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Survival and Growth Performance of Mahogany (*Swietenia macrophylla* King) Wildlings Using Biochar Soil Amendment

Jushtine M. David[1], *Leana S. Galicia*[2]

[1] *Pampanga State Agricultural University, San Agustin, Magalang, Pampanga, Philippines*
[2] *Pampanga State Agricultural University, San Agustin, Magalang, Pampanga, Philippines*

ARTICLE INFORMATION

*Corresponding author:
LEANA S. GALICIA
E-mail: leana_galicia@psau.edu.ph

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ABSTRACT

The study was conducted to determine the effects of biochar application on the growth performance of mahogany wildlings. Four hundred eighty cuttings were used; treatments were arranged in Randomized Complete Block Design (RCDB), replicated 3 times and repeated three times. The study has four (4) treatments namely: T1 (Control), T2 (3:1 ratio of soil to biochar), T3 (2:3 ratio of biochar to soil) and T4 (2:2 ratio of biochar to soil). The study revealed that in terms of plant height, there is significant difference as referred to analysis of variance at 35 days after biochar application. T4 (mean of 23.81cm) is significantly higher than T1 (mean of 22.59cm) but not significantly different from T2 (mean of 23.33cm) and T3 (mean of 23.58cm). Analysis of variance revealed that there is no significant difference among treatment means in terms of diameter. At 70 days after biochar application, analysis of variance showed that there is significant difference in the number of leaves of mahogany wildlings i.e. treatment 4 (mean of 9.58) is significantly different from T1 (mean of 6.72), but not significantly different from T2 (mean of 7.68) and T3 (mean 8.47). Based on the analysis of variance in terms of root length, there is no difference among means. In terms of survival, there is no significant difference among treatment means. All treatments obtained a mean of 100% which proved that all treatments are comparable to each other.

The result concludes that application of biochar as soil amendment did not affect the mahogany wildlings in terms of plant diameter, root length, and survival. However, in terms of plant height and number of leaves, the application of biochar showed significant effects on mahogany wildlings. It was also revealed that application of biochar at 2:2 ratio of biochar to soil performed better than other treatments.

INTRODUCTION

Mahogany (*Swietenia macrophylla* King) is a member of the family Meliaceae, and is one of the best-known and more frequently used tree species of forest stands. Due to its biological and commercial characteristics, mahogany has a large potential to become the basis for a sustainable use and management system of the tropical forest, applied in the framework of appropriate silvicultural practices. Genetic diversity in the tropical forests, where the mahogany grows, is rapidly decreasing due among other reasons to deforestation processes and natural population fragmentation. The first phenomenon reduces the population size and natural communities' fragmentation; it makes the gene exchange difficult and may isolate continuous populations of a given species until its genetic diversity is lost, as a result of endogamy and genetic erosion. These phenomena highlight the

enormous risks that tropical forest resources face, especially some species of commercial value such as mahogany, therefore justifying the urgent need to better understand genetic diversity at its different levels and use such knowledge in the management, improvement, and conservation practices of those important genetic forest resources (Kumar, 2015).

Soil is the most important source and an abode for many nutrients and microflora. Due to the rapid depletion of agricultural areas and soil quality by means of an ever-increasing population and excessive addition of chemical fertilizers, rehabilitated attention is a need of the hour to maintain sustainable approaches in agricultural crop production (Jyotiet al. 2019).

One of the traditional ways to improve the energy efficiency of agricultural systems is to the soil part of the biomass produced by crops, which in many cases is removed from the field to be used for other purposes or even destroyed. Returning crop waste into the soil, either without any processing or through organic amendments represents a management strategy that, in addition to the improvement of energy efficiency for agro-ecosystems, may help to combat soil degradation phenomena. Soil amendment includes all inorganic and organic substances mixed into the soil for achieving a better soil constitution regarding plant productivity. Soil amendment does not include mulching, which include substances lying on top of the soil. The reason for soil amendment is to provide a better environment for roots and plant growth: this includes the improvement of the soil structure and water holding capacity, the availability of nutrients, and the living conditions for soil organisms which are important for the plants to grow. Furthermore, a better soil texture and better root growth avoid soil degradation during heavy rains or in windy regions. It also supports the nutrient cycle when organic amendments are used (e.g. manure). Of course, it is also very important that a crop is planted which is suitable for the given climate. Basically, any organic or inorganic material that is added to the soil and improves its quality can be considered a soil amendment (West Coast Seeds, 2011).

