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Increased Growth of RED Jabon (*Anthocephalus macrophyllus*) Seedlings using Various Doses of Compost Fertiliser on Used Gold Mine Planting Media

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ABSTRACT

Mining operations disrupt the equilibrium of terrestrial ecosystems, leading to a decline in soil fertility and overall environmental quality. The adverse effects of such activities can severely impact forest ecosystems, resulting in disturbances to physical, chemical, and biological conditions. Consequently, initiatives aimed at restoring soil health to its pre-mining state are essential, often involving revegetation efforts. The cultivation of red jabon trees in nutrient-deficient and less fertile soils necessitates the incorporation of organic matter to enhance soil quality, typically achieved through the application of compost. This study aimed to evaluate the effects and optimal ratios of compost mixed with ex-gold mining soil on the growth of red jabon seedlings. The experimental design included four treatment groups and five replications, yielding a total of 20 experimental units. The treatments for compost application were as follows: D1 = control (no compost), D2 = 10% compost + 90% ex-gold mining soil, D3 = 30% compost + 70% ex-gold mining soil, and D4 = 50% compost + 50% ex-gold mining soil. The parameters observed included survival rate, height growth, diameter growth, dry weight of the plants, and root-to-crown ratio. The findings indicated that the application of compost significantly influenced the growth of red jabon seedlings. Notably, treatment D4 (50% compost + 50% ex-gold mining soil) yielded the most favorable results, achieving a survival rate of 100%, a height increase of 16.56 cm, a diameter increase of 2.21 mm, a dry weight of 40.73 g, and a root-to-crown ratio of 4.84.

Keywords: *A. macrophyllus*, Compost, Growth, Used Gold Mine

1. INTRODUCTION

Forests serve as vital reservoirs of natural resources essential for the sustenance of various life forms. The vegetation within these ecosystems plays a crucial role in carbon sequestration (Pebriandi et al., 2024), provides habitats for diverse animal species (Angraini et al., 2024), and has increasingly become a site for recreational activities and ecotourism (Pajri et al., 2023). Natural resources can be categorized into two main types: renewable and non-renewable. Non-renewable resources primarily encompass those derived from mining activities, which are currently facing significant challenges due to the widespread conversion of forested areas for alternative uses, particularly mining (Henrianto et al., 2019).

While mining can enhance local economic development, it simultaneously disrupts the ecological balance of terrestrial ecosystems, leading to diminished soil productivity and environmental degradation (Sittadewi, 2016). The adverse effects of mining operations can severely damage forest ecosystems, resulting in alterations to the physical, chemical, and biological characteristics of the soil. This includes changes in soil morphology, the presence of elevated heavy metal concentrations in former mining sites, reduced soil pH, and a decline in the populations of soil microorganisms that are essential for plant growth (Sancayaningsih & Suharno, 2013). Additionally, tailings produced from gold mining processes are laden with minerals and heavy metals, including mercury (Hg) (Pamayo & Trihadiningrum, 2015).

Restoration initiatives aimed at returning soil to its original state involve the implementation of revegetation practices, specifically the replanting and upkeep of former mining sites. A critical factor in the success of these revegetation efforts is the careful selection of plant species.

Red Jabon, known for its adaptability to various environmental conditions, is particularly noteworthy in this context (Irawan & Hidayah, 2016). This species demonstrates a remarkable ability to thrive in marginal growth environments and does not necessitate specific growth conditions (Husni, 2017). As a pioneer species, Red Jabon exhibits rapid growth across diverse soil types, including clay, rocky substrates, and moist alluvial soils found along riverbanks. Its seeds and seedlings are readily available and can be easily cultivated in less fertile or suboptimal land (Bachtiar, 2018). To enhance the efficacy of utilizing Red Jabon (*Anthocephalus macrophyllus*) on nutrient-poor ex-gold mining sites, the incorporation of organic matter through fertilization is essential to improve soil quality.

