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Thinning on the Growth of Red Jabon Trees *(Anthocephallus Macrophyllus)* in the Industrial Plantation Forest Area

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Abstract: This study aims to observe the growth of red jabon (Anthocephalus macrophyllus) plants at various thinning intensities. Red jabon is a native Indonesian plant species that have the potential to develop forest plantations and reforestation ex-mining land. The research measured stem diameter and plant height at each thinning intensity. The study results are expected to provide information on the potential of red jabon cultivation and become a recommendation for red jabon wood farmers to improve the quality of company and farmer income. This research is expected to contribute to the development of thinning activities in improving the quality of red jabon tree stands, as well as providing a better understanding of this plant's cultivation and potential benefits. The thinning intensity applied 6 months the growth of Red Jabon trees in the Industrial Plantation Forest Area of PT. Global Citra Lestari showed a significant effect on stem diameter increment, 40% intensity treatment has a promising potential to enhance both stem diameter and height growth.

Keywords: *Anthocephallus Macrophyllus*; Plantation Forest; Red Jabon Trees; Thinning

Introduction

Red Jabon *(Anthocephalus macrophyllus)* is a native Indonesian plant species with potential for development in afforestation programs and various other purposes such as land reclamation, reforestation, and shade trees (Mansur & Tuheteru, 2010; Sharma & Sinha, 2022). The community has successfully cultivated Jabon trees in rehabilitation areas, community forests, and Industrial Plantation Forests (HTI). For instance, the Research and Development Agency for HTI KTG (Katingan Timber Group) Gorontalo (2017) and PT. Gorontalo Citra Lestari has a land area of around 46,170 ha with a total boundary length of 294.24 km for the cultivation of Red Jabon trees. The total land area planted with Red Jabon trees from March 2013 to October 2017 was 7315.31 ha. Its production continues to increase due to its relatively short planting cycle of 5-8 years. Hence, the quality of individual wood in Red Jabon cultivation areas must be improved.

One method that can be utilized to manage the quality issues is thinning, which improves the quality of Red Jabon trees by reducing the number of trees in a specific area to alleviate competition among individuals (Yuniarti et al., 2023). Its objective is to enhance the Red Jabon tree stands' quality depending on the land condition and tree age, thinning can be carried out using various criteria (Mulyana et al., 2012). This research aimed to observe the growth of Red Jabon trees, including stem diameter and height, at different thinning intensities. This study's findings are expected to provide insight related to Red Jabon's cultivation potential and serve as recommendations for the farmers in maintaining and improving the quality income for both the company and the farmers.

This research revolves around enhancing the quality of Red Jabon tree stands through a technique called thinning (Sandalayuk et al., 2019; Tuheteru et al., 2019). Thinning involves selectively removing trees to reduce competition and improve stand quality (Sudrajat

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et al., 2015). The study stands out due to its exclusive focus on Red Jabon trees, tailoring insights to their unique growth traits. While thinning is established, its application to Red Jabon might be relatively unexplored.

The study likely examines various thinning intensities' effects on Red Jabon growth, considering the local environment's factors like soil, climate, and forestry practices (Krisnawati et al., 2019). By offering practical advice on optimizing quality and yield through growth response analysis under different thinning levels, the research becomes an actionable resource for individuals engaged in Red Jabon cultivation. Overall, it contributes to understanding Red Jabon's potential for sustainable land use, particularly in afforestation and reforestation efforts.

Method

Data Collection Method

This study applied the RCBD (Randomized Complete Block Design) method (A'ida et al., 2019; Chaerani et al., 2019; Sudrajat et al., 2019). The main plot size was 20 m x 20 m, with the removal of 3 worst trees every 10 rows for thinning at 30% and 40% intensity. Thinning at 50% intensity followed a checkerboard pattern. The thinning activities involved the following stages: etermining the thinning plot locations for 4-year-old red Jabon trees at the PT GCL site. Measuring the height and diameter for each thinning plot; recording the total height and branch-free height of each trimmed tree; and trimming the trees to assortments with a length of 2.7 meters. Recording the assortment diameter with and without bark.

The parameters observed in this study are as follows: height and diameter at each thinning frequency; least significant difference among each thinning frequency; significance of each treatment on the growth of Jabon trees (Junaedi et al., 2021).

