International Journal of Basic Sciences and Applied Computing (IJBSAC)
ISSN: 2394-367X (Online), Volume-10 Issue-5, January 2024

# Review on Rooting and Shooting Growth Performance of Populus Alba in Hydroponic Soil Cultures

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***Abstract:** In a greenhouse soil and hydroponic media experiment was carried out with plastic bottles to examine the effects of biochar, azolla, and moss as growth media components on root and shooting development performance in tiny cuttings of populous plants. Root installations were observed using the cutting length, cutting thickness, and cutting ages. The information showed that certain modifications and root media had a major impact on the populus establishment. The number of roots, length of roots, number of leaves, shoot height, and rooting percentage of the rooted mini-cuttings were also measured. Out of all the supplements and rooting media, moss (25 mg L-1) outperformed water in the current study in terms of rooting percent (100%), number of roots (16.33), and root formation.*

***Keywords:** Roots, Shoots, Soil culture, Green House, Biochar*

## I. INTRODUCTION

Populous is highly prized for many uses because of its quick growth, wide genetic variation, and capacity for coppice production. It has the ability to provide power, agroforestry, and biofuels produced from cellulose, which are useful sources of raw materials for plywood, fiber, and lumber. Additionally, phytotechnologies use it for cleanup [18][13]. Historically, poplar wood was also considered a potential source of renewable carbon for biodiesel and bioenergy [13]. Many of the greatest poplar genotypes have been created by both traditional and molecular breeding programs.

The commencement of the rooting process of cuttings is contingent upon the physiological state of the stock plants. The regeneration of the cuttings may be impacted by seasonal variations in the hormone and carbohydrate content of the stock materials [4]. According to [6], summer is the ideal time of year for poplar softwood cuttings to root because the donor plants are in their ideal physiological state for vegetative multiplication. Because poplar hardwood cuttings require energy to regenerate, shoot location and cutting length are also crucial factors in the rooting process.

The size of the cutting (length and diameter) and its initial location on the stock plant were shown to be connected to the presence of hormones and carbohydrates.

**Manuscript received on 18 December 2023 | Revised Manuscript received on 27 December 2023 | Manuscript Accepted on 15 January 2024 | Manuscript published on 30 January 2024.**
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According to [3], poplar's ability to root is also significantly influenced by the cutting's diameter. Cuttings taken from the base of the shoot produced longer and heavier roots than those taken from the top of the shoot. Generally speaking, cuttings' capacity to root can also be influenced by the age of the stock plant.

Because plant lignification promotes the synthesis of rooting inhibitors, cuttings from older plants may be less likely than cuttings from younger plants to develop adventitious roots. Cutting materials should ideally be done on a younger tree, with the base of the shoot being the ideal location. Poplars contribute significant productivity (25–50 m3·per hectare annually) and leaf litter to the surface soil throughout a brief rotation of 6–12 years [19]. Researching the capacity to root could yield insights for the creation of better cultural technologies and growth promotion [7]. Since rooting is the first biological prerequisite for stand development, such approaches could increase the likelihood that commercial plantations will be deployed successfully. The following goals were used to evaluate this review.

- To investigate how the rooting and shooting qualities of populous alba cultures are affected by cutting length, thickness, and age.
- To assess the impact of azolla, moss, soil, sand and biochar as additions on Populus alba growth in hydroponic culture.
- To investigate how salinity and temperature fluctuations affect Populus alba's roots and shoot growth.

## II. METHODS OF REVIEW

### A. Experimental Materials and Design

A mature (1-2 years) donor prolific alba plant and a three-month seedling served as the sources of cutting materials. When choosing both young and mature donor plants, appropriate physiological conditions that support ready adventitious roots and immunity to pests and diseases were taken into account. Since soaking in water prior to the experiment initiates rooting and greatly enhances the survival and growth of Populus during establishment, seedlings and cuttings of mature donor plants enclosed in bags were transported to the propagation site and soaked in water until the experiment [5][22][23].

In hydroponic culture, the effects of salinity and additives (biochar, Azzola, and moss) were investigated. The donor plant's age, which came in two stages (juvenile and mature) was the primary treatment factor.

*Retrieval Number: 100.1/ijbsac.E051010050124*
*DOI:10.35940/ijbsac.E0510.10050124*
*Journal Website: www.ijbsac.org*



*Published By:*
*Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)*

The cutting length, which came in three stages short (10 cm), medium (20 cm), and long (30 cm), was the secondary treatment element. Three replications of each treatment factor were conducted. For the duration of the experiment, 108 cuttings from each of the three replications were used for each treatment. The temperature within the greenhouse was kept between 23.4 and 42.2 degrees Celsius with a relative humidity of 10 to 60%, whereas the outside temperature ranged between 20.4 and 32 degrees Celsius with a relative humidity of 10 to 45%. To prevent desiccation damage, the cuttings were continuously watered and checked on every day. In the current study, an effort was also made to examine how charcoal, moss, and Azzola, in various concentrations, affected the ability of mini-cuttings to root in hydroponic rooting media.