The fertilizer applied in this context is compost derived from chicken manure. This type of manure is known to enhance soil nutrient levels and facilitate the absorption of nutrients by plants. Compared to other types of manure, chicken manure fertilizer offers distinct advantages in terms of nutrient absorption efficiency and its composition, which includes essential elements such as nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca) (Kusuma, 2016). To promote growth, the incorporation of organic matter is essential (Ningsih et al., 2024). Organic matter serves as a vital nutrient source (Darlis et al., 2024) and is anticipated to enhance both plant growth and adaptability (Darlis et al., 2023).

Compost stands out as a promising organic material for this purpose. It represents an environmentally sustainable approach to maintaining ecological balance. Currently, much of the available waste remains

underutilized; however, with proper management, it can be transformed into valuable liquid fertilizer (Hamzah et al., 2020). Household waste, in particular, poses significant environmental challenges (Nadira et al., 2023). The application of organic materials, such as liquid fertilizers, not only supports plant growth but also contributes to the improvement of soil's physical properties (Azhari et al., 2022; Pebriandi et al., 2021).

The findings of the study conducted by Tendean et al. (2017) indicated that the administration of chicken manure compost can facilitate the growth of Lamtoro seedlings. The optimal dose composition was determined to be 80%. The findings of the study (Asmawati et al., 2015) indicated that the administration of chicken manure compost can enhance the growth of cocoa seedlings, with the optimal dose composition being 15%. The provision of compost to Meranti seedlings has been demonstrated to affect their growth (Pebriandi et al., 2023). It is anticipated that the incorporation of compost into soil previously subjected to gold mining will enhance soil quality, thereby facilitating the growth of robust plant life. The objective of this study is to ascertain the impact of compost administration and the optimal compost composition on the growth of red jabon seedlings in ex-gold mining planting media.

2. MATERIAL AND METHODS

This study was carried out at the Experimental Garden and Forestry Laboratory within the Faculty of Agriculture at the University of Riau. The research spanned a duration of two months, specifically from July to September 2023. The materials utilized in this investigation included *A. macrophyllus* seedlings, compost, water, and soil derived from former gold mining activities. The equipment employed comprised stationery, mobile phone cameras, laptops, tally sheets, 1 kg polybags, labels, buckets, scales, ovens, scissors, hoes, rulers, calipers, and SPSS software version 25.

A non-factorial completely randomized design (CRD) was implemented, featuring four distinct treatments with five replications, resulting in a total of 20 experimental units. Each unit contained five seedlings, culminating in a total of 100 seedlings. The application of compost fertilizer in this study was categorized as follows: D1 = Former gold mining land (without compost), D2 = 10% compost fertilizer + 90% former gold mining land, D3 = 30% compost fertilizer + 70% former gold mining land, and D4 = 50% compost fertilizer + 50% former gold mining land.

Preliminary treatment of planting media used is ex-gold mine soil after which the ex-gold mine soil is composited. Planting media that has been mixed incubated for 1 (one) week before weaning. Watering is done twice a day in the morning and evening. If there is rain, watering is not done.

The parameters measured to see the growth of red jabon seedlings with various doses of compost fertilizer are the percentage of plant life, increase in plant height and diameter, plant dry weight and root crown ratio.

a) Calculation of the percentage of seedling life is carried out at the end of the study. The percentage of life is the number of seedlings that are able to survive with the total number of seedlings planted and is expressed in percent (%).

b) Height measurements are carried out using a ruler with centimeters (cm) units. Observation of height growth is carried out by measuring the base of the stem to the growing point of the seedling shoot.

c) Observation of the increase in seedling diameter is carried out by measuring the neck of the seedling stem using a caliper in millimeters (mm). The increase in seedling diameter is produced from the diameter at the end of each measurement interval minus the initial diameter.

d) Plant dry weight measurements were carried out at the end of the study by taking 3 seedlings from the treatment. Each sample was cleaned and each sample was cut consisting of the crown and root parts and dried for 2 hours. Then each part was put into a different envelope and ovened at a temperature of 103 ± 2 ° C for 24 hours then weighed for dry weight, then ovened again at a temperature of 103 ± 2 ° C for 2 hours to obtain a constant dry weight.