Data Analysis Method

The analysis method used to test the hypotheses and analyze the variables includes:

Qualitative Method

A qualitative method is a research approach used to describe, analyze, and interpret field data descriptively (Castleberry & Nolen, 2018; Lindgren et al., 2020). Its primary objective is to obtain a comprehensive understanding (Hendren et al., 2023). Compared to quantitative, this method does not focus on hypothesis testing but emphasizes a deep understanding of the data's concepts, perspectives, and meanings.

Data collection in the qualitative method consisted of participatory observation, interviews, document analysis, or content analysis (Moser & Korstjens, 2018; Muzari et al., 2022). The collected data is analyzed using an inductive approach, in which the data is identified and described descriptively (Pearse, 2019). The qualitative analysis includes organizing, coding, and categorizing data. Data interpretation is conducted by linking the findings to relevant theories or frameworks.

The qualitative method is appropriate for research to explore, understand, and examine social contexts (Stahl & King, 2020). It allows the researcher to obtain a broader perspective, comprehend the complexity of the context, and explore the meanings of the data. However, the results of qualitative research cannot be broadly generalized due to its subjective and interpretive approach, but they provide a profound understanding of the studied phenomenon.

Quantitative Method

The employed quantitative method in this study is the multiple linear regression analysis models to analyze the influence of independent variables on the dependent variable. According to Mbatchou et al. (2021), multiple linear regression analysis is a quantitative approach used to examine the relationship between one dependent variable and two or more independent variables. The independent variables are employed as predictors in this approach to determine their contribution in explaining the variation in the dependent variable.

Multiple linear regression techniques were employed in this study to statistically analyze the data from the research sample as well as to determine the influence of independent variables on the dependent variable (McKelvey & Zavoina, 1975). This study enables the researcher to formulate predictions based on the model created and provide information about the contribution of the said variable.

The utilization of the quantitative method, such as multiple linear regression analysis, offers a potent approach for testing hypotheses and statistically assessing correlations between variables (Abu-Bader & Jones, 2021). This method enhances understanding of the relationship between the independent and dependent variables. The formulation of multiple linear regression analysis is as follows equation 1.

$$Y = a + b_1 X_1 \quad (1)$$

Details:
Y: Red Jabon Plant (Anthocephalus macrophyllus Roxb.)
X_1: Thinning Technique
a : Constant value
b : Regression coefficient

Model Fit Test (F Test (Fisher)

The F test is used to determine if the independent variables (X) simultaneously influence the dependent variable (Y). A comparison of the Fcount and Ftable values is used to conduct the test. If the Fcount □ Ftable) indicates that the independent variables have a significant simultaneous effect on the dependent variable, using a 95% degree of freedom or a significance level of α = 5% (0.05).

Result and Discussion

The initial growth data for thinning in the Red Jabon species at the PT GCL location indicates the average height and diameter values, as listed in the table 1.

Table 1. Increase in diameter after 6 months of thinning

Treatment	Height (m)	Diameter (cm)
P0 (control)	14.42	13.32
P1 (thinning 30%)	13.91	14.15
P2 (thinning 40%)	14.18	13.56
P3 (thinning 50%)	14.08	14.56

The measurement from Table 1 was conducted twice, namely initially and 6 months after thinning. The purpose was to examine trees' diameter and height changes based on the applied thinning method.

The Influence of Thinning on the Diameter Growth of Red Jabon

The following is a recapitulation diagram of the average diameter of the 4-year-old red Jabon at PT GCL 6 months after thinning.

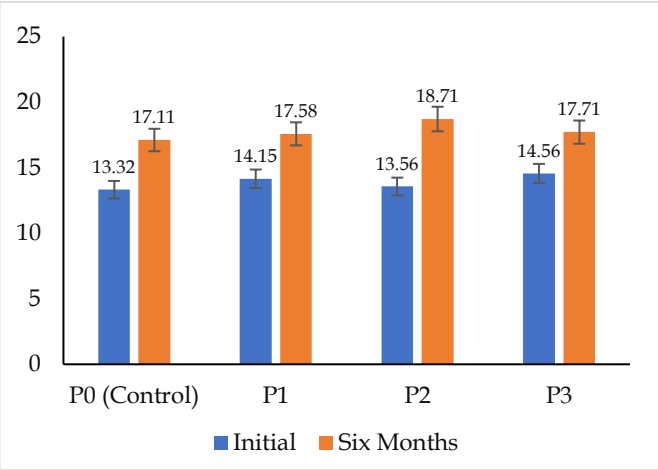

Figure 1. Graph of the average increase in the Red Jabon's diameter after six months