### B. Procedure of Vegetative Propagation

Azolla was also gathered from marshy areas, while moss was gathered from the area surrounding Saint Mary Church. Other sources of amendments included biochar that was purchased from the market and ground into mortar. After that, the azolla and moss were crushed, dried, and made into a powder that could be combined with water. Next, 0 g, 10 g, and 25 g of powdered biochar, moss, and azolla per liter of water were combined with the powders. In order to test various treatment parameters, the cutting length was finally measured in centimeters and planted in plastic pots. A total of 36 cuttings were used for each treatment.

**First factor:** treatments connected to cuttings; cuttings are collected and treated in water to prevent desiccation damage prior to the experiment. A total of 108 cuttings were used in this treatment, with 36 cuttings for each treatment at cutting lengths of 10, 20, and 30 cm and three replications. The cutting age of the donor plant varied from 36 cuttings from a 3-month-old donor plant to 36 cuttings from 1-2-year-old donor populous plants that were planted at the nursery site. Three different cutting thicknesses thin, medium, and thick were employed for each. In this cutting-related treatment, 288 cuttings were employed overall. Cuttings of 20 cm were used for cutting age and thickness.

**Factor two:** the growth-promoting effects of water and salt; The apical, intermediate, and basal positions of stem cuttings were used to separate cuttings from the shoots of both juvenile and mature donor plants. The degree of the effects of salt stress on populous growth in relation to cutting location was then assessed by planting 20 cm length cuttings and submerging them in a saline solution for 21 days. Treatments included 0 grams, 10 grams, and 25 grams of salt per litter of clean water. Next, the quality and rooting of every cutting from every treatment was graded on a 0–5 scale, where 0 was dead and 5 was for high-quality, well-rooted cuttings.

In this treatment, a total of 36 cuttings with three replications were placed in pure water as a control, and another 12 cuttings with three replications total, placing 36 cuttings of populus in a saline solution that was prepared at a rate of 10 g of salt per water litter and 36 cuttings at a rate of 25 g of salt per water litter, or 36 cuttings at a rate of 10 g of salt per water litter and 25 g of salt per water litter.

**Factor three:** Effects of amendments on growth: Biochar, moss, and azola were applied to each treatment. In pure water, 108 cuttings were planted with 0, 10, and 25 g of biochar per litter of pure water. In pure water + moss, 72 cuttings were planted at 0, 10, and 25 g of moss per litter of pure water. At 0, 10, and 25 g per litter of pure water, 72 cuttings were planted in pure water plus Azola.

**Factor 4:** Effects of temperature on growth: In these treatments, the effects of temperature on cutting propagation in soil media were assessed using 36 cuttings outside the greenhouse, totaling 72 cuttings, and 12 cuttings with three replications, totaling 36 cuttings at a uniform 20 cm cutting length of populous alba in the side greenhouse.

Factor 5: Treatments related to substrate and their impact on growth to assess variation in populous alba proliferation, this treatment used red soil, sand soil, and mixtures of biochar as substrates or growth media. 108 cuttings were planted in sand soil + biochar at 0, 10, 25, and 50 gm biochar per kg of sandy soil, while 108 cuttings were planted in red soil + biochar at 0, 10, 25, and 50 gm per kg of red soil. This is how the biochar was added to both types of soil. Rooting percentage, number of roots per cutting, length of roots per cutting, number of leaves per cutting, shoot height per cutting, number of branches per cutting, root dimeter per cutting, shoot dimeter per cutting leaf area, and fresh and dry weight of root and shoot were among the parameters related to rooting and shooting that were measured and correlated. After 30 to 45 days from the day of planting, cuttings were evaluated, and if a cutting had at least one root, it was deemed rooted. Before determining the number and length of the roots, the sand and soil were taken out of the rooted cuttings, and the roots were then cleaned and separated from the cuttings.

### C. Statistical Data Analysis

In order to examine the impacts of cutting age variation on roots and growth performance, two independent samples both inside and outside the greenhouse were analyzed using descriptive statistics, analysis of variance, correlation, and independent sample t-test. The statistical analysis methods for the various treatments were performed using the SPSS-Statistical programs for social science version 21. The significant effect of treatments was tested, and means of various treatments were compared, using the analysis of variance (ANOVA) procedures.

## III. RESULTS AND DISCUSSION

### A. Impact of Cutting Length and Thickness

Shoot height, leaf area, and branch number were all significantly impacted by cutting length at $P \leq 0.05$ (Table 1). However, as Table 1 shows, cutting thickness significantly affected measures including root percentage, shoot height, root dimeter, and shoot dimeter at $p<0.05$. Despite the fact that the cutting length effect did not reveal significant changes for every shooting and rooting performance, morphological variances were observed, particularly in shooting performance, where a comparatively 10 cm cutting length produced superior results.