The root crown ratio is a comparison of the dry weight of the crown and the dry weight of the roots. The root crown ratio measurement was carried out at the end of the study

The data obtained from the study were analyzed statistically using SPSS version 25. If the results of the analysis of variance were significantly different, it was continued with Duncan's multiple range test at the 5% level. The research flow diagram can be seen in Figure 1.

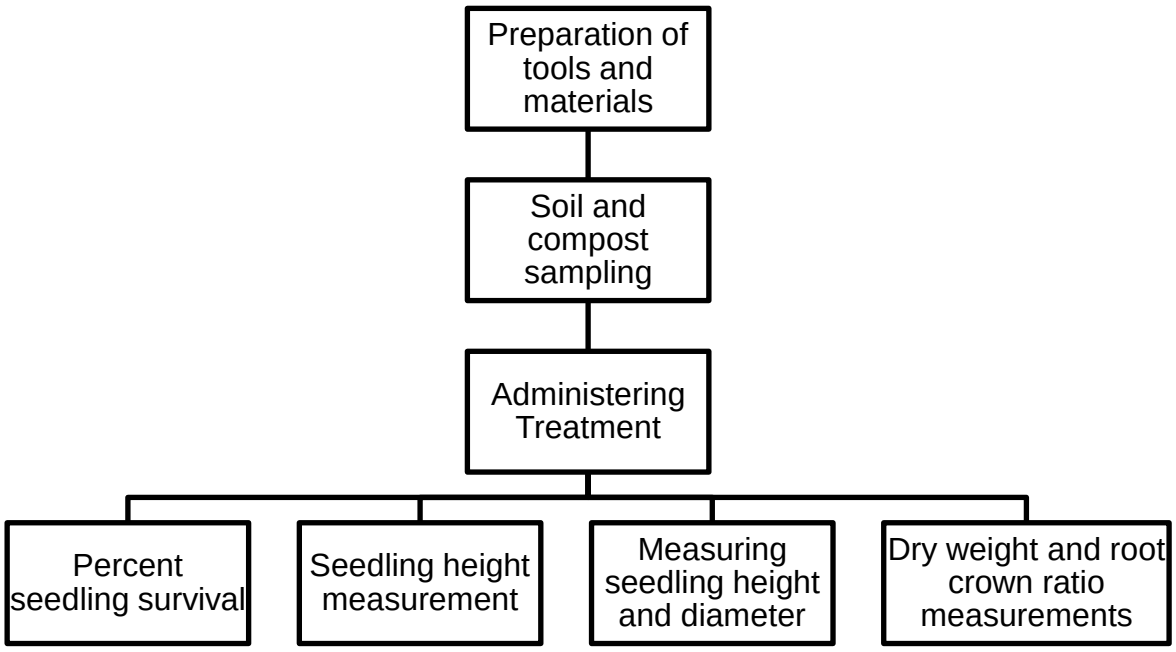

Figure 1. Research Flow Diagram

3. RESULT AND DISCUSSION

3.1 Percentage of seedling survival

The results of the observation of the percentage of life showed that the application of compost fertiliser had a significant effect on the percentage of life of red jabon seedlings. The results of the observation of the percentage of life are shown in Table 1.

Table 1. Percentage of living *Anthocephalus macrophyllus* seedlings aged four months

No.	Treatment	Survival rate (%)
1	D4	100±1.15[a]
2	D3	100±0.45[a]
3	D2	92±0.84[a]
4	D1	68±0.23[b]

Notes: Numbers followed by small letters in each row in the same column are significantly different according to the DNMRT test at the 5% level.

