Progeny Test on Plant Growth Of 2-Year-Old Jabon Merah (*Anthocephalus macrophyllus* Roxb. Havil.) in Gowa, South Sulawesi, Indonesia: Preliminary Study

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Abstract. Jabon Merah (*Anthocephalus macrophyllus* Roxb. Havil) is a fast growing local species and has bright economic and market prospects. However, the cultivation is unable to accelerate the productivity of this species. One of the breeding strategies to overcome this problem is to establish Seedling Seed Orchard of progeny test were later converted into seed orchard after one up to several selective thinning. This research was aimed to study the growth of Jabon merah’s families from ten seed zonations in Sulawesi. It was conducted in a Randomized completely block design (RCBD) consisted of 108 families, four treeplots, and seven blocks with planting spacing of 4x3 meters. The measurement was performed at 24 month-old trees, i.e., tree height and diameter. Percentage of the living tree after two years based on progeny test was 69% with 6.1 m of mean height and 7.8 cm of mean diameter at chest height. Heritability of family for height and diameter at chest height were 0.2337 and 0.1873, respectively. Correlation between genetic and tree height and diameter traits was 0.9121.

1. Introduction

Jabon Merah (*Anthocephalus macrophyllus* (Roxb.) Havil) is a priority alternative tree for developing forest producing timber [1]. It is also a perspective to be developed over community programs, for instance, Community Forest and Community Forest Plantation [2]. This species is classified as a fast growing tree that can reach up to 18 m in height and 42 cm in diameter in the good cultivation condition [3] and well known as raw material for pulp and paper industries, plywood and carpentry. It is categorized into Durability Class IV and Strength Class II-III, having long fiber, thin fiber wall thickness and grouped into the second class of quality for pulp and paper [4].

Efforts on increasing productivity of Jabon Merah in forest plantations have to be performed continually through proper cultivation system and application of superior seeds produced from plant breeding programs. The 2nd Regional of Forest Plant Seeding (BPTH Wilayah II) as technical implementation unit has the main responsibility of which to provide superior seeds by establishing Seed Orchard of progeny test of Jabon Merah in 2015. This orchard will be later converted into Seedling Seed Orchard after several selection steps aimed to obtain the best parents and progenies.
Progeny test is a trial in repetition form performed for determining the genetic structure of the parents by observing the progenies characteristics derived from generative propagation [3]. It purposes to estimate the breeding value of the parents by comparing the performances of the progenies and is more accurate because the evaluated progenies from each parent are under same environment condition [5]. The objective of this study was to evaluate the growth of 2-year-old Jabon Merah at Seedling Seed Orchard of progeny test.

2. Material and Method

2.1. Research time and site
The research was done in January up to February 2018 at Seedling Seed Orchard of progeny test of Sulawesi Strains of Jabon Merah in Belabori village, Gowa district, South Sulawesi, Indonesia. The climate in Gowa is wet tropic, with an average of rainfall up to 319.4 mm/month (Number of rainy days is about 148 days in 2013). Bellator village is divided into dystropepts and tropudults soils. Genetic Resource Area has dystropepts soil, and it is classified as lowland seed zonation with altitude ranged 75-90 meters above sea level.

2.2. Plant materials
Plant materials used in the study were 2 year-old Jabon Merah. This research site was formed in Randomized completely block design (RCBD) consisted of 108 families, four tree plots and seven blocks with planting spacing of 4x3 meters.

2.3. Research methods
The research was initiated by measuring the growth of Jabon Merah at the study site. The observed parameters were a percentage of a living tree, tree height (measuring from trunk base to growing point) and diameter (measuring as high as 130 cm). Data were then analyzed to estimate mean of tree growth, variance in evaluated families, estimation of heritability and correlation between genetic and observed traits.

2.4. Data analysis
The Data were analyzed in RCBD ANOVA with a linear model:

\[ Y_{ijk} = \mu + B_i + BF_{ij} + \epsilon_{ijk} \]

Where:
- \( Y_{ijk} \): The \( i \)th individual from \( k \)th family in \( i \)th block
- \( \mu \): The baseline mean
- \( B_i \): The \( i \)th block effect
- \( BF_{ij} \): The interaction between \( i \)th block in \( k \)th family
- \( \epsilon_{ijk} \): The random error

Genetic factors against total parameters were analyzed by calculating heritability of individual, the heritability of family and correlation genetic using Zobel and Talbert’s (1984) equations:

\[ h^2_f = \frac{\sigma_f^2}{\sigma_f^2 + (\sigma_{bh}^2 + \sigma_{e}^2)} \]

\[ h^2_i = \frac{4 \sigma_f^2}{\sigma_f^2 + \sigma_{bh}^2 + \sigma_e^2} \]

\[ rGi = \frac{\sigma_{rxy}}{\sqrt{(\sigma_{rx}^2 \cdot \sigma_{ry}^2)}} \]