Retrieval Number: 100.1/ijbsac.E051010050124
DOI:10.35940/ijbsac.E0510.10050124
Journal Website: www.ijbsac.org



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The impacts of cutting length did not significantly alter the percentages of populus roots, as indicated in (Figure 1). Given that the rooting percentages at cutting lengths of 10 cm, 20 cm, and 30 cm, respectively, were 75 percent, 88.8%, and 77.7%. Figure 2 illustrates how different populus cutting routing strategies affected the findings. Specifically, thin and medium-thickness cuttings performed better than thick cuttings. The rooting percentages of the 108 cuttings (36 cuttings for each treatment) were 91.6%, 86.1%, and 55.5% for the thin, medium, and thick cuttings, respectively.

**Table 1. Effects of Cutting Length and Cutting Thickness on Root Number Per Cutting, Root Length Per Cutting, Leaf Number Per Cutting and Shoot Height Per Cutting in Soil.**

| Cutting related Factors | | Root number Per cutting | Root length per cutting(cm) | Leaf number precutting | Shoot height per cutting(cm) |
|---|---|---|---|---|---|
| Cutting length | 10 cm | 8.33<br>4.09a | 15.83<br>2.20a | 28.00<br>3.05a | 29.60<br>0.20a |
| | 20 cm | 6.33 ±<br>1.33a | 17.83<br>1.92a | 34.67<br>4.71a | 38.60<br>3.08ab |
| | 30 cm | 10.3<br>±6.83 a | 18.00<br>0.57a | 46.67<br>4.91b | 45.50<br>2.11b |
| F<br>P value | | 0.18<br>0.84 | 0.49<br>0.63 | 5.68<br>0.04 | 13.57<br>0.006 |
| Cutting thickness | Thin | 7.33<br>0.88a | 14.83<br>1.45a | 17.67<br>4.17a | 26.76<br>1.63a |
| | M thick | 5.00<br>0.00a | 14.33<br>0.28a | 22.33<br>3.75a | 25.83<br>1.92ab |
| | Thick | 3.67<br>1.20a | 16.43<br>2.79a | 36.00<br>9.53a | 33.10<br>1.51b |
| F<br>P value | | 4.65<br>0.06 | 0.34<br>0.73 | | 5.42<br>0.045 |

Note: Mean± SE followed by the same letters is not significantly different (p<0.05).

## B. Effect of Stock Plant Maturation (Cutting Age)

Cuttings' rooting reactions differed greatly depending on the type of stock plant or donor plant maturity (Figure 2) (25%) and resulted in more roots being produced per rooted cutting. Only the percentage of roots was considerably impacted by the cutting age. Cuttings from a three-month-old stock plant rooted 50% better than cuttings from a tree that was one to two years old. T test results showed that root length and leaf number were not substantially impacted by stock plant maturation (p<0.05), as the same colors in the picture below illustrate. Due to the cutting age influence on populus rooting in the hydroponic media, Figure 3 only shows the rooting percentage of the 3-month cuttings to be superior at p<0.05 than the 1-2-year cuttings.

## C. Effects of Biochar on Growth Performance of Populus Alba

In the current investigation, prolific root and shoot growth in hydroponics rose as the rate of biochar increased, however this relationship was not statistically significant until the fourth week. Table 2 displays the leaf area after adding 10 gm, 25 gm, and 50 gm of biochar in comparison to the control (0 g of biochar amendment per liter). Every treatment resulted in noticeably better growth performances (p<0.05). Figure 4 shows the proportion of rooting. As seen in the above (Figure 4), the rooting of Populus was significantly affected by the water biochar amendment at 10 g/L and 25 g/L compared to 0 g/L (control) (p<0.05). The percentages of rooting at 25 g/L, 10 g/L, and 0 g/L of water biochar amendment were, respectively, 81.9%, 80.6%, and 22.2%.

**Table 2. Effects of Biochar on Root Number, Root Length, Leaf Number, And Shoot Height Per Cutting of Populus in Hydroponic Media**

| Biochar | Root number per cutting | Root length per cutting (cm) | Leaf number per cutting | Shoot height per cutting (cm) |
|---|---|---|---|---|
| 0 gm/L | 1.00<br>0.00a | 10.50<br>2.08a | 7.33<br>1.45b | 13.66<br>1.92a |
| 10 gm/L | 7.67<br>0.88b | 14.33<br>1.85ac | 20.00<br>1.00c | 28.60<br>0.78b |
| 25 gm/L | 8.33<br>0.88b | 19.83<br>1.76c | 21.67<br>1.20c | 26.66<br>1.01b |
| F | 31.71 | 6.064 | 40.46 | 37.11 |
| P value | 0.001 | 0.036 | 0.000 | 0.000 |

Note: The ±SE (standard error) followed by the same letters is not significantly different at p<0.05.