Table 1. The Average Number of Pods per Plant shows the results of observations on the number of pods for various treatments and LOF concentration levels per liter of water. This table includes two treatments (Control and 3.5 Tons/ha) and four LOF concentration variations (Control, 10 ml/l, 30 ml/l, and 50 ml/l), with the average number of pods per plant displayed for each combination of treatment and concentration.

The percentage of plant survival is an indicator to determine the success of planting. The percentage of red jabon seedling survival in this study showed that the D1 treatment of 68% was classified as moderate and the D2 to D4 treatments of 92% to 100% were classified as the best. This shows that *A. macrophyllus* plants grow and adapt well. According to (Bima et al., 2020) states that the percentage of survival is supported by the ability of plants to adapt to the environment and genes and environmental factors that affect the percentage of survival are sufficient water, availability of nutrients from the media and fertilizers and freedom from pests and diseases. Based on the research results, the planting media in the D3 treatment (former gold mining soil (without compost) and D4 (50% compost fertilizer + 50% former gold mining soil) were better compared to other planting media compositions. It is suspected that the right application of compost can improve the structure of the former gold mining soil used as a planting medium for red jabon seedlings with a very good 100% survival rate. The percentage of survival in the D1 treatment was the lowest, which was classified as moderate. This is in line with the opinion of (Ma`rief, 2013) in (Awaliah et al., 2019) stating that the percentage value of plant survival ranging from 91% -100% is classified as the best, 76% -90% is classified as good, 55% -75% is classified as moderate and the percentage of survival less than 55% is classified as bad.

Seedlings in treatment D1 (without compost/control) died in the 2nd week with characteristics of yellowing leaves, shriveling leaves, and falling off and wilting until the plant died. This is thought to be because the texture of the planting medium used is rough, does not form aggregates like soil, and has low water holding capacity. Planting media has a major impact on plant growth in terms of nutrient availability, water, weak media that affects oxygen availability, porosity, lack of NPK nutrients, water deficit due to low soil infiltration, soil compaction and sedimentation and high heavy metal content. (Wasis & Baskara, 2013). The condition of the former gold mining planting medium, the percentage of life in treatment D1 was 68% with characteristics of low nutrient content, thought to be one of the causes of its suboptimal growth. In agreement with (Sunardi et al., 2021) that the range of plant growth percentages that are considered successful and worthy of being maintained in rehabilitation activities is 51% -75%.

3.2 Height Increase (cm)

Plant height is a measure of plant growth that is easily seen directly. Plant height measurements were observed for 8 (eight) weeks of observation and measured once a week. The results of observations of height increase are shown in Table 2.

Table 2. Average height increase of four-month-old *Anthocephalus macrophyllus* seedlings

No.	Treatment	Height Increase (cm)
1	D4	16,56±1,15[a]
2	D3	14,04±0,45[b]
3	D2	8,25±0,84[c]
4	D1	2,69±0,23[d]

Notes: Numbers followed by small letters in each row in the same column are significantly different according to the DNMRT test at the 5% level.

Table 2 shows that the level of seedling height increase was statistically significantly different between each treatment. Treatment D4 (50% compost + 50% ex-gold mining soil) was the best treatment for seedling height increase compared to other treatments. Height growth in seedling treatment D4 was

16.56 cm. This shows that providing sufficient compost in the ex-gold mining planting medium can increase soil fertility and encourage healthy root growth. According to (Safuf et al., 2015) that the N element is useful for increasing the growth of shoots, leaves and stems of plants along with increasing fertilizer doses, so that plant height will also increase. Plants fertilized with compost will generally have better quality compared to plants that are not fertilized with compost. The role of organic matter can increase plant growth directly through changes in soil properties and characteristics. The average height growth of *A. macrophyllus* seedlings during the 8-week observation had varying values. The height growth of *A. macrophyllus* each week can be seen in Figure 2.