An alternative to returning biomass into the soil is the integration of biochar as an organic amendment in the crop production process. The term biochar can be defined as a carbonaceous material obtained from biomass by thermal decomposition at low or no oxygen concentration, through a thermo-chemical process known as pyrolysis. There is also consensus that its specific application to soil is expected to sustainably sequester carbon and improve soil functions (Lehmann et al. 2021).

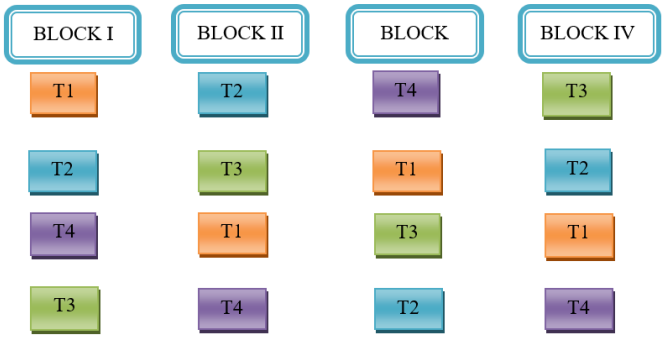
Therefore, the main objective of the study was to determine the effect of biochar application in potted mahogany wildlings after transplanting.

MATERIALS AND METHODS

Experimental Design and Treatment

Treatments were arranged in Randomized Complete Block Design (RCDB). Thirty (30) wildlings per treatment will be used and replicated thrice. A total of four hundred eighty (480) mahogany wildlings were used in this experiment.

Experimental Layout



LEGEND:

T1 = Control
T2 = 3:1 ratio of soil to biochar
T3 = 2:3 ratio of biochar to soil
T4 = 2:2 ratio of biochar to soil

Source of Biochar

The biochar that was used in this research is commercial charcoal obtained from agricultural (rice hulls) wastes through a pyrolysis process provided by Sambali Beach Farm in Pampanga, Philippines. Sambali Beach Farm is founded in 2000 by Ching Camara, the farm is at the forefront of Biochar in the Philippines, and it is the official Biochar-making center accredited by the Philippine Biochar Association (PBiA).

Nutrient Content of Biochar

Department of Agriculture, Regional Soils Laboratory of San Fernando, Pampanga stated that the biochar was analyzed and tested as fertilizer and the usual parameters tested are nitrogen (N), phosphorus (P), and potassium (K). According to the study of Purakayastha et al. (2019), biochar can supply nutrients such as nitrogen (N),

phosphorus (P), potassium (K), and other trace elements inherently present in the original feedstock used for biochar production.

Constructing the Nursery Building

The researcher first leveled the soil to make it even to the ground, and then a suitable area was measured to use in experiments. The mainframe of the site is bamboo. Roof and fence materials are also bamboo panels that are covered with a garden net. The researcher also used coconut or banana leaves to cover the roof so that some sunlight can still pass through, these will help to support the plants during their recovery period.

Pot preparation

Garden soil and its incorporation into biochar is the substrate used in this research. The soil media were sterilized for 40 minutes. Afterward, it was mixed manually into biochar in their corresponding volume before placing in pots wherein 8" x 8" size of polyethylene bags were used as experimental pots.

Wildlings Preparation

Mahogany wildlings were collected from the Mahogany Forest of Mount Arayat National Park (now Mount Arayat Protected Landscape), Ayala, Magalang, Pampanga. The researcher chose wildlings that are healthy and free from diseases.

Transplanting of Wildlings

The wildlings were transplanted in prepared polyethylene bags. Leafages of the mahogany wildlings were cut to retain one-third to one-half of the original length to reduce transpiration and the plants were placed in a partially shaded area. In twenty (25) days after transplanting the initial data was gathered.