## D. Moss's Impact on Populus Growth in Hydroponic Media

As seen in Figure 5, the hydroponic medium with moss (25g/l) and 10g/l showed higher percentages of rooting (100%) and 77.8%, respectively, as compared to 0g/l moss (control) and other media combinations. As shown in Table 3 below, applications of 10g/l and 25g/l moss similarly demonstrated significant variations in the number of roots per cutting and the number of leaves per cutting, but no significant difference was found in the root length per cutting or the shoot height per cutting (p<0.05).As seen in the above Figure 5, moss applications at 10 g/L and 25 g/L of water had a significant impact on populus rooting in hydroponic growth media when compared to applications of 0 g moss/L water (control). Of the 36 cuttings for each treatment, applications of 25 g moss/L water resulted in the best rooting outcome (100%), followed by applications of 10 g moss/L water (77.8%), and finally, 0 g moss/L (control) showed a rooting percentage of 16.7%. 108 cuttings, therefore, were utilized for each treatment.

**Table 3. Effects of Moss on Root (%), Root Number Per Cutting, Root Length Per Cutting, Leaf Numbers Per Cutting, And Shoot Height Per Cutting of Populous Alba in Hydroponic Media N = 36 Cuttings for Each Treatment.**

| Moss+moss | Root number per cutting | Root length per cutting (cm) | Leaf number per cutting | Shoot height per cutting (cm) |
|---|---|---|---|---|
| 0 gm/L | 3.00<br>1.15a | 14.33<br>4.10a | 11.67<br>0.88d | 27.00<br>3.12b |
| 10 g/L | 13.33<br>1.76b | 9.33<br>1.36a | 18.67<br>0.88bc | 24.16<br>3.17b |
| 25g/L | 16.33<br>1.45b | 7.16<br>0.44a | 19.67<br>2.33bc | 22.83<br>2.25b |
| F | 22.39 | 2.14 | 8.14 | 1.64 |
| P value | 0.002 | 0.20 | 0.02 | 0.27 |

Note: The mean ±SE followed by the same letters is not significantly different at p<0.05.

## E. Azolla's Effects on Populus Rooting and Shooting Performance

The physical and chemical characteristics of the soil, particularly nitrogen, organic matter, and other cations like magnesium, calcium, and sodium released into the soil increase the amount of critical nutrients for plant growth [2][25].

Retrieval Number: 100.1/ijbsac.E051010050124
DOI:10.35940/ijbsac.E0510.10050124
Journal Website: www.ijbsac.org



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Application of azolla has been found to significantly improve these properties. The activity of soil enzymes, including phosphatase, amylase, cellulose, and dehydrogenase, is significantly increased when nitrogen-fixing green manures like azolla and sesbania are combined [10]. According to Table 4, there was no significant difference found in terms of root length per cutting or shoot height per cutting at pp<0.05. However, in the current study, applications of 10g/l and 25g/l of Azolla showed significant differences in terms of the number of roots per cutting and leaf number per cutting compared to without Azolla amendment (control).

**Table 4. Effects of Azolla on Root Length, Root Number Per Cutting, Leaf Number Per Cutting and Shoot Height Per Cutting in Hydroponic Media**

| Azolla+water | Root length per cutting (cm) | Root number per cutting | Leaf number per cutting | Shoot height per cutting (cm) |
|---|---|---|---|---|
| 0 gm azola/L | 10.83<br>1.69a | 6.00<br>1.52a | 12.67<br>3.18a | 26.66<br>0.60ab |
| 10 gm/L | 9.00<br>2.29a | 12.00<br>0.77b | 35.00<br>5.68b | 28.00<br>3.51ab |
| 25 gm L | 6.33<br>0.44a | 16.33<br>1.33c | 45.33<br>2.60b | 32.66<br>1.16ab |
| F | 1.85 | 18.175 | 16.991 | 2.12 |
| P value | 0.23 | 0.003 | 0.003 | 0.20 |

Note: Mean+SE followed by the same letters are not significantly different at p<0.05.

### F. Effects of Temperature

Temperature's impact on the rooting process When compared to uncontrolled outside treatments, enhanced enzymatic activity may be the cause of higher rooting performance in populous cuttings. This activity forms calluses, root primordia, and adventitious roots. When we compare the same cuttings' rooting times inside and outside the greenhouse, we find that the interior greenhouse rooted three days earlier than the outside greenhouse, even though all other conditions remained the same. As a result, there was a significant difference at p<0.05 in the root percentage per cutting, root number per cutting, leaf number per cutting, and shoot height per cutting. An independent sample t-test revealed that all of the rooting and shooting parameters shown in the figure below performed better within the greenhouse. Figure 6 illustrates how temperature changes within the greenhouse had a greater impact on root percentage, root count, root length, shoot height, and number of leaves than outside the greenhouse in all rooting and shooting parameters, as indicated by the various colors. Every parameter showed significant variations at p<0.05.