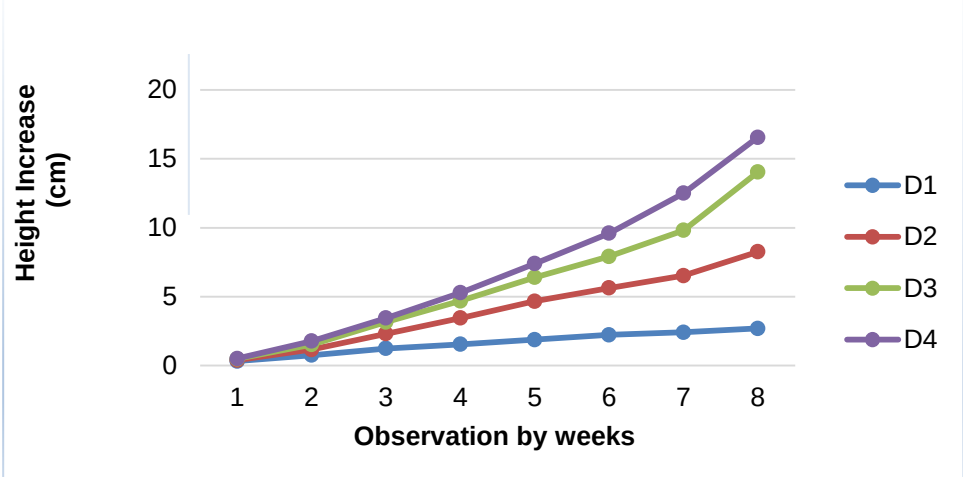

Figure 2. Graph of height growth of four month old *Anthocephalus macrophyllus* seedlings

Based on the graph above, it shows that the response of composting to the growth of red jabon seedlings increased every week, but in the 1st to 2nd week in Figure 2, slow growth was suspected to be caused by seedlings that had experienced a little stress after shipping. The treatment without compost/control did not have a large height growth. This is thought to be due to the availability of nutrients that are insufficient in the soil so that plants cannot grow optimally. The availability of sufficient nutrients in the soil can increase plant height by providing N, P, and K elements simultaneously which play a role in plant growth (Haryadi et al., 2015). The average increase in the height of red jabon seedlings ranged from 2.69 cm - 16.56 cm. The average increase in the height of red jabon seedlings for each treatment was 2.69 cm, 8.25 cm, 14.04 cm and 16.56 cm, respectively. The best average increase in the height of red jabon seedlings was in the D4 treatment (50% compost + 50% ex-gold mining soil), which was 16.56 cm. The increase in the height of *A. macrophyllus* seedlings was caused by increasing the dose of compost fertilizer to the optimum limit. It can be seen in Figure 2 that the dose of compost fertilizer in the D4 treatment showed a better increase in height compared to other treatments in succession. According to (Starsy et al., 2020), the composition of compost fertilizer with a large dose in the planting medium will provide a large space for the roots to grow and develop properly, so that the roots can play a role in absorbing water and nutrients optimally, thus increasing the growth of seedling height..

3.3 Diameter Increase

Measurement of plant diameter was observed during 8 (eight) weeks of observation and measured once a week. The results of diameter increase observations are shown in Table 3.

Table 3 shows the growth rate of seedling diameter showed a statistically

significant difference between each treatment. Treatment D4 (50% compost + 50% ex-gold mining soil) was the best treatment for seedling diameter growth compared to other treatments. Treatment D4 increased seedling diameter by 2.21 mm. The provision of compost fertilizer is thought to improve soil structure and provide sufficient nutrients in the ex-gold mining planting medium. Compost helps nutrient-poor soil to provide nutrients needed by plants, so that nutrients in media with compost application are higher than media that are not treated, so that the absorption of nutrients by the roots is large (Herantoro et al., 2015). The average growth of *A. macrophyllus* seedling diameter during the 8-week observation had varying values. The growth of *A. macrophyllus* height each week can be seen in Figure 3.

