

Growth Variation of *Swietenia macrophylla* King. Progeny Trial at 18 Months of Age in Trenggalek East Java

Mashudi^{1,*} Sugeng Pudjiono¹ Dedi Setiadi¹ Nur Hidayati² Maman Sulaeman³
Liliana Baskorowati⁴ Rina Laksmi Hendrati⁴ Mudji Susanto⁴

¹Senior researcher, Centre for Forest Biotechnology and Tree Improvement

²Junior researcher, Centre for Forest Biotechnology and Tree Improvement

³Technician, Centre for Forest Biotechnology and Tree Improvement

⁴Professor research, Centre for Forest Biotechnology and Tree Improvement

*Corresponding author. Email: masshudy@yahoo.com

ABSTRACT

Swietenia macrophylla King. as known as wide leaf mahogany is a type of exotic species from Latin America that is common planted in Indonesia. This species is widely cultivated in several regions in Indonesia due to the high demand for carpentry timber. Therefore, to meet the high demand of wide leaf mahogany wood, the development of plantation forests of *S. macrophylla* with high productivity is very much needed. Development of plantation forests with high productivity requires the support of improvement seeds. Therefore, this study was conducted to determine the survival rate, growth variation between land race and between mother trees of 18 months old of *S. macrophylla* progeny trial. This progeny trial at the end of the selection can be converted into a seedling seed orchard (SSO) to produce the improvement seeds. Incomplete Block Design with two factors, i.e. land race (5 levels) and mother tree (50 levels) was used in this study. *The results of the analysis showed that the survival rates of plant was significantly different between the land race but not among the mother trees.* The average of survival rate of this species is only 71.58%, due to the landslide during the rainy season, burnt during the dry season and also *exposed to stem borer attacks.* Growth parameters (height and stem diameter) were significantly different between land race and mother tree. It showed that the Bondowoso land race exhibited the best performance of height and stem diameter, respectively 151.55 cm and 21.97 mm. The best mother tree in terms of growth (height and stem diameter) were exhibited on 19 individual tresses, with a range from 130.38 to 171.64 cm for height character and from 20.46 to 26.47 mm for stem diameter character.

Keywords: *growth variation, progeny trial, land race, mother tree, Swietenia macrophylla*

1. INTRODUCTION

Wide leaf mahogany (*Swietenia macrophylla* King.) is an important timber-producing species in Indonesia. Mahogany timber generally used for several purposes including as construction materials, plywood (plywood / veneer), furniture, panels, frames, floors, car body, boat interior and molding [1]. The high economic value of mahogany caused increasing the development of mahogany plantations; especially the local people in several regions including Java, South Kalimantan and Nusa Tenggara tend to plant this species due to high demand of the

timber [2]. To support the development of plantations of *S. macrophylla* with high productivity, the availability of improvement seeds is very important.

S. macrophylla is an introduced species planted by the Dutch since the 1890s [2]. It was further conveyed that, natural habitats of this species are in Latin America. Although it is an introduced species, this species has a high genetic diversity [3,4]. In term of tree breeding, high genetic diversity is very important; it means that having high diversity will lead the opportunity for having a superior tree by selection. At the end of the selection of selected trees in the progeny trial can be converted into seed

orchard. In this study the *S. macrophylla* progeny trial was established in Trenggalek, East Java. The seed source of the progeny trial comes from 5 land races, collected from Banjar-West Java, Dlingo-Bantul, Samigaluh-Kulonprogo, Bon-dowoso-East Java, and Lombok-West Nusa Tenggara [5]. Periodic measurements every 6 months of survival rate, height and stem diameter were undertaken to determine the diversity of plant growth. Those data were analyzed as a basic information for the implementation of the selection. Therefore, this study was conducted to find out the survival rate, growth variation between land races and between mother trees of *S. macrophylla* progeny trial at 18 months of age.

2. MATERIALS AND METHODS

2.1. Location

The research was carried out on the *S. macrophylla* progeny trial in Dompnyong Village, Bendungan District, Trenggalek Regency, East Java Province in June 2018. The study site located 729 m above sea level, latitude 7°55,483' LS and longitude 111°43,221' BT. The soil type of study site is Litosol and the amount of rainfall in 2017 was 5,083 mm [6].