Based on Figure 1, depicts the red Jabon trees' average growth in terms of increase in stem diameter, including treatment P0 (Control): 3.79 cm, P1 (Thinning 30%): 3.43 cm, P2 (Thinning 40%): 5.15 cm, and P3 (Thinning 50%): 3.15 cm. The diameter increase demonstrates the most significant effect addition in stem diameter with a thinning intensity of 40% compared to 50%, and the lowest was in the control treatment or without thinning. This indicates that trees require appropriate thinning practices to optimize increase, considering that thinning aims to provide adequate sunlight and nutrients.

At 10 years, the Mean Annual Increment (MAI) and Current Annual Increment (CAI) of volume were recorded as 30.52 m^3/ha/year and 30.69 m^3/ha/year, respectively. This can be observed when the increment curves intersect at the age of 10 years. The increase will decrease after te10 years, from 30.52 m^3/ha/year to 28.81 m^3/ha/year, once it has reached its maximum growth. This indicates that Red Jabon can be harvested at the age of 10 years, though they can be left to grow until the age of 12 years (Sandalayuk et al., 2019; Widyani et al., 2023).

According to Girsang (2022) research, the rate of photosynthesis, which is influenced by the amount of sunlight intensity received and respiration, is directly related to the plant diameter's increase. Insufficient light intensity leads to suboptimal photosynthesis, while excessive light intensity affects stomatal activity and reduces transpiration, resulting in inhibited plant growth (Martias et al., 2021; Sudrajat et al., 2022). The different sunlight intensities result in varying increase parameters in plants. Meanwhile, that light indirectly influences plant growth and development, as the carbohydrates produced through photosynthesis are used to form plant organs (Rao et al., 2023).

Additionally, a significant factor in plant growth is plant density. Excessive plant density leads to nutrient competition, while low plant density reduces nutrient availability in the soil. The Red Jabon trees are considered light-demanding and require full exposure to sunlight throughout their life cycle, similar to other pioneer species. These plants are also capable of adapting to unfavorable growing conditions. Sunlight has an impact on the process of photosynthesis, which produces energy for growth. Red Jabon trees planted in shaded areas tend to have tall but slender tree forms (Harmoko et al., 2020).

According to PROSEA (Plant Resources of South-East Asia), Red Jabon in Brunei grow at a rate of 7 cm/year in diameter from 0-6 or 8 years. Afterward, the growth rate decreases to 3 cm/year until the trees reach 20 years of age. In contrast, this study shows that the 4-year-old Red Jabon tree showed an increase in diameter,

specifically a 5.15 cm increment after thinning with a 40% intensity. This demonstrates that thinning has a significant impact, which is supported by the F-test conducted on the measurements for 6 months after thinning. This study demonstrated a significant effect of thinning on the diameter growth of Red Jabon trees 6 months after thinning. This can be seen in the results of the variance analysis as seen Table 2.

Table 2. Analysis of variance in the 4-year-old red Jabon thinning experiment at PT GCL for stem diameter

Variance	Freedom Degree	Sum Square	Computed F	Tabular F	
				5%	1%
Replication	2	1.46	5.73	4.75	9.75
Treatment	3	22.41			
Error	6	7.82			
Total	11	31.70			

In Table 2, the $F_{count} > F_{table}$, indicates that the thinning treatment significantly affects the 1% significance level. In the variance analysis calculation, it was found that the thinning intensity does not have a significant impact at a 5% significance level, which due to the F test, the calculated F value is smaller than the F table at the 5% significance level.

The Influence of Thinning on the Height Growth of Red Jabon.

The average height of a 4-year-old red Jabon at PT GCL 6 months after thinning is shown in the recapitulation as seen in Figure 2.