### G. Effects of Substrate on Growth of Populus Cuttings

In the current study, populous root length grew as the rate of biochar increased in sand that had been amended with it. The porosity of the biochar, which improves water infiltration in pots, may be the cause of the higher growth in biochar-treated plants as compared to control plants. Compared to the sand with biochar treatments, the red soil with biochar combination had more roots per cutting and more roots overall. This could be because the red soil has more nutrient availability than the sand, which has lower nutrient availability than the red soil. When biochar is added to red soil and sand, the effect is greater in the red soil than in the control (which does not include charcoal amendment). Typically, the charges in biochar boost the growth medium's ability to exchange cations, providing additional nutrients to the plants. Figure 7 illustrates that while root length performed better in sandy soil than in red soil, shoot height and the number of roots per cutting were substantially larger in red soil. Leaf number, on the other hand, did not significantly vary at p<0.05.

### H. Effects of Salt Stress on Propagations of Populus Cuttings

The results showed that the effects of salt were more noticeable than those in non-saline (control) conditions. 36 cuttings from the experiment were planted at 10 g of salt per liter, 25 g of litter, 0 g as the control, and so on for each treatment. After a week, the cuttings began to somewhat shoot, but by the second week, they had begun to dry, and by the third week, every cutting had dried. However, the control group demonstrated strong rooting and shooting skills and persevered during the period of data collection and recording for analysis.

### I. Correlation Between Fresh and Dry Weight of Root and Shoot

In red soil and sand substrate, there was a p<0.05 significant positive connection between the fresh weights and dry weights of plants with respect to root dry weight and shoot dry weight (Tables 5 and 6).

**Table 5. Correlation Between Fresh and Dry Weight of Shoot and Root Grown in Red Soil**

| Red Soil+biochar | SHFW | RFW | SHDW | RDW |
|---|---|---|---|---|
| SHFW | 1 | | | |
| RFW | 0.58* | 1 | | |
| SHDW | 0.99** | 0.55 | 1 | |
| RDW | 0.53 | 0.98** | 0.52 | 1 |

**Table 6. Correlation Between Fresh and Dry Weight of Shoot and Root Grown in Sand**

| Sand+biochar | SHFW | RFW | SHDW | RDW |
|---|---|---|---|---|
| SHFW | 1 | | | |
| RFW | 0.60* | 1 | | . |
| SHDW | 0.96** | 0.64* | 1 | |
| RDW | 0.47 | 0.90** | 0.56 | 1 |

* Correlation is significant at the 0.05 level (2-tailed):
**Correlation is significant at the 0.01 level (2-tailed).

The review's findings on rooting capacity showed that populous alba was subjected to significantly higher rooting abilities during mini-cutting management and induction treatments. With a 25 g/L moss application, a high root percentage (100%) was seen, indicating that Alba alba may be mass-propagated in greenhouse circumstances and may exhibit improved survivability in field conditions after a year. The effectiveness of our hardening approach was being demonstrated by mini-cuttings that were planted under field circumstances. It is crucial to keep in mind that growth additives affect the percentage of rooting as well as the quantity and quality of roots as well as the rate at which the rooting process begins. For many tropical tree species, such as Eucalyptus spp [15] and Triplochiton scleroxylon [11], positive correlations between cutting length and rooting have been documented.

International Journal of Basic Sciences and Applied Computing (IJBSAC)
ISSN: 2394-367X (Online), Volume-10 Issue-5, January 2024