2.2. Materials

The research was conducted at 18 months old of *S. macrophylla* progeny test, consisting of fifty mother trees from five land races. The seed from Banjar-West Java of 15 mother trees; Dlingo-Bantul of 7 mother trees; Samigaluh-Kulonprogo of 10 mother trees, Bondowoso-East Java of 2 mother trees and Lombok-West Nusa Tenggara of 16 mother trees [5]. The geographical location and altitude of the 5 land races are presented in Table 1. another material used is a tally sheet to record the measurement. Then the instrument used in this study is a pole meter to measure the plant height and calipers to measure the stem diameter. The height and the stem diameter were measured with the sampling intensity of 100%. The height of the plant was assessed by measuring the base of the stem to the top of the plant, and the diameter of the stem by measuring at a height of ± 5 cm from the ground surface. To simplify the measurement, tally sheets are printed and arranged according to plant design.

2.3. Design and Data Analysis

The Incomplete Block Design (IBD) with 2 factors, namely land race and mother tree were used

for this research due to the site location has a high slope. The mother tree (nested) in the land race in this study. Land race factor consists of 5 levels and the mother tree factor consists of 50 levels. Each mother tree consisting of 3 tree plots and 6 blocks as replication with a spacing of 4 x 2 meter. In the field, tree plot planting follows the contour direction at a distance of 2 meter between plants. To determine diversity, the data were analyzed for variance using the following model [7] :

$$Y_{ijklm} = \mu + B_i + R_j(B_i) + C_k(B_i) + P_l + F_m(P_l) + B_i * F_m(P_l) + \varepsilon_{ijklm} \quad (1)$$

Where:

- Y_{ijklm} : observation of the i^{th} block, the j^{th} row nested in the i^{th} block, the k^{th} column nested in the i^{th} block, the l^{th} land race and the m^{th} mother tree nested in the l^{th} land race;
- μ : average of the general observations;
- B_i : effect of the i^{th} block;
- $R_j(B_i)$: effect of the j^{th} row nested in the i^{th} block;
- $C_k(B_i)$: effect of the k^{th} column nested in the i^{th} block;
- P_l : effect of the l^{th} land race;
- $F_m(P_l)$: effect of the m^{th} mother tree nested in the l^{th} land race;
- $B_i * F_m(P_l)$: effect of the interaction between the i^{th} block with the m^{th} mother tree nested in the l^{th} land race;
- ε_{ijklm} : random residual error.

Duncan Multiple Range Test (DMRT) will be undertaken to determine the differences in each treatment if the results of analysis of variance showed significant differences at the maximum test level of 5%.

3. RESULT AND DISCUSSION

3.1. Survival Rate

The survival rate acknowledged as one factor reflecting the adaptability of plants at a new location. At 18 months old, the percentage of *S. macrophylla* survival rate among land races were from 66.00 to 80.56% (average 71.58%) and the percent survival rate inter-mother tree showed from 38.89 to 88.89 (average 71.58%). [5] revealed that the average of survival rate of 6-months-old of *S. macrophylla* was 84.44%, therefore the survival rate of 18-months-old decreased significantly. Reducing the survival rate on this progeny trial due to loss of several plants caused by landslides during the rainy season, fire during the

dry season. Moreover, in the study site it was found that several plants damaged by stem borer attacks, attacking the base of the stem caused plant un-able to survive. Stem borers was also reported damage on the 1-year-old of *S. macrophylla* progeny trial in Kemampo, Banyuasin, South Sumatra [9]. According to [10, 11, 12] young *S. macrophylla* plants were very susceptible to stem borer attack of *Hypsipyla* spp. High attack of *Hypsipyla* stem borer pests also reported in the provenan trial and progeny trial of *S. macrophylla* in Peninsula, Mexico [13]. Furthermore, to determine the variation between treatments, an analysis of variance was performed with the results presented in Table 2.

The analysis of variance (Table 2) shows that the survival rate among land race was differ significantly; while the percent of survival rate between mother trees did not differ significantly. The results of the analysis of variance in this study differed from the results of the study of [5] on plants aged 6-months in the same trial plot. This phenomenon can be understood because the

Table 1. Latitude and altitude of *S. macrophylla* seed sources

No.	Land race	Province	Longitude and latitude	Altitude (m asl)
1	Banjar, Ciamis	West Jawa	007°21,144' - 007°30,026' SL 108°29,393' - 108°39,667' EL	75 – 250
2	Dlingo, Bantul	Special Region of Yogyakarta	007°55,225' - 007°56,00' SL 110°24,650' - 110°25,251' EL	250 – 380
3	Samigaluh, Kulonprogo	Special Region of Yogyakarta	007°40,217' - 007°41,155' SL 110°07,417' - 110°08,100' EL	400 – 500
4	Bondowoso	East Jawa	007°50,315' - 007°59,448 SL 113°48, 217' - 113°59,671' EL	700 – 800
5	Lombok	West Nusa Tenggara	008°31,913' - 008°40,835' SL 116°14,311' - 116°23,718' EL	250 – 500