Table 3. Mean diameter increase of *Anthocephalus macrophyllus* seedlings at four months of age

No	Treatment	Diameter Increase (mm)
1	D4	2,21±0,12[a]
2	D3	1,77±0,09[b]
3	D2	1,18±0,09[c]
4	D1	0,42±0,06[d]

Notes: Numbers followed by small letters in each row in the same column are significantly different according to the DNMRT test at the 5% level.

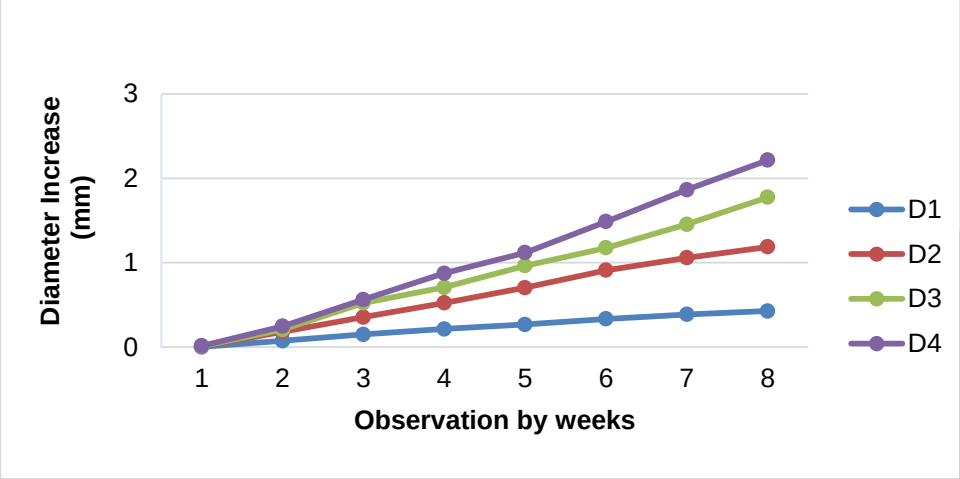

Figure 3. Diameter growth graph of four-month-old *Anthocephalus macrophyllus* seedlings

Figure 3 shows that the growth of the diameter of *A. macrophyllus* seedlings increased every week, but in the treatment without compost/control, the growth of the plant diameter was quite slow. Treatment D1 (without compost/control) was the lowest treatment at 0.42 mm. The planting medium used is thought to be unable to provide sufficient nutrients for *A. macrophyllus* seedlings. According to (Samsudin et al., 2017) the nutrient K plays a role in increasing the diameter of the plant as a connecting tissue between roots and leaves in the transpiration process. Fertilizer affects plant growth and physiological processes that occur in the plant body. The provision of compost to the planting medium shows that the stem diameter of the seedlings is better than without the use of compost. This is in accordance with (Puspadewi et al., 2016) that the provision of compost can provide good stem diameter development which is influenced by the availability of P and K nutrients. The P element plays a role in enlarging cell tissue and stimulating plant cell division and the K

element plays a role in strengthening the stem of *A. macrophyllus* seedlings.

3.4 Dry Weight

Table 4 shows that the provision of compost fertilizer with various doses has a significant effect on the dry weight of *A. macrophyllus* plants. The results of observations on dry weight are shown in Table 4.

Table 4. Dry weight of four-month-old *Anthocephalus macrophyllus* seedlings

No	Treatment	Dry Weight (g)
1	D4	40,73±0,51[a]
2	D3	23,02±0,39[b]
3	D2	19,30±0,18[c]
4	D1	12,50±0,13[d]

Notes: Numbers followed by small letters in each row in the same column are significantly different according to the DNMRT test at the 5% level.

