The Effect of Shading and Non-Shading on the Growth of *Shorea parvifolia* Seedlings in an Ex Situ Conservation Area

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Abstract: This study aimed to analyze the effect of shaded and unshaded conditions on the growth of three-year-old *Shorea parvifolia* seedlings in the ex-situ conservation area of Politeknik Pertanian Negeri Samarinda. The research was conducted over a period of one month using 60 seedlings, which were divided into two treatment groups: 30 seedlings under shade and 30 seedlings without shade. The observed variables included total height (cm) and stem diameter at 20 cm above ground level (cm). Data were analyzed using a two-sample t-test assuming equal variances. The results showed that the mean height and diameter of unshaded seedlings were significantly higher than those of shaded seedlings. The mean diameter in the unshaded treatment was 2.91 cm, compared to 1.52 cm under shade. The mean height of unshaded seedlings was 244.6 cm, while that of shaded seedlings was 149.37 cm. The t-test results indicated that the calculated t-values for diameter (10.40) and height (8.63) were greater than the critical t-value (2.00) at a 5% significance level, with p-values < 0.05. Therefore, it can be concluded that unshaded conditions are more favorable for the growth of three-year-old *Shorea parvifolia* seedlings.

Keywords: *Shorea Parvifolia, Shading, Growth, Ex-Situ Conservation.*

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I. INTRODUCTION

Tropical rainforests in Indonesia represent one of the ecosystems with the highest biodiversity levels in the world. One of the dominant plant groups in Southeast Asian tropical forests is the Dipterocarpaceae, which holds significant ecological and economic value. Dipterocarpaceae play a major role in maintaining forest ecosystem balance, including regulating the hydrological cycle, providing oxygen, and serving as habitat for diverse flora and fauna. However, the high rate of deforestation and forest degradation caused by land conversion, illegal logging, and forest fires has threatened the survival of many Dipterocarpaceae species, including *Shorea parvifolia*. This species, locally known as “meranti sarang punai,” belongs to the red meranti group, has high timber value, and is widely distributed in Sumatra, Kalimantan, and Peninsular Malaysia (Ashton, 2004).

Conservation efforts have become urgent to prevent the extinction of this species. Conservation can be carried out both in situ (within its natural habitat) and ex situ (outside its natural habitat). Ex-situ conservation, such as the establishment of collection gardens or arboreta, serves as an important alternative when in-situ conditions are no longer feasible or for purposes of research and future population recovery (Frankel et al., 1995). However, the success of ex-situ conservation strongly depends on our understanding of the ecological requirements of the species concerned, particularly during the early growth phase, which is highly vulnerable.

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One of the most critical ecological factors determining the growth success of tree seedlings in tropical environments is light intensity (Whitmore, 1998). Tropical forests are characterized by dense canopies, which often force seedlings to grow under heavy shade. Shading influences various physiological processes such as photosynthesis, respiration, and biomass allocation (Bazzaz & Pickett, 1980). In contrast, unshaded conditions, such as in open areas or logging gaps, provide much higher light intensity.

The growth response of tree seedlings to light availability is one of the key ecological aspects determining regeneration success and species survival in tropical forests. Within the Dipterocarpaceae family, responses to light vary: some species are shade-tolerant, while others are gap-demanding and grow rapidly under high-light conditions (Aiba & Nakashizuka, 2005). Studies on various *Shorea* species indicate that *S. parvifolia* tends to grow well under partial shading and is often described as relatively shade-tolerant during the seedling stage. However, responses to shading may vary depending on seedling age, soil conditions, water availability, and management practices (Paine et al., 2012).

At the age of three years, meranti seedlings enter a crucial developmental phase: their size and health at this stage serve as indicators of early adaptation to microhabitat conditions and predictors of survival and growth into later stages. Quantitative data on height, root-collar diameter, crown development, biomass allocation, and survival rates at the age of three years are highly valuable for assessing the effectiveness of shading treatments and for developing technical recommendations in ex-situ conservation (Krisnawati et al., 2011).