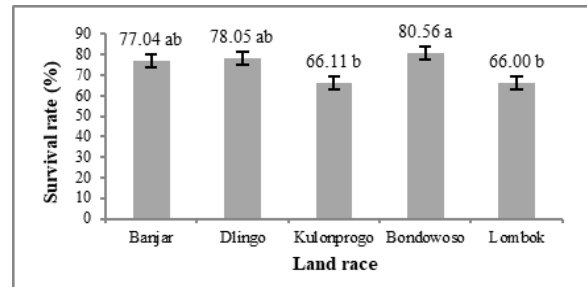
References Sources : [4, 8] .

Table 2. Variace analysis of survival rate of *S. macrophylla* progeny trial at18 months old in Trenggalek, East Jawa

Source of variation	Degree of freedom	Sum of square	Mean square	F value	Pr > F
Block	5	20419.7476	4083.9495	6.17	<0.0001
Row (Block)	54	86145.7080	1595.2909	2.41	<0.0001
Colom (Block)	24	28460.3970	1185.8499	1.79	0.0180
Land race	4	9927.2068	2481.8017	3.75*	0.0060
Mother tree (Land race)	45	28662.7273	636.9495	0.96ns	0.5460
Error	166	109888.9656	661.9817		
Total	298	283504.7523			

Remarks: * = significantly different at the 0.05 level.ns= not significant at the 0.00 level

measurement of plants is still very young, therefore the growth will increase concordance with the age. To determine the effect of land race on survial rates, the DMRT was carried out as present in Figure 1.



Remarks : The numbers following by the same letters were not significantly different at the 0.05 level.

Figure 1. Survival rates between land race of *S. macrophylla* progeny trial at 18 months of age

The DMRT results (Figure 1) showed that the three land races with the best survival rate were Bondowoso, Dlingo, and Banjar respectively, while the land races of Lombok and Kulonprogo have lower survival rates. This result indicated that at a young age the *S. macrophylla* plants from the Lombok and Kulonprogo land races were more susceptible to death due to pest attacks compared to other land races; it also showed that the ability to survive at the new environmental conditions of those land races were less than others.

3.2. Growth Variation

The analysis showed that the growth (height and stem diameter) of *S. macrophylla* at 18 months old were quite varied. Height between mother trees ranged from 84.40 to 171.64 cm (an average of 126.79 ± 42.91 cm) and stem diameter between the mother trees ranged from 12.20 to 26.47 mm (an average of $19, 15 \pm 6.22$ mm). To find out the diversity between land races and mother trees, an analysis of variance was performed with the results presented in Table 3.

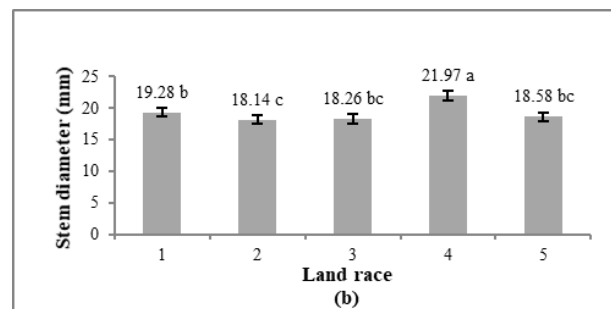
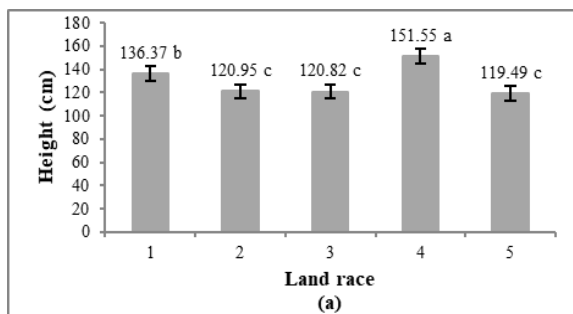
Table 3. Variance analysis of growth (height and stem diameter) of *S. macrophylla* progeny trial at 18 months of age in Trenggalek, East Java

