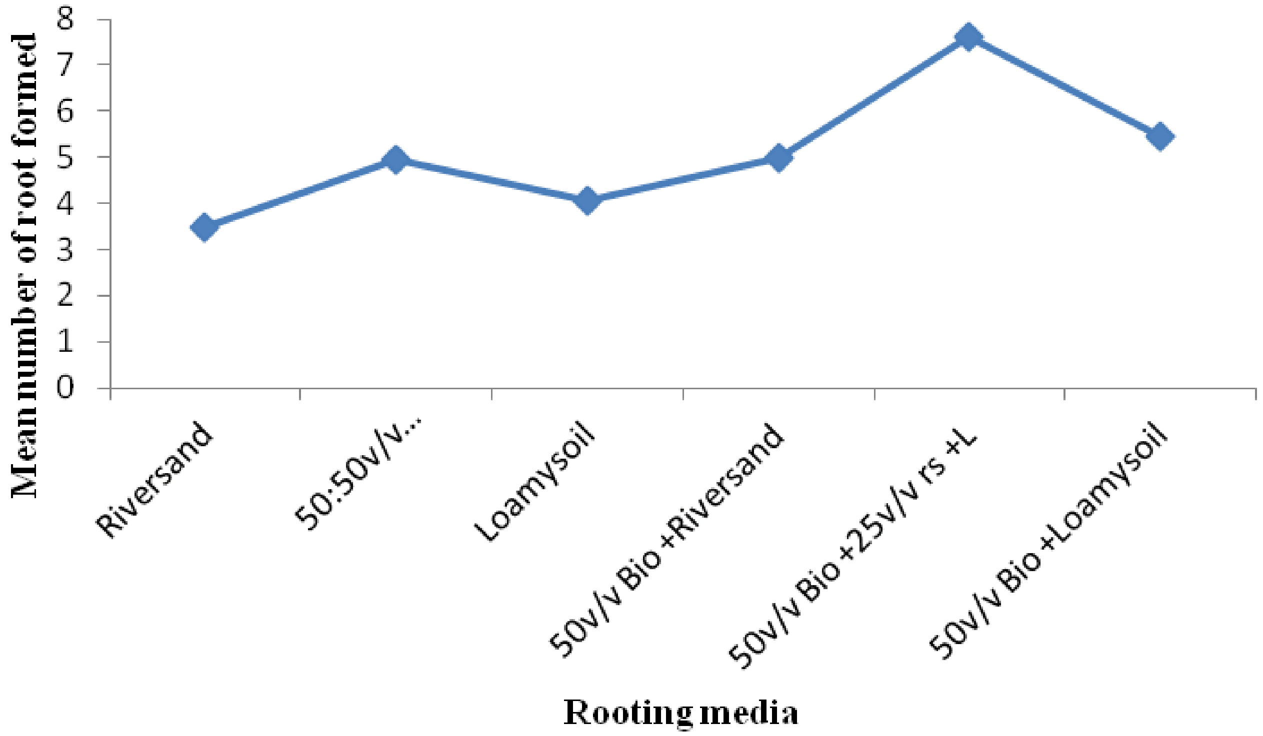

Figure 8: Effects of rooting media on mean number of roots formed by the African mahogany *species*.