Maintenance of the Experimental Plot

The area of the study was monitored to keep the plants safe. Manual removal of weeds in the plants was conducted every day. To maintain the moisture of the mahogany wildlings, watering equally was done as needed.

Data Gathering Procedure

The gathering of data was conducted every 7 days for 35 days of the duration of the study. The following parameters were gathered:

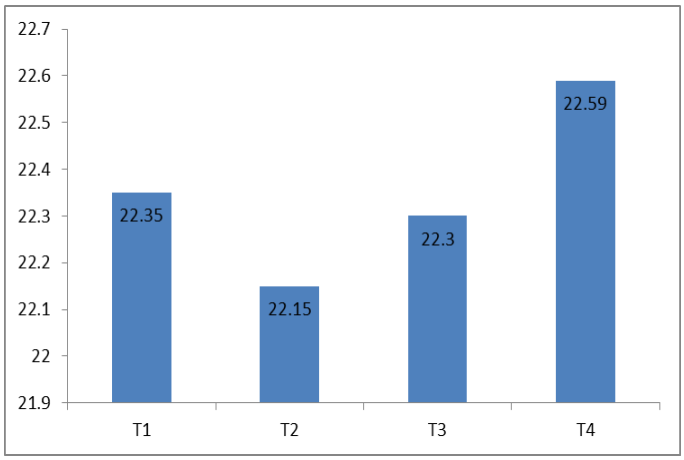
1. Plant height Increment. The height of plants was measured 25 days after transplanting (initial), then the following was measured every 7 days for 35 days after biochar application (DABA). Plants will measure using tape measured 2 cm above the base up to the highest apex of the plant.
2. Stem Diameter Increment. The diameters of plants were measured 25 days after transplanting (initial), and then the following was measured every 7 days for 35 DABA. Plants were measured using a digital calliper 2cm above the base of the plant. A permanent mark was the basis for measuring the plant diameter.
3. Number of Leaves. Leaves were counted and marked with permanent marker 25 days after transplanting (initial), and the leaves produced and visible on the plant, including the tips of new leaves just beginning to emerge were counted every 7 days at 35 DABA.
4. Length of roots in (cm) - determine the length of roots of mahogany wildlings at 35 DABA. The roots were measured from the base up to the root apex using a tape measure;
5. Percent of Survival. Determine the percent of survival of all the treated mahogany seedlings at 35 DABA.

Statistical Analysis

The data gathered in this study were statistically analyzed using one-way analysis of variance (ANOVA) in Randomized Complete Block Design (RCBD) to determine if there are significant differences among the parameter tested. Further, posthoc tests using LSD were carried out to identify specific treatments that bear significant differences.

RESULTS AND DISCUSSION

Figure 1 showed the initial plant height of the mahogany wildlings. Treatment 1 measures 22.35cm, T2 22.15cm, T3 22.3 and T4 measures 22.59cm.

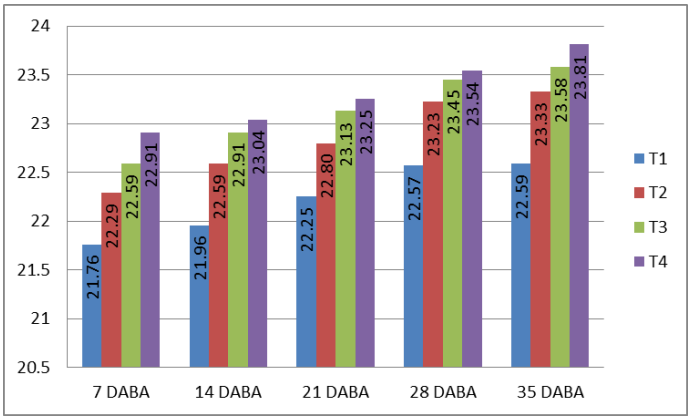


T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 1. Initial plant height at 25 days after transplanting