Table 4 shows the dry weight of seedlings statistically showing a statistically significant difference between each treatment. The results of the study ranged from 12.50 g-40.73 g. The best treatment was shown in treatment D4 (50% compost + 50% ex-gold mining soil). The 50% compost fertilizer used is thought to be optimal so that it provides the best dry weight of the plant. According to (Bima et al., 2020) that high plant growth in roots, leaves and stems increases dry weight. According to (Andry & Wawan, 2017) that increasing the dose of treatment is accompanied by the addition of nutrients such as N, P and K which are needed by plants to increase vegetative growth and development so that it affects the dry weight of the plant.

3.5 Root Crown Ratio

Table 5 shows that the provision of compost fertilizer with various doses has a significant effect on the ratio of the root crown of *A. macrophyllus* plants. The results of the analysis of variance can be seen in table 5.

Table 5. Root crown ratio of four month old *Anthocephalus macrophyllus*

No	Treatment	Root Crown Ratio
1	D4	4,84±0,04[a]
2	D3	4,65[ab]±0,08
3	D2	4,53[b]±0,06
4	D1	2,83[c]±0,05

Notes: Numbers followed by small letters in each row in the same column are significantly different according to the DNMRT test at the 5% level.

Table 5 shows the highest root crown ratio, which is found in treatment D4 (50% compost + 50% ex-gold mining soil). The provision of 50% compost fertilizer is thought to provide sufficient nutrition for *A. macrophyllus* seedlings, so that it can increase the growth of shoots and roots in *A. macrophyllus* seedlings. According to (Andry & Wawan, 2017) that the increase in biological activity is caused by the stimulation of organic compounds produced by microorganisms in the compost fertilizer which can ultimately interact with the physical and chemical properties of the soil so as to increase root and crown growth. The lowest growth in treatment D1 (without compost fertilizer application). It is suspected that the nutrients are minimally absorbed by the plants because the planting medium used is soil with nutrients. In agreement with (Prasetyo et al., 2022) that soil with low nutrient content in treatment D1 (without compost application) is thought to not be able to support plant growth properly because the lack of nutrients can inhibit plant growth and development and affect plant productivity through less than optimal root growth. According to (Siregar et al., 2015) the ratio of crowns and roots indicates the characteristics of plant growth in its ability

to absorb nutrients, depending on the condition of the planting media used. The ratio of crowns and roots indicates the quality of quality seedlings. The availability of quality seedlings plays an important role in reforestation and forest rehabilitation efforts to reduce deforestation (Mardhiansyah et al., 2024). The comparison of each *A. macrophyllus* plant treatment can be seen in Figure 4.

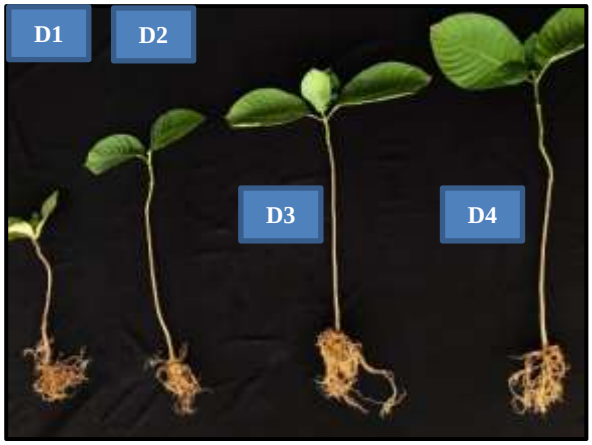

Figure 4. Comparison of each *A. macrophyllus* plant treatment

4. CONCLUSION

The provision of compost fertilizer in the planting media of former gold mines has a significant impact on the growth of *Anthocephalus macrophyllus* seedlings. The planting media composition of the D4 treatment (50% compost fertilizer + 50% former gold mine soil) was identified as the optimal treatment for the growth of red jabon seedlings (*Anthocephalus macrophyllus*). This treatment resulted in a 100% survival rate, an increase in height of 16.56 cm, an increase in diameter of 2.21 mm, a dry plant weight of 40.73 g, and a root crown ratio of 4.84.

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