Moreover, understanding how shading influences physiological parameters (e.g., photosynthesis, leaf morphology) and ecological factors (e.g., competition with ground vegetation, pest attacks) in meranti seedlings can help design nursery and planting protocols that enhance restoration success. Experimental studies on dipterocarp seedlings have shown that shading often reduces absolute growth rates but may increase survival under certain conditions, indicating a trade-off between rapid growth under high light and survival under shade (Paine et al., 2012).

Based on these considerations, systematic and well-documented research on the growth of three-year-old *Shorea parvifolia* seedlings under shaded and unshaded conditions in the ex-situ conservation area of Politeknik Pertanian Negeri Samarinda is highly needed. The results of this study are expected to provide empirical evidence to: (1) assess the effects of shading on growth and survival of meranti seedlings; (2) develop technical recommendations for nursery practices and ex-situ management; and (3) contribute to science-based conservation and forest rehabilitation efforts.

II. METHODS

➢ *Time and Location of Study*

The study was conducted over a period of two months, covering both preparation and data collection. The research took place in the ex-situ conservation area of State Agricultural Polytechnic of Samarinda East Kalimantan.

➢ *Materials and Tools*

- Materials: Sixty three-year-old *Shorea parvifolia* (meranti) seedlings, divided into two groups:

✓ Group A (Unshaded): 30 seedlings growing in an open area.
✓ Group B (Shaded): 30 seedlings growing under shaded conditions.

- Tools: Measuring tape, microcaliper, labels or markers, notebook, camera, and stationery.

➢ *Research Method*

This study employed a comparative method with a quantitative approach. Growth data of seedlings (diameter and height) from both groups (shaded and unshaded) were measured and compared to test for significant differences using the t-test.

➢ *Research Procedure*

- Preparation of equipment and labeling of seedlings.
- Selection of data using a purposive sampling method for shaded and unshaded seedlings.
- Measurement of growth parameters:

✓ Stem diameter was measured at 20 cm above ground level.
✓ Total height was measured from ground level to the apical shoot.

➢ *Data Analysis*

The collected data were analyzed to determine the effect of shading on seedling growth using a t-test assuming equal variances at a 5% significance level.

- Null Hypothesis (H_0): There is no significant difference in mean growth (height and diameter) between shaded and unshaded *Shorea parvifolia* seedlings.
- Alternative Hypothesis (H_1): There is a significant difference in mean growth (height and diameter) between shaded and unshaded *Shorea parvifolia* seedlings.

The t-test was applied to compare the means of the two groups to determine whether the differences were statistically significant.

The formula for the t-test (Equal Variances Assumed) is as follows:

- *Calculation of the T-Value:*

$$T_{hitung} = \frac{\overline{X}_1 - \overline{X}_2}{Se_{pooled}}$$

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- *Calculation of Pooled Standard Deviation (S_{pooled}) :*

$$S_{Pooled} = \sqrt{\frac{\sum X_1^2 - \frac{(\sum X_1)^2}{n_1} + \sum X_2^2 - \frac{(\sum X_2)^2}{n_2}}{n_1 + n_2 - 2}}$$

- *Calculation of the Standard Error of the Pooled Variance ((Se_{pooled})):*

$$Se_{pooled} = S_{pooled}\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

Where:

- ✓ (t_{cal}) = calculated t-value
- ✓ $\bar{x}_1$ = mean of Group A
- ✓ $\bar{x}_2$ = mean of Group B
- ✓ (n_1) = sample size of Group A
- ✓ (n_2) = sample size of Group B
- ✓ (S_{pooled}) = pooled standard deviation

➢ *Decision Criteria:*

- Compare the calculated t-value with the critical t-value from the t-distribution table at a given significance level (α) and degrees of freedom (df).

- ✓ aIf (t_{calculated} > t_{table}), then there is a significant difference between the two groups, H_0 is rejected and H_1 is accepted.
- ✓ If (t_{calculated} \leq t_{table}), then there is no significant difference, H_0 is accepted and H_1 is rejected.

- Determine the p-value from the t-test results.

- ✓ If ($p < 0.05$), the mean difference in growth between the two groups is considered statistically significant, indicating that shading has a real effect on the growth of *Shorea parvifolia* seedlings.
- ✓ Conversely, if ($p > 0.05$), the difference is not significant, indicating that shading does not have a substantial effect.