Seven (7) days after biochar application highest mean was recorded under T4 obtained a mean of 22.91cm followed by T3 a mean of 22.59cm, T2 a mean of 22.29cm, and the lowest mean was obtained at T1 a mean of 21.76cm. Fourteen (14) days after biochar application highest mean was recorded under T4 obtained a mean of 23.04cm followed by T3 a mean of 22.91cm, T2 a mean of 22.59cm, and the lowest mean was obtained at T1 a mean of 21.96cm. Twenty-one (21) days after biochar application highest mean was recorded under T4 obtained a mean of 23.25cm followed by T3 a mean of 23.13cm, T2 a mean of 22.80cm, and the lowest mean was obtained at T1 a mean of 22.25cm. 28 DABA highest mean was recorded under T4 obtained with a mean of 23.54cm followed by T3 with a mean of 23.45cm, T2 with a mean of 23.23cm, and the lowest mean was obtained at T1 with a mean of 22.57cm, and 35 DABA's highest mean was recorded under T4 obtained with a mean of 23.81cm followed by T3 with a mean of 23.58cm, T2 with a mean of 23.33cm, and the lowest mean was obtained at T1 with a mean of 22.59 cm.

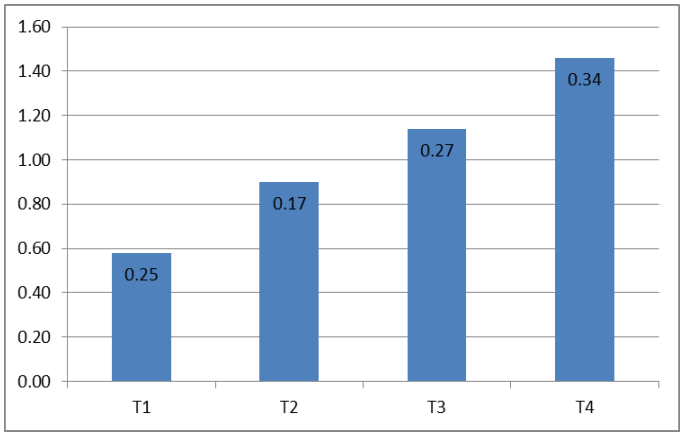
Figure 2 showed the calculated mean, in the plant height of mahogany wildlings. The analysis of variance shows that there is a significant difference ($P<0.05$) in terms of height across treatments at 35 days after biochar application. The LSD analysis revealed that T4 obtained a mean of 23.81cm is significantly higher than T1 a mean of 22.59cm but not significantly different from T2 a mean of 23.33cm and T3 a mean of 23.58cm.



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 2. Mean plant total height (cm)

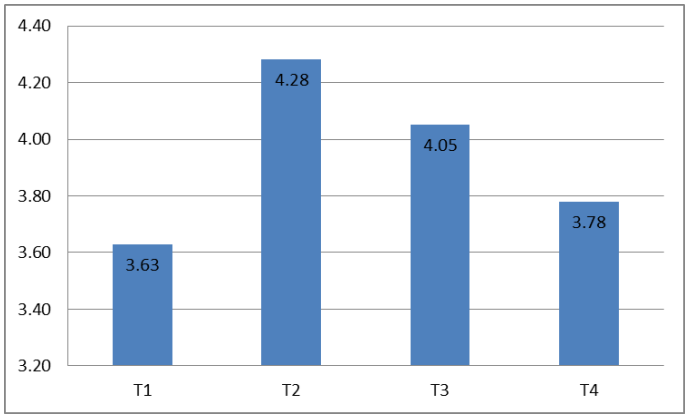
Biochar has been shown to promote plant productivity and yield through several mechanisms. Physical conditions change with biochar, its dark color alters thermal allowing more time for growth compared with controls (Beiderman and Harpole, 2012). The biochar-induces improvement in soil water holding capacity and soil nitrogen or phosphorus availability enhancing plant productivity. The increase in soil alkalinity following biochar amendment could also be beneficial to plant growth, which was further supported by our findings indicating an increase in biochar Ph (Yu. et al. 2018).