Source of Variation	Degree of Freedom	Mean Square	
		Height	Stem Diameter
Block	5	45021.4026	2037.4793
Row (Block)	54	6927.4937	175.6592
Col (Block)	24	10987.9192	227.2536
Land Race	4	16071.1608**	222.2490**
Mother Tree (Land Race)	46	5313.1919**	111.5582**
Block*Mother Tree (Land Race)	147	2993.3886**	71.1474**
Error	366	1841.334	38.7086
Total	646		

Remarks: ** = significantly different at the 0.01 level

Growth (height and stem diameter) of 18-months-old *S. macrophylla* varied significantly between land races, mother trees and the interaction of replication (block) and mother trees (Table 3). Variation of growth between land races and mother trees commonly occurs in several woody plant due to the adaptability of species to the new environment; it also occurs when the seedlings were 5-months-old [4]. The diversity among land races had been reported by [3] on *S. macrophylla* from Central Java and East Java using isozyme markers; it has a proportion of diversity among land races of 23% and within the

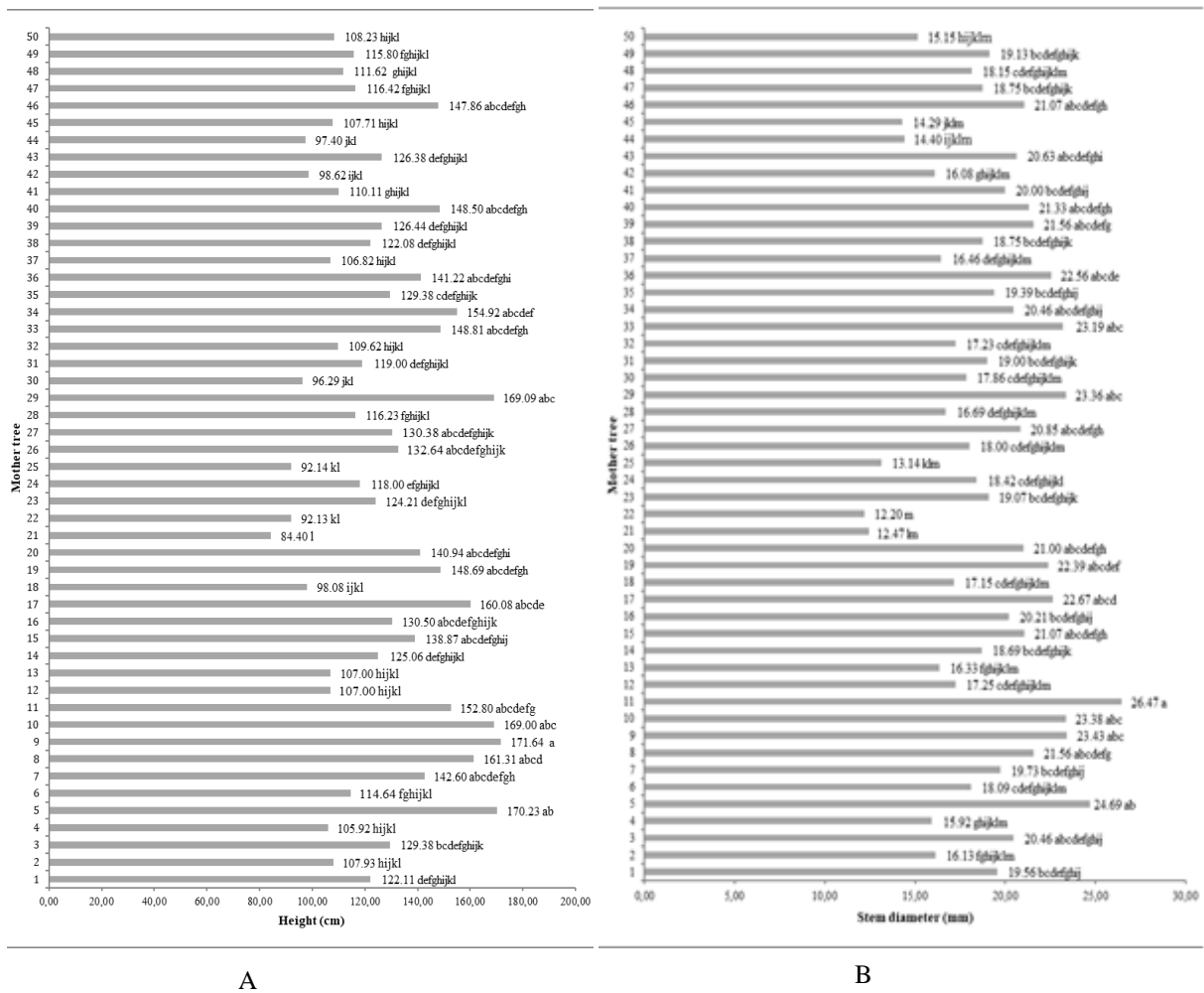
land race of 77%. [14, 15 and 16] also informed that land race influenced the growth of *S. macrophylla* seedlings/plants. Significant influence of the interaction of the mother tree*block (land race) on the growth of *S. macrophylla* might occurred due to the progeny trial location were not homogeny in terms of the level pest and diseases, slope and soil nutrient. Duncan test on the diversity of height and stem diameter growth between land races are presented in Figure 2, while the diversity of height growth and stem diameter between mother trees are presented in Figure 3a and Figure 3b.