III. RESULTS AND DISCUSSION

➢ *Research Results*

Based on the data obtained, the following summarizes the results of the t-test for the diameter and height parameters of *Shorea parvifolia* seedlings. It should be noted that Group A refers to unshaded seedlings, while Group B refers to shaded seedlings.

- *T-Test Results for Diameter*

Table 1 T-Test Results for Diameter

Treatment	N	Mean	Variance	S-Pooled	t-stat	t-crit	P
Non-Shading (A)	30	2,9087	0,2757	0,2682	10,3957	2,0017	3,61243E-15
Shading (B)	30	1,5187	0,2607				

The calculated t-value (10.396) was much greater than the critical t-value (2.002). The p-value (3.61×10^{-15}) was far below the significance level of 0.05. This indicates a highly significant difference in mean diameter between unshaded and shaded treatments. The mean diameter increment in the unshaded group was significantly higher than in the shaded group.

- *T-Test Results for Height*

Table 2 T-Test Results for Height

Treatment	N	Mean	Variance	V-Pooled	t-stat	t-crit	P
Non-Shading (A)	30	244,60	1301,83	1828,5201	8,6255	2,0017	2,76518E-12
Shading (B)	30	149,37	2355,21				

The calculated t-value (8.626) was greater than the critical t-value (2.002). The p-value (2.77×10^{-12}) was far below 0.05. This result indicates a highly significant difference in mean height between unshaded and shaded treatments. The mean height of the unshaded group was significantly higher than that of the shaded group.

➢ *Discussion*

The results of this study indicate that unshaded conditions promoted greater diameter and height growth of *Shorea parvifolia* seedlings compared to shaded conditions. The differences were statistically significant, with p-values well below 0.05 for both growth parameters.

Shading tended to suppress height and diameter growth due to light limitation, which reduced the plant's capacity to perform photosynthesis optimally. According to Kuswandi & Indrawan (2016), several *Shorea* species exhibit faster growth under open conditions, although such conditions may also increase the risk of environmental stress.

Physiologically, this difference can be explained by the role of light in supporting photosynthesis. Seedlings growing in unshaded environments received higher light intensity, which increased photosynthetic rates and resulted in greater production of assimilates that could be allocated to stem and leaf growth (Taiz & Zeiger, 2010). This condition accelerated biomass accumulation, reflected in increased stem diameter and height (Larcher, 2003).

Conversely, under shaded conditions, light availability was limited, which reduced photosynthetic efficiency and consequently lowered vegetative growth rates (Poorter et al., 2006). As a tropical forest tree, meranti seedlings are known to be shade-tolerant at the early seedling stage; however, during the sapling stage they tend to require higher light intensity to accelerate growth (Appanah & Turnbull, 1998). Therefore, the results of this study are consistent with ecophysiological theory, which states that semi-tolerant to light-demanding species exhibit better growth performance under full-light conditions.

The practical implication of these findings is the importance of shade management in nursery and forest rehabilitation practices. For meranti, gradual shade reduction or planting in open areas may accelerate height and diameter growth, enabling seedlings to reach plantable size more quickly. However, it is also necessary to consider potential risks of excessive radiation, high temperature, or drought stress under unshaded conditions; hence, proper microclimate management remains essential.

IV. CONCLUSION

Based on the statistical analysis using the t-test, it can be concluded that the unshaded treatment had a highly significant and positive effect on the growth of three-year-old *Shorea parvifolia* seedlings. Seedlings grown in open areas (without shade) exhibited considerably higher average increases in both diameter and height compared to those grown under shade.

RECOMMENDATIONS

Based on the above conclusion, several recommendations can be proposed for future conservation and management of *Shorea parvifolia*:

- *For Ex-Situ Conservation:*

  Three-year-old *Shorea parvifolia* seedlings can be planted in open areas with full sunlight exposure to stimulate faster growth. This approach can serve as an effective strategy for land rehabilitation or reforestation programs.

- *Further Research:*

  It is recommended to conduct long-term studies to observe the growth trends of *Shorea parvifolia* seedlings under both treatments. Additionally, future research should include the measurement of other environmental variables, such as specific light intensity (using a lux meter), temperature, humidity, and soil nutrient content, in order to obtain a more comprehensive understanding of the factors influencing growth.

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