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 3. Mean plant height (cm) increment

Plant height increment was calculated as shown in Figure 3, T1 obtained a mean of 0.25cm, followed by T2 with 0.17cm, T3 measures 0.27cm, and T4 with 0.34cm which was recorded to be the highest increment obtained in the wildlings. This showed that T4 is significantly higher than T1, but not significantly different from T2 and T3 as referred to analysis of variance.



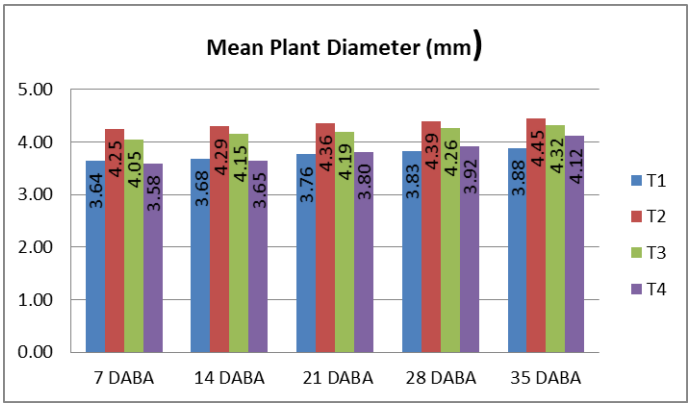
T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 4. Initial plant stem diameter (mm)

The initial plant stem diameter (mm) was also measured as shown at Figure 4 treatment 1 measures 3.63mm, T2 4.28mm, 4.05mm, T3 4.05mm and 3.78mm.Figure 5 showed that at seven (7) to thirty- five (35) days after biochar application analysis of variance revealed that there is no significant difference among treatment means. Seven (7) days after biochar application highest

mean was recorded under T2 obtained a mean of 4.25mm, followed by T3 a mean of 4.05mm, T1 a mean of 3.64mm, and the lowest was obtained at T4 a mean of 3.58mm. 14 DABA highest mean was recorded under T2 obtained with a mean of 4.29 mm, followed by T3 with a mean of 4.15mm, T1 with a mean of 3.68mm, and the lowest was obtained at T4 with a mean of 3.65mm. 21 DABA highest mean was recorded under T2 obtained with a mean of 4.36 mm, followed by T3 with a mean of 4.19 mm, T4 a mean of 3.80 mm, and the lowest was obtained at T1 with a mean of 3.76mm. 28 DABA highest mean was recorded under T2 obtained at a mean of 4.39mm, followed by T3 with a mean of 4.26mm, T4 with a mean of 3.92mm, and the lowest was obtained at T1 with a mean of 3.83 mm and 35 DABA highest mean was recorded under T2 obtained a mean of 4.45 mm, followed by T3 a mean of 4.32mm, T4 a mean of 4.12 mm, and the lowest was obtained at T1 a mean of 3.88mm.

These were revealed to be comparable to each other, although there is an observed numerical difference between the highest and lowest mean. This indicates that the wildlings used were almost homogenous in diameter.



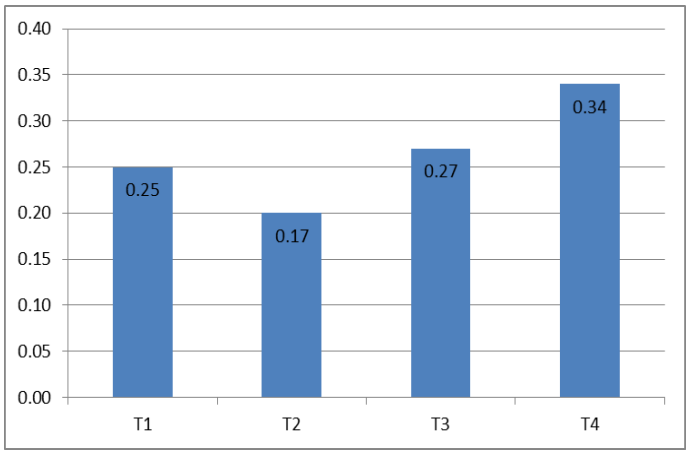
T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 5.Stem diameter (mm)

This chart shows that the growth of the wildlings is correlated to their mortality rate in this study. Though the results state that they didn't have any significant difference, they still projected a numerical significance as they have a consistent increase from 7 to 35 days after biochar application even if it's relatively low. If they continue to show growth at this pace, despite how low, definitely, they would still thrive.