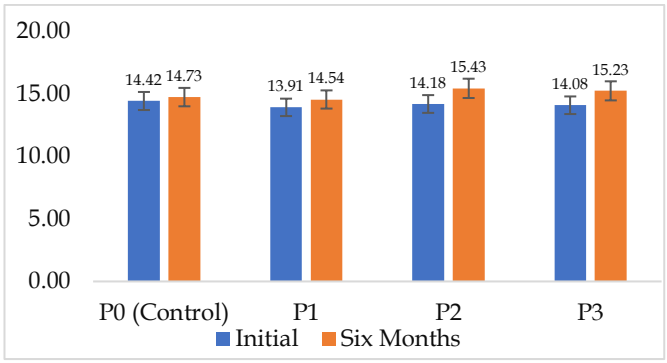

Figure 2. Graph of the average increase in Red Jabon's height after six months.

Based on Figure 3, the average growth of red Jabon trees on the parameter of plant height increase is as follows: treatment P0 (Control): 0.31 m, P1 (Thinning 30%): 0.63 m, P2 (Thinning 40%): 1.25 m and, P3 (Thinning 50%): 1.15 m. Data in Figure 3 indicates that the 50% thinning intensity is expected to possess high potential for the height growth of the red Jabon at PT GCL. However, the plant was most influenced by the thinning intensity of 40%. As explained in this study, thinning affects increasing stem diameter. Light intensity increases with lower plant density, while excessively low plant density reduces soil nutrient availability due to excessive sunlight and increased plant death (Poorter et al., 2019). This would hinder plant photosynthesis, resulting in suboptimal height growth due to competition for nutrients and sunlight absorption.

High plant density can hinder plant growth, especially in terms of height, due to competition for nutrients, space, and pest infestation. In this study, the influence of thinning intensity on plant height is caused by pests and diseases, leading to bent stems and stunted growth in some Jabon trees (Tuheteru, 2003).

In this study, thinning has not shown a significant effect, as supported the PROSEA (Plant Resources of South-East Asia), the Jabon trees in Brunei grew in height at a rate of 3 meters per year between the ages of 0 and 6 and 8 years. Subsequently, the growth rate decreased to 2 centimeters per year until the plant was 20 years old. In contrast, this study found that the highest growth value for Jabon trees occurred with a 40% thinning intensity, resulting in a height increase of 1.25 m for 6 months or approximately 3 m/year.

It was discovered in this study that the increase in the height of the Red Jabon 6 months after thinning had not demonstrated a significant effect after the F test was conducted in the thinning study at 6 months after thinning. This can be seen in the analysis results of variance in Table 2.

Table 2. Variance analysis for plant height in the 4-year-old red Jabon thinning experiment at PT BCL.

Variance	Freedom Degree	Sum Square	Mean Square	Calculate	Tabular F	
				F	5%	1%
Replication	2	2.94	1.47	0.65	4.75	9.72
Treatment	3	4.08	1.36			
Error	6	12.62	2.10			
Total	11	19.64				

$F_{count} < F_{table}$, the thinning intensity does not significantly affect the tree height at 6 months after thinning. The result of variance analysis reveals that thinning intensity does not significantly affect the height of Red Jabon trees 6 months after thinning. This is due to the fact that in the F test, the F count is smaller than the F table at the 5% significance level.

Conclusion

Based on the research conducted, it can be concluded the thinning intensity applied 6 months after thinning on the growth of Red Jabon trees in the Industrial Plantation Forest Area of PT. Global Citra Lestari showed a significant effect on stem diameter increment, while its impact on the increase in height was less significant. This is due to the growth parameters of Jabon trees influencing the competition levels and environmental factors. Based on this research, the 40% intensity treatment has a promising potential to enhance both stem diameter and height growth of the Red Jabon trees.

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Author Contributions
Daud conceptualized the research idea, methodological design, data analysis, funding acquisition, investigative process, writing-original draft, management and coordination responsibility for the research activity planning and execution. Masrukhin, Murni Djabar, Alexander Ruruh, and Ernikawati guided, wrote-reviewed and edited, supervised and validated the instruments used in the research.

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Conflicts of Interest
The author declares no conflict of interest. The data published in this article, both in data collection, analysis, data interpretation, in writing manuscripts or in the decision to publish research results, there is no conflict of interest with any party.

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