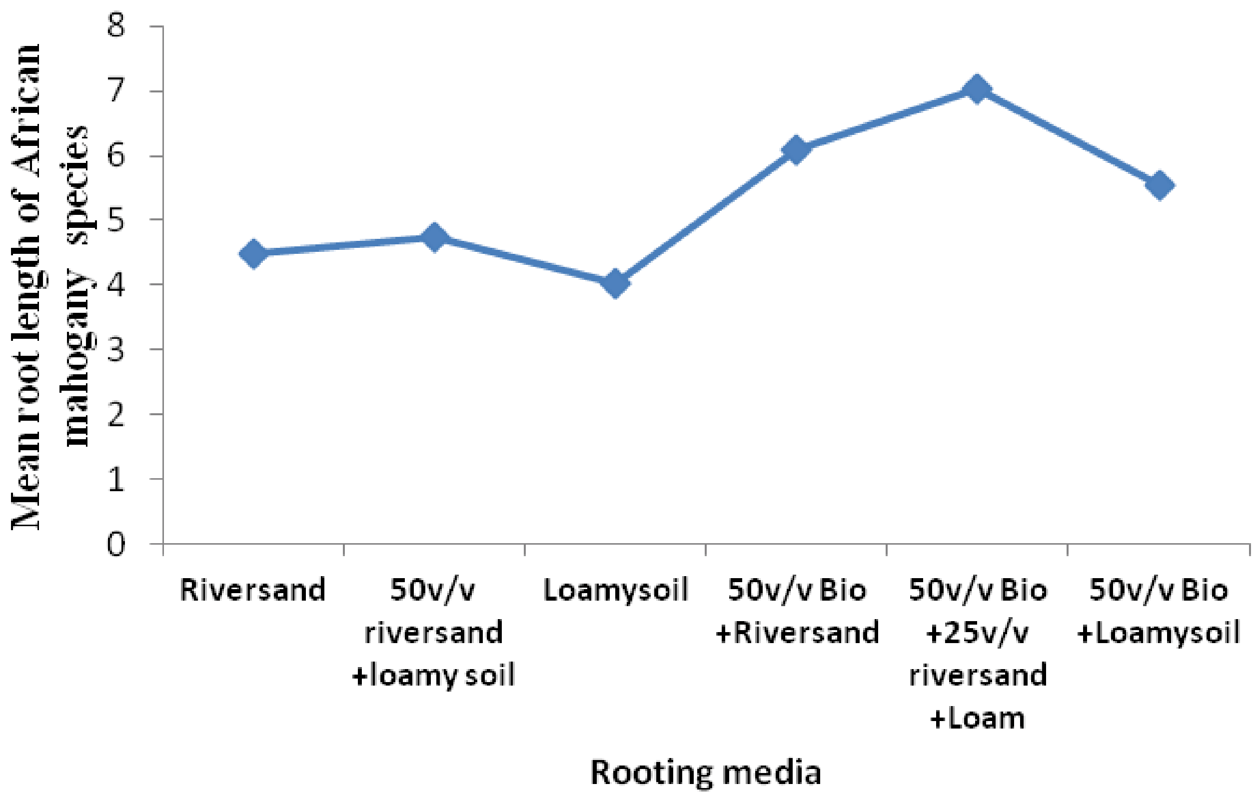

Figure 9: Effects of the rooting media on mean root length growth of the African mahogany species.

species performances showed that *K. grandifoliola* yielded the overall highest number of roots formed per cutting (7.6; Figure 1), whiles the greatest mean values of root length (6.9cm) and survival of the cuttings (over 80%) were recorded for *K. ivorensis* leafy cuttings rooted in the 50v biochar + 25v/v riversand and loamy soil which varied remarkably from the rooting responses in the other media (Figure 3, Figure 7, P < 0.05). The study also found that the 50v biochar + 25v/v riversand and loam varied greatly (P<0.05) from the other media rooting response for most parameters assessed for both *K. ivorensis* and *K. grandifoliola* with mean maximum number of roots formed per cutting (6.8), root length (7.03cm) and percentage survival of the cuttings (75.08%) (Figure 8, Figure 9, Figure 10). Generally, the control treatment riversand recorded the lowest mean number of roots (3.48) and survival (45%) for both *K. grandifoliola* and *K. ivorensis* while loamy soil yielded the least root length (4.02cm) (Figure 8, Figure 9, Figure 10). There were no remarkable differences for number of roots formed by *K. ivorensis* leafy stem cutting propagated in riversand and the other companion media without biochar additions; the 50v/v riversand + loam, and loamy soil (Figure 5, P > 0.05). However, root length growth of *K. ivorensis* in the biochar media varied slightly from the control media without biochar additions (Figure 6, P < 0.05). Apart from the 50v Biochar + 25v/v river-sand and loam, which differed significantly from the other media for survival rate of *K. ivorensis* cuttings, there were no major interaction between the control media and the other two biochar treatments: 50v/v biochar + riversand, and 50v/v biochar + loamy soil (Figure 7).