Where:
- \( h^2_f \): Heritability of family
- \( h^2_i \): Heritability of individual
- \( \sigma^2_f \): Variance of family
- \( \sigma^2_e \): Variance of environment
- \( t \): Number of individual repetition
b : Number of blocks
\( \sigma^2_{fb} \) : Interaction variance between family and block
rG : Correlation of genetic
\( \sigma_f(\text{xy}) \) : Component of covariance for x and y
\( \sigma^2_f(x) \) : Component of covariance for x
\( \sigma^2_f(y) \) : Component of covariance for y

3. Results and discussion

3.1. Percentage of a living tree, tree height and diameter, and family rank

The Progeny test on two-year-old Jabon Merah presented in Figure 1, Figure 2 and Table 1 show percentage of living tree of all evaluated families in 10 seed zonations ranged from 64.5% up to 78.6% and percentage mean of the living tree was 70.2%. Jabon Merah family from Red yellow Mediterranean lowland seasonal forest in North Buton had the highest percentage of the living tree (78.6%), whilst that of from Red yellow Mediterranean karst forest in Buton had the lowest one (64.5%). Some studies proved Jabon Merah cannot grow optimally in areas containing low water content [6] or shallow groundwater depth [7]. [8] stated Jabon merah is able to grow in wide range of site conditions. Some individuals of this species thrive in 23 to 628 meters above sea level with A up to E of climate types and low to high soil fertility. Variety in side conditions indicate Jabon merah has a wide range of growth environments and adaptability as it grows well though planted in different zonations.

The best growth was observed on the family from Red yellow Mediterranean lowland seasonal forest in Muna (7.3 m of tree height mean and 9.5 cm of diameter mean). Figure 2. depicts that there was a correlation between tree height and diameter traits.

Family rank is a crucial factor as it measures the performance of evaluated families in a progeny test later used in breeding selection as well as advanced breeding programs [9]. The rank is commonly based on desired traits, such as tree height, diameter, specific weight, sap productivity, branch type and shape. In this study, tree height and diameter were observed.

![Figure 1. Percentage of living tree based on seed zonation](image1)

![Figure 2. Tree height and diameter](image2)
Table 1. Tree height and diameter based on seed zonation

| No | Tree zonation                                                                 | Number of the tree (individual) | Number of the living tree (individual) | Mean Height (m) | Diame ter at chest height (cm) | Percentag e of the living tree (%) |
|----|--------------------------------------------------------------------------------|---------------------------------|----------------------------------------|-----------------|-------------------------------|-----------------------------------|
| 1  | 7.2/Aluvial lowland seasonal forest/Konawe-South Konawe/Kolaka                  | 392                             | 262                                    | 6.1             | 7.7                           | 66.8                              |
| 2  | 9.9/Red yellow podzolic seasonal forest/Luwu                                    | 224                             | 159                                    | 6.1             | 7.7                           | 71.0                              |
| 3  | 1/lowland rain forest/Luwu-Wajo                                                  | 280                             | 182                                    | 5.9             | 7.5                           | 65.0                              |
| 4  | 1.10/ Red yellow Mediterranean lowland rain forest/East Luwu                    | 84                              | 59                                     | 6.6             | 8.6                           | 70.2                              |
| 5  | 7.9/Red yellow Mediterranean lowland seasonal forest/Muna                       | 308                             | 224                                    | 7.3             | 9.5                           | 72.7                              |
| 6  | 10/Karst forest/Muna                                                            | 140                             | 106                                    | 6.1             | 7.8                           | 75.7                              |
| 7  | 10.3/Red yellow Mediterranean karst forest/Buton                                | 392                             | 253                                    | 6.1             | 7.9                           | 64.5                              |
| 8  | 7.9/Red yellow Mediterranean lowland seasonal forest/North Buton                | 280                             | 220                                    | 6.0             | 7.8                           | 78.6                              |
| 9  | 8/Lowland seasonal forest/Banggai                                                | 784                             | 531                                    | 6.1             | 8.0                           | 67.7                              |
| 10 | 1.9/Red yellow podzolic lowland rain forest/Sidrap                              | 140                             | 97                                     | 6.4             | 8.3                           | 69.3                              |