Remarks: 1 = Banjar; 2 = Dlingo; 3 = Kulonprogo; 4 = Bondowoso and 5 = Lombok.

The numbers followed by the same letters were not significantly different at the 0.01 level.

Figure 2. DMRT of height (a) and stem diameter (b) between land race of *S. macrophylla* progeny trial at 18 months of age



Remarks: The numbers followed by the same letters were not significantly different at the 0.01 level

Figure 3. DMRT of: A. Height and B. Stem diameter between mother trees of *S. macrophylla* progeny trial at 18 months of age.

The average of growth (height and stem diameter) *S. macrophylla* from Bondowoso land race exhibited the best growth compared to plants from other land races (Figure 2). Greater growth of mahogany from Bondowoso land race might due to the same elevation of progeny trial site in Trenggalek (Table 1), so the growth of Bondowoso land race plants is more optimum compared to other land races. [17] reported that the elevation difference will interfere with plant physiology activities which affecting plant growth. Previous study of *Alstonia angustiloba* progeny trial, showed that elevation differences also significantly affect plant growth among populations at 1 year old in Wonogiri, Central Java [18]. Diversity of growth between seed sources (land race) also occurs in *S. macrophylla* progeny trial at two In order to determine the growth diversity among the mother trees of *S. macrophylla* at this progeny trial, the Duncan test of height determined that mother

trees separated in 12 groups (Figure 3a) and the Duncan test of stem diameters separated in 13 groups (Figure 3b). The best growth (height and stem diameter) was determined at 19 mother trees, with the range from 130.38 to 171.64 cm and from 20.46 to 26.47 mm respectively (Figure 3a and Figure 3b). The results of the study at 6-months-old were informed that the height growth of *S. macrophylla* progeny trial were grouped in 14 groups and stem diameters clustered in 13 groups [5]. This phenomenon shows that the diversity of plant height has decreased. This happens due to high mortality of trees during interval of 6 to 18 months-old, so that the diversity of plant height has decreased. Decrease in growth diversity due to the large number of plants mortality also occurred in the 2-year-old progeny trial of *Alstonia angustiloba* in Wonogiri, Central Java [19]. However, this research was carried out on very young plants, so the diversity of growth

in height and stem diameter is still very likely to change. locations in Northern Mindano, Philippines [20].

In order to determine the growth diversity among the mother trees of *S. macrophylla* at this progeny trial, the Duncan test of height determined that mother trees separated in 12 groups (Figure 3a) and the Duncan test of stem diameters separated in 13 groups (Figure 3b). The best growth (height and stem diameter) was determined at 19 mother trees, with the range from 130.38 to 171.64 cm and from 20.46 to 26.47 mm respectively (Figure 3a and Figure 3b). The results of the study at 6-months-old were informed that the height growth of *S. macrophylla* progeny trial were grouped in 14 groups and stem diameters clustered in 13 groups [5]. This phenomenon shows that the diversity of plant height has decreased. This happens due to high mortality of trees during interval of 6 to 18 months-old, so that the diversity of plant height has decreased. Decrease in growth diversity due to the large number of plants mortality also occurred in the 2-year-old progeny trial of *Alstonia angustiloba* in Wonogiri, Central Java [19]. However, this research was carried out on very young plants, so the diversity of growth in height and stem diameter is still very likely to change.

4. CONCLUSION

The mortality of 18-months-old of *S. macrophylla* is quite high due to the landslide during the rainy season, burnt during the dry season and also exposed to stem borer attacks. Survival rate of plant is significantly affected by land race, while the mother tree has no significant effect on the survival rate of plant.

Land race and mother tree have a very significant effect on the growth of the height and the stem diameter of *S. macrophylla* progeny trial at 18 months of age. The interaction of the block with the mother tree also has a very significant effect on the growth of the height and the stem diameter of *S. macrophylla* progeny trial at 18 months of age.

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