Discussion

Several factors have been investigated to influence rooting of cuttings of African mahogany species in the vegetative propagation system. These include age of stock plant, leaf area and auxin on *K. ivorensis and K. anthotheca* [25,19], cutting position of stock-plant in *Khaya* and *Entandrophragma* spp. [16], growth regulators on *K. senegalensis* [4], Indole-3-Butyric Acid on *K .ivorensis* [10,44].

The rooting media influences the early development, roots formation and survival of stock plants in the vegetative propagation [16,28,29,45]. There is no universally recommended soil media for propagation of elite mahogany genotype, hence techniques of improving the growing media characteristics for adequate growth of the stock-plants is paramount to ensuring availability of planting materials for regeneration of the species. In our study, the best rooting ability of K. *ivorensis* and *K. grandifoliola* leafy stem cuttings was recorded in the 50v biochar + 25v/v riversand and loamy soil. The rooting performance of both mahogany species in the 50v biochar + 25v/v riversand and loamy soil was generally greater than the 20v biochar + 40v/v riversand and loamy soil, as well as the other media with and without biochar mixtures. The 50v biochar + 25v/v riversand and loamy soil significantly yielded highest mean number of roots per cutting, root length and survival rate of cuttings in both *K. ivorensis* and *K. grandifoliola*.

Leafy stem cuttings of many tropical tree species successfully develop root and shoots in a variety of rooting medium [16,14,29,45,46]. In related studies [16], recorded highest rooting percentage, and roots formed per cuttings of