Table 2. Family rank of 2-year-old Jabon Merah

| Family rank | Family |
|-------------|--------|
| 1 - 10      | 27, 41, 65, 95, 39, 103, 96, 21, 17, 97 |
| 11 - 20     | 4, 56, 80, 55, 8, 82, 81, 23, 90, 89   |
| 21 - 30     | 36, 37, 47, 51, 108, 63, 32, 20, 75, 30 |
| 31 - 40     | 50, 14, 5, 13, 104, 38, 12, 67, 68, 85 |
| 41 - 50     | 18, 87, 84, 43, 76, 91, 25, 19, 58, 60 |
| 51 - 60     | 9, 29, 31, 54, 86, 69, 42, 66, 1, 99   |
| 61 - 70     | 78, 15, 3, 52, 24, 65, 102, 6, 26, 94  |
| 71 - 80     | 88, 62, 48, 77, 59, 100, 16, 46, 107, 53 |
| 81 - 90     | 10, 83, 105, 71, 74, 44, 35, 92, 61, 7  |
| 91 - 100    | 98, 228, 33, 93, 22, 106, 70, 45, 79, 64 |
| 101 - 108   | 72, 57, 34, 11, 101, 49, 73, 40        |

Table 2 presents #27 family had the best performance and stability among evaluated families from East Luwu. #41 and #39 families from North Buton, #95 family from Banggai, #103 family from Luwu-Wajo, #96, and #97 from Sidrap and #21 and #17 from Luwu also showed good performances. It is
proved that seeds from various seed zonations can adapt to different site conditions and it is similar to [10] that reported the range of adaptability and growth environment of Jabon Merah are wide.

3.2. Heritability and correlation between tree height and diameter

Heritability is a variable described how strong a trait controlled by a genetic factor [11]. Heritability is utilized to determine selection type in tree breeding program that can produce high productivity [12] and estimates contribution proportion of genetic factor inherited from the parents to its progenies [10].

### Table 3. Heritability, genetic correlation on tree height and diameter

| Parameter | Heritability Individual | Heritability Family | Genetic correlation |
|-----------|-------------------------|---------------------|---------------------|
| Height    | 0.0312                  | 0.2337              | 0.9121              |
| Diameter  | 0.0216                  | 0.1873              |                     |

[13] reported heritability of individual (h²i) ≤ 0.1 means low, 0.1-0.3 of h²i is moderate, (h²i) > 0.3 is high, meanwhile heritability of family (h²f) ≤ 0.4 is low, 0.4–0.6 of h²f is moderate and h²f > 0.6 is high. Heritability of individual in 2-year-old Jabon Merah on tree height and diameter was low. Estimation of family heritability on tree height was 0.2337; it indicated that 23.37% of tree height trait was genetically inherited and the remaining 76.63% was affected by environment factor. Moreover, estimation of family heritability on tree diameter indicated that 18.73% of diameter trait was genetically inherited and 81.27% of it was influenced by environment factor. It showed that genetic factor had low contribution against total variation of the phenotype. The increasing genetic contribution will be companied by tree age [14] and different plant growth phases [15].

Contrast to this study, a study by [16] reported higher heritability of family in 2-year-old Jabon Merah (0.32 in tree height and 0.38 in tree diameter). It was assumed as the evaluated trees were too young and consequently, traits controlled by genetic had not been expressed properly yet. Other studies showed that 6 month-old Jabon Merah in Parungpanjang site had lower heritability of family (0.093 in height and 0.066 in diameter) compared to 12 months old (0.150 in height and 0.178 in diameter). The low heritability is affected by tree age and number of observation unit (number of individuals per family) as well as the number of block/repetition [8].

Genetic correlation is the level of relationship between traits controlled by genetic, and it is used in selection activities [10]. Genetic correlation between tree height and diameter was 0.9121. It indicated that by improving tree height trait, the diameter would increase by 91.21%. Forest trees commonly have positive genetic correlation and high. Progeny test on 12 month-old Paraserianthes falcataria in Cikampek was 0.90 [17], and that of 18 month-old Araucaria cunninghamii was 0.80 [18]. The analysis of genetic relationship Anthocephalus macrophyllus showed that moderate level of genetic diversity [19].

4. Conclusion

Growth variation and genetic parameters on progeny test of 2-year-old Jabon Merah had low heritability of individual and family. Genetic correlation between height and diameter traits showed a high correlation. The best growth of the family on tree height and diameter was observed on #27 family from Red yellow Mediterranean lowland rain forest in East Luwu. Estimation on the heritability of individual was 0.0312, and that of the family was 0.2337 (tree height), while heritability of individual and family on tree diameter were 0.0216 and 0.1873, respectively, with 0.9121 of genetic correlation on progeny test of 2 year-old Jabon merah.

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