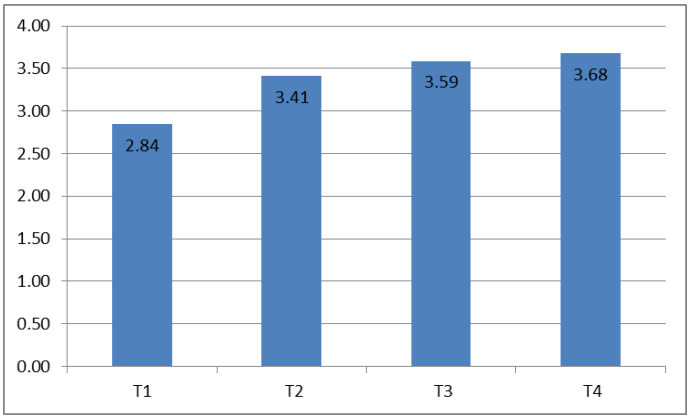
Plant diameter was also calculated for increment as illustrated in Figure 6 T1 obtained a mean diameter increment of 0.25mm, T2 of 0.17mm, T3 with 0.27mm, and T4 with 0.34mm. All treatments are comparable in terms of plant diameter as reflected in the analysis of variance which reveals no significant difference. The lower stem diameter growth indicates that these plants had a reduced rate of photosynthesis (Kozlowski and Pallardy, 1997).

In general, biochar amendment increases soil nitrogen availability and retention; improves soil water-holding capacity, increases soil pH and action exchange capacity, decreases soil bulk density, facilitates beneficial microorganisms, and limits the bioavailability of heavy metals, which are associated with increases in plant photosynthesis. In addition, biochar amendment and the induced changes in soil properties can also affect plant performance by altering growth and traits (Chen et al. 2019).



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 6. Stem diameter (mm) increment

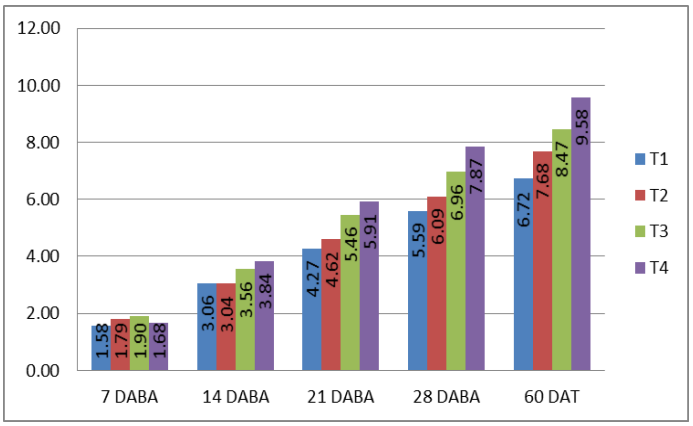


T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 7. Initial number of plant leaves

The initial number of plant leaves was also measured as shown in Figure 7 treatment 1 measured 2.84, T2 3.41, T3 3.59, and T4 measured 3.68.