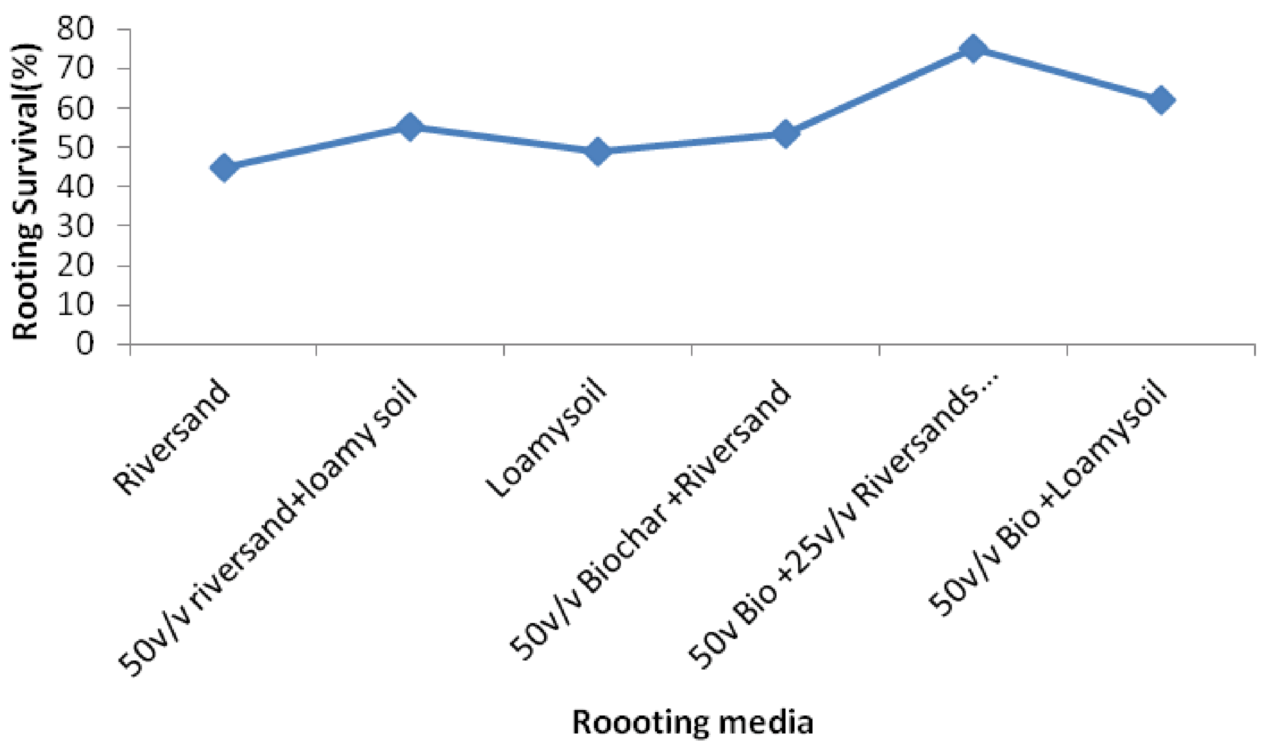

Figure 10: Effects of rooting media on mean percentage survival of the african mahogany species.

Khaya species in the 50v/v mixtures of river-sand and topsoil whereas the top-soil medium yielded best rooting response of *Entandrophragma* species under the same propagation environment.

Studies on propagation of other tree species using various soil subtrates yielded maximum rooting percentage of *Milicia excelsa*, *Irvingia gabonensis* and *Cordia alliodora* cuttings *Simmondstia chinensis* cuttings [14,45-47].

The relationship between species response to rooting and the substrate performances may possibly relate to genetic characteristics of the species, propagation environment and their ability to promote root formation, root elongation and survival rate of stem cuttings. The requirement for rooting, growth and survival of stem cuttings may differ among plant species [14,28,46]. Earlier reports indicate that the optimum characteristics of a suitable rooting medium such as rich nutrient content, good aeration, water holding capacity and drainage among others could facilitate maximum and effective rooting ability of stock-plants in the vegetative propagation system [27,28,43,48]. In addition, soil texture is found to mediate plant water absorption and availability for plants rooting, further growth, functioning and development [49,50]. Suitable medium therefore provides a balanced environment to increase the rooting efficiency and maximum growth of the softwood cuttings during propagation [27,28,51].

The significantly highest rooting response in our study observed in the 50v biochar and 25v/v riversand and loam could therefore be attributed to the relatively good and balanced characteristics of the media in mixtures for sufficient nutrient supply, water holding ability and aeration which favored adequate rooting capacity of both *K. grandifoliola* and *K. ivorensis* cuttings. Thus, the different levels of biochar application (20v and 50v biochar) to the soil media riversand, loamy soil and mixtures of riversand and loam exhibited greatest rooting ability than their control media without biochar. The use of biochar as soil amendment or growing substrate is linked to soil water retention, enhanced beneficial soil micro-organisms and organic matter in soils needed for growth and development of crops and plant species [32,34,36,37,39,52].

Different amounts of biochar amendment to soil for nursery plants and crops are noted to increase plant vigor and nutrient absorption potential for growth and production of good quality seedlings [32,41,42,53]. Some studies reported that biochar have few or no major effect on crop growth [54]. It is however emphasized that depending on the type of substrate, crop plant and the purpose of application, biochar addition ranging from 15v/v to 70v/v to soils could have considerable impact on plants growth [40,42,52]. While Conversa, et al., [40] found remarkable seedling growth of *Pelargonium zonale* plants with increasing biochar from zero to 70v/v biochar addition to soil, Vaugh, et al., [41] observed few differences in plant growth but marked height growth of tomato cultivars (*Solanum lycopersicum*) with 15v/v biochar growing medium.