It is believed that these correlations between cutting length and rooting capacity highlight the significance of the stem's stored carbohydrates, which promote adventitious root growth [11]. However, since stored food in small cuttings is sufficient, there was no significant link found between cutting length and rooting potential in the considerably bigger cuttings used in this investigation. Table 1 above illustrates that the remaining rooting and shooting characteristics were not significantly impacted by cutting length; the only variables that were changed by cutting length were the number of leaves per cutting, shoot height per cutting, and branch number per cutting ($p<0.05$). There were differences in the rooting potential of the three mini-cuttings (thin, medium thickness, and thick cuttings) according to the cutting thickness. In terms of root percentage per treatment, thin cuttings performed better than medium and thick cuttings. As seen above in Table 1, Tukey's multiple comparison test indicates that the variation is significant at $p<0.05$. Significant variance was also seen in the root and shoot dimeters ($p<0.05$). It was discovered that the age of the stock plant was the most important factor influencing the vegetative proliferation of populous alba by stem cuttings. Compared to cuttings taken from older, 1-2 year trees, the 3-month-old seedlings generated more roots and rooted more deeply, with a significant difference observed at $p<0.05$. Stock plant cuttings that were one to two years old could not root successfully. Cuttings from 3-month-old stock plants performed well in the rooting and shooting criteria, despite the fact that the variation is not significant for all growth characteristics. Active cell division at the root apices and shoot meristematic tissue may be the cause of the variation. The age of donor plants is important for rooting since stem cuttings of populous species taken from young donor plants rooted considerably better than cuttings taken from mature donor plants. According to research on other species, the potential of stem cuttings to generate adventitious roots diminishes as the donor plant ages [8]. This study supports those findings. Due to their youthful ontogenetic, physiological, and chronological ages as well as perhaps their low synthesis of secondary metabolites, stem cuttings taken from juvenile donor plants are typically thought to be easy to propagate by cuttings [8]. Because donor plants are older, stem cuttings' potential to root may decrease. This could be because endogenous auxins are less present or because inhibitory substances that prevent rooting have accumulated [8][16]. When comparing the concentration forms of the Azolla application to the untreated or control group, significant difference was seen. The number of roots per cutting and the number of leaves per cutting improved with applications of 25 gram of azolla per liter of water. Azolla has a crucial role in providing and fixing atmospheric nitrogen to support plant growth and roots. Consistent with this result, other research conducted in Cuttack showed that the application of Azolla considerably increased crop output and crop N uptake when compared to treatments that did not include Azolla [14]. When biochar was added, Poplus alba's rooting percentage, number, length, and shoot height all rose noticeably in comparison to treatments that did not apply biochar (control). As a result, every metric shown that applying biochar was superior than control. Biochar may have long-term effects on growth, as evidenced by the large effect it had on the number of leaves at a later stage of growth. Similar to this, it has been noted that applying biochar as a soil amendment enhances soil quality and increases soil fertility through raising soil pH, enhancing moisture retention, drawing in more beneficial fungi and other microbes, enhancing cation exchange, and maintaining soil nutrients [1]. Additionally peaty and clay soils, biochar improved plant height and green biomass and increased the rate of germination in all investigated soils. Plant development can be encouraged and the value of agricultural products that have not been harvested increased by biochar [12]. In the current study, populus growth rose with an increasing rate of biochar in sand, water, and red soil with biochar amendment. This increase was statistically significant at the fourth week at ($p<0.05$). as moss was applied, the number of roots increased significantly in a different way than with other treatments as compared to the control. Since oxygen promotes microbial activity, the additive values of moss were utilized as a source of oxygen to speed up metabolism in the propagation system. This therapy showed the largest root number per treatment up to 100%. Of the 36 cuttings that were initially planted, all 36 of them completely root at a rate of 25 grams of moss per litter of pure water. Similar to the current study, other Indian studies have revealed that, when it comes to the impact of rooting media on the rooting percentage, the media containing sand and peat moss showed a higher percentage of rooting than other media, regardless of the PGRs used [17]. Populus alba is greatly impacted by temperature in terms of rooting and shooting. In the greenhouse, 33 of the 36 cuttings that were planted were rooted after four weeks, however only 16 of the 36 cuttings that were put outside in the shadow area were rooted after four weeks. This is because temperature is crucial for plant growth in order to maximize enzyme activity. As seen in Figure 6 above, shoot height also revealed a noticeably superior outcome within the greenhouse. The current study compared the applicability of red soil and sand with various combinations of biochar on the roots and shooting performance of populous alba in treatments connected to substrate. According to the experiment's findings, root length and other rooting parameters in sand produced comparatively superior outcomes, however root number and shoot height produced positive results when cuttings were planted in red soil at $p<0.05$. The porosity of sand may facilitate easy root movement downward, which is why root length functions better in it. Red soil may also exhibit the highest root number and shoot height because of the presence of nutrients in the soil, which allows plants to produce more roots per plant than in sandy soil. However, on both sand and red soil substrate medium, the addition of the biochar amendment shown a substantial impact on the root length per cutting, root number per cuttings, leaf number per cuttings, and shoot height of Populus alba. In comparison to the control, cuttings planted in salted media did not perform as well.