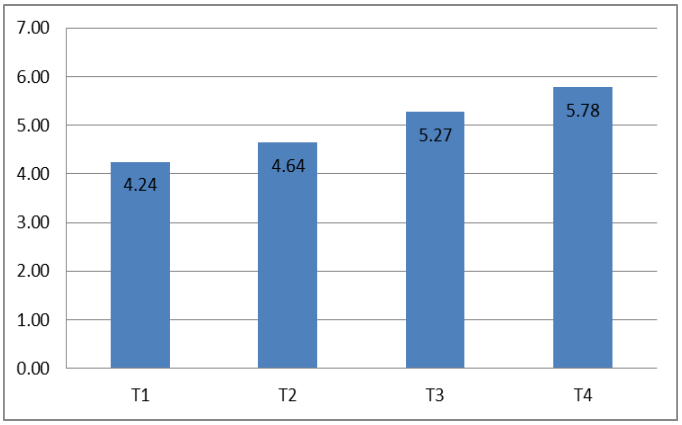
Figure 8 showed at thirty-five (35) days after biochar application, analysis of variance showed that there is a significant difference (P<0.05) across treatments. The LSD analysis revealed that the number of leaves in treatment 4 obtained a mean of 9.58 is significantly different from T1 a mean of 6.72, but not significantly different from T2 a mean of 7.68, and T3 a mean of 8.47.



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 8. Number of new leaves

As shown in Figure 8, number of new leaves was observed significantly at the higher application of biochar. When biochar is applied to the soil, it comes in close contact with the plant root and has a direct effect on root growth, thereby affecting root morphology, which in turn has a profound impact on the growth of the plant shoot (Q. Zhu et al., 2018).

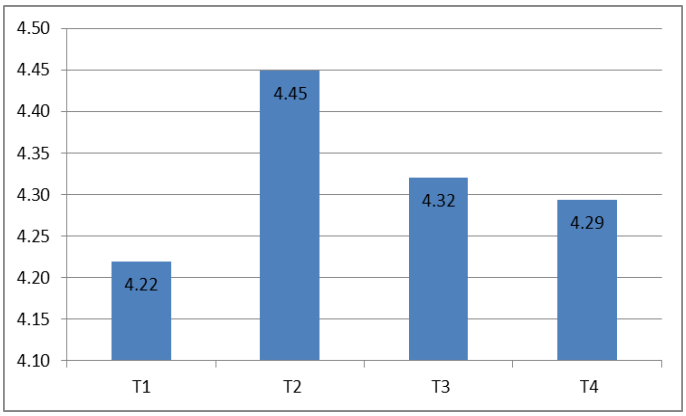


T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 9. Added Leaves

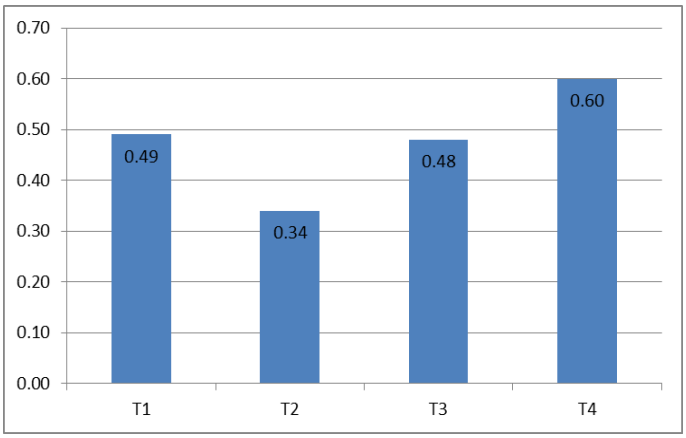
Added leaves were also calculated as illustrated in Figure 9 wherein T1 obtained a mean of 4.24, T2 with a mean of 4.64, T3 with a mean of 5.27, and T4 with 5.78. It was revealed that there are significant differences in terms of the number of leaves as referred to in the analysis of variance.

The initial root length of the plants shown in Figure 10 treatment 1 measured 4.22cm, T2 4.45cm, T3 4.32cm, and T4 measures 4.29cm. Based on the analysis of variance, the difference among means is not significant. This showed that all treatments applied to mahogany wildlings have no effects in terms of root length. This indicates that the root length of the wildlings used was almost uniform.