Our findings agree with other studies that biochar have a considerable influence on rooting efficiency of mahogany species when suitable levels of biochar (50v/v) were added as a catalyst to enrich the soil for maximum rooting. Usually, suitable soil media provides favorable physical conditions and adequate nutrients to the cuttings for growth and survival. Riversand medium recorded lowest mean number of roots and survival rate for both *K. grandifoliola* and *K. ivorensis* whereas loamy soil yielded the least root length. As widely known, the large pore space of riversand medium enhances oxygen diffusion, and loamy soil is noted for its rich organic matter [28,51], probably a suite of these elements was required to initiate root formation, root length and survival. In previous studies, lowest percentage rooting in *M. excelsa*, *K. grandifoliola* and *Endrophrama angolense* occurred in riversand medium [14,16]. Thus, compared to the mixed medium, perhaps the low water holding capacity of riversand and low oxygen diffusion in loamy soil might have resulted in the low rooting performances of mahogany stem cutting utilized in the present study. The young cuttings could be exposed to moisture stress in a medium with low water retention capacity and dense media without proper aeration may also impede the ability to form roots and grow successfully.

The study further showed a clear variation in African mahogany species performance to rooting among the biochar-soils and control media. In the same propagation system, *K. grandifoliola* cuttings yielded highest number roots per cutting but maximum length of rooted cuttings and survival rate were recorded for *K. ivorensis* cuttings. stem cuttings of the same age of stock-plant in the same propagation environment.

The maximum survival of cuttings and root length growth of *K. ivorensis* in the 50v biochar + 25v/v riversand and loamy soil than *K. grandifoliola* could perhaps be attributed to their intrinsic genetic characteristics which reflected their response to rooting in the different media. There were no significant differences in the rooting performance of the 20v/v biochar treatments to soil and the control media, nevertheless *K. grandifoliola* yielded better rooting responses than its related species *K. ivorensis.*

K. ivorensis yielded significantly higher survival rate, roots formed per rooted cuttings where as *K. grandifoliola* recorded the highest length of rooted cutting in the 50v biochar + 25v/v riversand and loamy soil. Species response to propagation treatments are thus influenced by the distinct genetic compositions and the environmental conditions [16,17,19,28]. Naturally, *K. ivorensis* grows well in wet/ moist soils where as *K. grandifoliola* is found in the moist semi-deciduous and sparsely in the transition and dry zones [2,6,7,15]. The stock plants used in the study were collected from the semi-deciduous forest zone in which both species co-occur. *K. ivorensis* and *K. grandifoliola* yielded best rooting ability in the 50v biochar + 25v/v riversand + loam suggesting that the microclimate within the propagator was suitable for growth of both mahogany species. Thus, The main differences in the values of rooting response of the mahogany species under the same propagation environment thus reflects their distinct genetic make-up which influences their adaptation to propagation techniques.

Conclusion

The study has demonstrated that biochar soil amendment can be used as a catalyst to increase the rooting efficiency of the African mahogany species, *K. grandifoliola* and *K. ivorensis* leafy stem cuttings in the vegetative propagation system. Biochar incorporation in restoration of mahogany in 20 and 50 by volume additions to soil media river-sand, loam, and mixtures of river-sand up to 100% performed relatively better in rooting efficiency than their companion control soils without biochar. The 50v biochar and 25v/v riversand and loam consistently yielded maximum number of roots, root length growth and mean survival rate of both *K. grandifoliola* and *K. ivorensis*. 50v biochar and 25v/v riversand and loam medium is remarkably suitable and therefore recommended for vegetative propagation of these mahogany species for efficient restoration of the species in plantations and for conservation of superior genotypes. *K. ivorensis* recorded highest survival rate of cuttings which was 5% higher than *K. grandifoliola* in the 50v biochar + 25v/v riversand and loamy soil. On the other hand, *K. grandifoliola* also yielded a greater number of roots per cutting and remarkable root length than its related species in the same 50v biochar + 25v/v riversand and loamy soil medium. This depicts a high species variation to biochar propagation treatments. The study strongly supports the addition of (50v/v) biochar to mixed soils of riversand and loam to boost rooting vigor, root length and survival of the vegetative cuttings for effective seeding production, conservation and sustainable management of the African mahogany species; *K. ivorensis* and *K. grandifoliola*.

Acknowledgments

We are grateful to the International Tropical Timber Organization project 'PD 528 Rev 1F' and Fellowship Ref 166/15S. We thank the vibrant field team at the Entomology Lab of CSIR-Forestry Research Institute of Ghana who helped in setting up the experiment.

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