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Thirty-six cuttings were planted with a control of 0 gm per litter, 25 gram per litter, and 10 gm salt per liter. Cuttings began to shoot a little after the first week, but by the second week, they were drying, and by the third week, all of the cuttings had dried. The control group displayed good roots and shooting, but nothing was retrieved from the dried cuttings. It is feasible to infer from this experiment that poplars cannot withstand salt stress. Consistent with the current study, other results indicated that poplars, which are often very acidic and wet, are intolerant of salty conditions and organic soils and should be avoided [20][24]. At high salinities, energy losses from increased respiration and/or salt pumping and the manufacture of organic solutes for osmotic adjustment [9][21] may be the cause of the salt-induced decrease in plant growth. relationships between the fresh and dry weights of the root and shoot in treatments pertaining to the substrate. Fresh weights and dry weights of Populus roots and shoots in treatments connected to substrate showed a strong positive correlation, as the results showed. Since it shows positive Pearson coefficients of correlation (r) at $p<0.05$ and $(0<r<1)$ for both sand and red soil substrate treatments, as indicated in Tables 5 and 6, the positive correlation between fresh weight and dry weight demonstrates the efficacy of sand and red soil for the growth of populus with combinations of biochar as amendment.

## IV. CONCLUSION

The analysis came to the conclusion that successful seedling production requires a high survival rate along with a high percentage of roots. Farmers who use Populus alba propagation should be informed about the highly promising vegetative propagation technique that was discovered in the current study employing small cuttings of the plant. It is possible to propagate populations in hot climates, as demonstrated by the creation of healthy roots and shoots with applications of charcoal, Azzola, and moss in hydroponics and soil-related medium (red soil and sand) in greenhouses. Populous growth in outdoor environments shown that small cutting techniques might be used to successfully propagate it. Vegetative propagation may shorten the time it takes for wood to be harvested from seeds to maturity since many low-income farmers are drawn to fast-growing, multipurpose tree species. Stem cutting propagation will be a quick and efficient way to multiply a species in large quantities, replacing the less successful germination of seeds. Because of its natural ability to adapt to environment, it is also advised to incorporate it into agroforestry systems, particularly in areas where soil degradation is known to occur. This will allow for the quicker restoration of the degraded region through reforestation.

## RECOMMENDATION

As review findings the following recommendation are forwarding:

- Current research demonstrates that methods of cultivating common plants in soil and hydroponic media using cuttings speed up the process of producing seedlings. Thus, foresters are able to apply this method.
- Populus plants should be planted along the edges of agricultural land and bodies of water because they help maintain soil fertility by controlling soil erosion and removing harmful chemicals through phytoremediation.


## ACKNOWLEDGEMENTS

The special word of thanks goes to the Harar biodiversity center and Bahir Dar University.


## DECLARATION STATEMENT

| | |
|---|---|
| Funding | No, I did not receive. |
| Conflicts of Interest | No conflicts of interest to the best of our knowledge. |
| Ethical Approval and Consent to Participate | No, the article does not require ethical approval and consent to participate with evidence. |
| Availability of Data and Material | Not relevant. |
| Authors Contributions | All authors have equal participation in this article. |