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 10. Initial root length (cm)



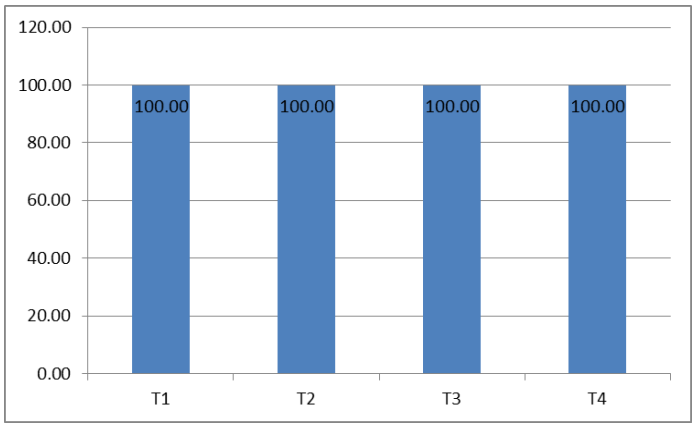
T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 11. Root length increment (cm)

When biochar is applied to the soil, it comes in close contact with the plant root and has a direct effect on root growth, thereby affecting root morphology, which in turn has a profound impact on the growth of the plant shoot (Q. Zhu et al. 2018).

Analysis of variance revealed that there is no significant difference among treatment means. All treatments

obtained a mean of 100 % which proved that all treatments are comparable to each other.



T1 = Control, T2 = 3:1 ratio of soil to biochar, T3 = 2:3 ratio of biochar to soil, T4 = 2:2 ratio of biochar to soil

Figure 12. Survival rate (%)

Summary of Findings

The study was conducted from May to July 2021in the yard of the David Family located at San Vicente, Magalang, Pampanga to determine the effects of different applications of biochar on the survival and growth performance of mahogany wildlings. Three hundred sixty wildlings were used. Treatments were arranged in Randomized Complete Block Design (RCDB). The study has four (4) treatments namely; T1 (Control), T2 (3:1 ratio of soil to biochar), T3 (2:3 ratio of biochar to soil), and T4 (2:2 ratio of biochar to soil). The treatments were replicated three times.

The study revealed that in terms of plant height, there is a significant difference as referred to the analysis of variance 35 days after biochar application. T4 obtained a mean of 23.81cm is significantly higher than T1 a mean of 22.59cm but not significantly different from T2 a mean of 23.33cm and T3 a mean of 23.58cm. Analysis of variance revealed that there is no significant difference among treatment means in terms of diameter. T1 obtained 3.88mm, T2 mean of 4.45mm, T3 a mean of 4.32mm, and T4 a mean of 4.12mm.At seventy 35 days after biochar application, analysis of variance showed that there is significant difference in the number of leaves of mahogany wildlings. Treatment 4 obtained a mean of 9.58 is significantly different from T1 a mean of 6.72, but not significantly different from T2 a mean of 7.68, and T3 a mean of 8.47. Based on the analysis of variance in terms of root length, it was revealed that there is no difference among means. T1 obtained 0.49cm, T2 mean of 0.34cm, T3 a mean of 0.48cm, and T4 a mean of 0.60cm.In terms of survival rate analysis of variance revealed that there is no significant difference among treatment means. All treatments obtained a mean of 100 % which proved that all treatments are comparable to each other.

CONCLUSION

Based on the result of the study, the application of biochar as soil amendment did not affect the mahogany wildlings in terms of plant diameter, root length, and survival. However, in terms of plant height and the number of leaves, the application of biochar showed significant effect on mahogany wildlings. It was also revealed that application of biochar at 2:2 (ratio of biochar to soil) performed better at other treatments.

For further study, the researcher recommends the following:

- Incorporate the use of other fertilizers with Biochar;
- Incorporate the use of Biochar in improving the growth of other species;
- Measure other parameters using other factors such as watering frequency; and
- Follow the prescribed data gathering period or even prolong it for better reliable results.

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DOCUMENTATIONS

1. Overview of the Study

A. Wildlings 25 days after transplanting

2. Application of biochar

B. 35 days after biochar application

3. Nursery set up

4. Soil Sterilization

5. Transplanting of Mahogany wildlings

6. Marking of Mahogany leaves

7. Marking for initial data gathering