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## APPENDIX I

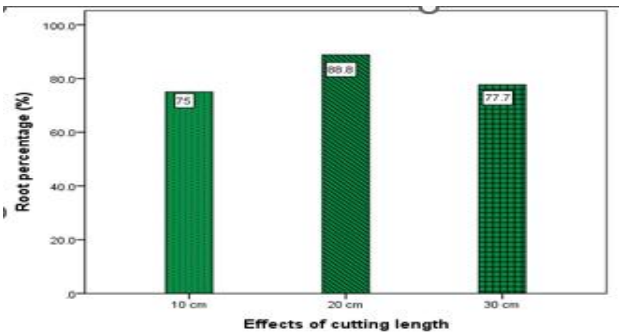


**Figure 1. Effects of Cutting Length on Rooting Percentages of Populus in Soil**

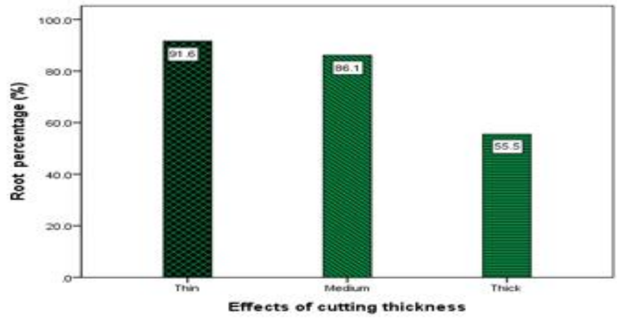


**Figure 2. Effects of Cutting Thickness on Rooting Percentages of Populus in Soil**

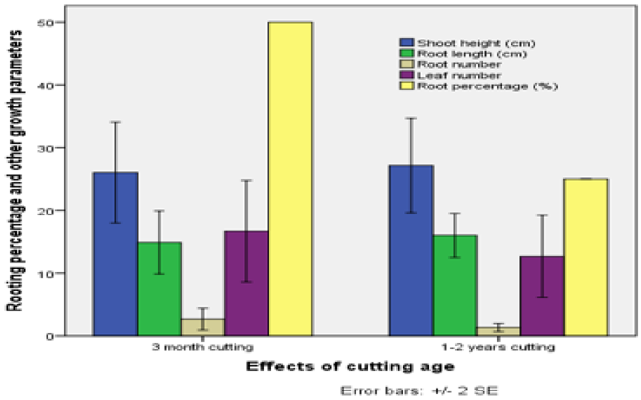


**Figure 3. Effects of Cutting Age on Rooting and Shootings of Populus in Hydroponic Media**

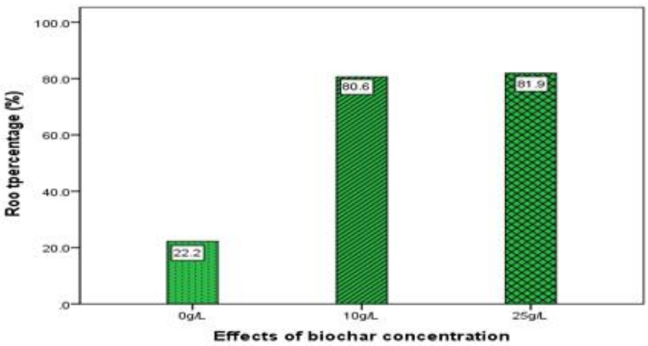


**Figure 4. Effects of Biochar Amendment on Rooting Percentages of Populus in Hydroponic Growth Media**

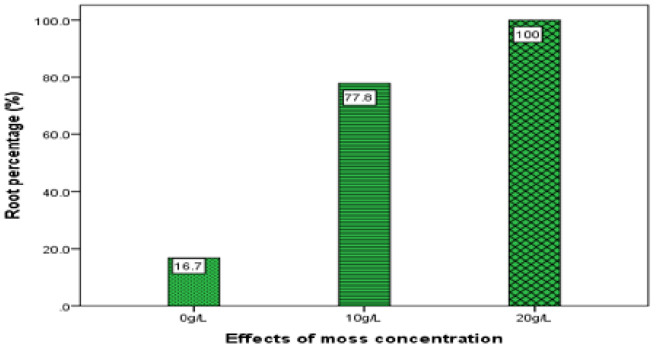


**Figure 5. Effects of Moss on Rooting of Populus in Hydroponic Growth Media**

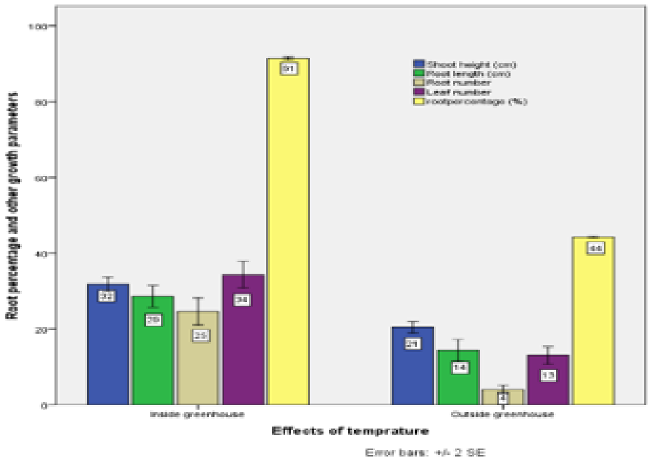


**Figure 6. Effects of Temperature on Root Percentage, Root Number Per Cutting, Root Length Per Cutting, Leaf Number Per Cutting, And Shoot Height Per Cutting in Red Soil**

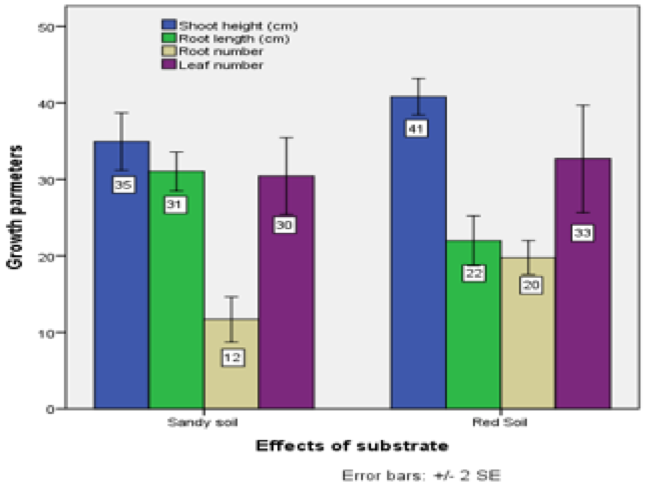


**Figure 7. Effects of Sand Versus Red Soil Substrate on the Growth of Populus Cuttings**



*Retrieval Number: 100.1/ijbsac.E051010050124*
*DOI:10.35940/ijbsac.E0510.10050124*
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