Selection of adaptive teak provenance in Gunungkidul

E Kurniasari1*, S Indrioko2 and Y W N Ratnaningrum3

1 Undergraduate student of Faculty of Forestry of Universitas Gadjah Mada Bulaksumur Yogyakarta 55281 Indonesia
2 Laboratory of Forest Tree Improvement, Faculty of Forestry, Universitas Gadjah Mada, Bulaksumur Yogyakarta 55281 Indonesia
3 Laboratory of Forest Seed Science and Technology, Faculty of Forestry, Universitas Gadjah Mada, Bulaksumur Yogyakarta 55281 Indonesia

Corresponding author’s e-mail address: ervina.kurniasari@mail.ugm.ac.id

Abstract. The teak planting program for rehabilitation and research, as well as for social forestry purposes, requires a constant supply of planting materials with good phenotype and genetic qualities. Most of teak seeds in Indonesia are collected from seed production areas, and even from unidentified stands when the improved stands are unavailable. Vegetative material production from hedge orchards has also been used in a lesser number due to the more complex production techniques and the more expensive cost. Therefore, it is a need to look for any other alternatives for teak planting material supplies. The success of Wanagama on rehabilitation of critical land area suggested an idea to increase the value of Wanagama plantations as a seed source. A 31 years old provenance trial plantation PPGM-T73-88 consists of 21 provenances, located in Compartment 17 Wanagama, made in 5 blocks, 4 tree plots, and 4 m x 4 m spacing, was selected to be an alternative seed source. This study was aimed to evaluate the possibility of the plantation to be a seed source, by selecting the adaptive provenances based on survival rate, height, and diameter. This study concluded that Malabar and Central Province provenances have the highest survival rate. Kouai and Deling provenances are the highest rank of height and diameter characteristics. Respectively, the heights of both provenances are 14.58 m and 13.86 m; the diameters are 31.95 cm and 34.73 cm. Key words: teak, provenance trial, seed source, Wanagama

1. Introduction
Teak (Tectona grandis) is one of the most common tree species in Indonesian agroforestry, because of its high demand and its silviculture has been well-known among farmers. Teak breeding in Indonesia had been started on 1932 by Badan Litbang Kehutanan in KPH Bojonegoro, KPH Randublatung, KPH Ngawi, and KPH Blitar. The trial plantations consist of 14 ecotypes, those are Indian teak (Malabar, Central Province, and Godavari), Indo-China teak (Hinh, Kay, Kouai, dan Kouoc), Muna teak, Java teak (Cepu, Pati, Ponorogo, Gundih, Kesamben), and 3 varieties (galstam, doreng, and knobel) [1].

The teak planting program for rehabilitation and research, as well as for social forestry purposes, requires a constant supply of planting materials with good phenotype and genetic qualities. Most of
Teak seeds in Indonesia are collected from seed production areas, and even from unidentified stands, due to the limited number of the improved stands and the insufficient of a high quality seed supply. Vegetative material production from hedge orchards has also been used in a lesser number due to the more complex production techniques and the more expensive cost. Therefore, it is a need to look for any other alternatives for teak planting material supplies.

In 1988, Forestry Faculty of Universitas Gadjah Mada built a provenance trial in Wanagama, Gunungkidul. The plantation consists of 21 provenances from Cepu, Bangilan, Muna, Ngliiron, Margasari, Ponorogo, Gundih, Deling, Java, Blora, Pati, Randublatung, Malabar, Central Province, Godavari, Thailand, Kay, Kouoc, Kouai, Burma, and Soe [2]. The success of Wanagama on rehabilitation of critical land area suggested an idea to increase the value of Wanagama plantations as a seed source for rehabilitation and research, as well as for social forestry purposes. This study was aimed to evaluate the possibility of the plantation to be a seed source, by selecting the adaptive provenances based on the height and diameter.

2. Materials and Methods

2.1. Study Sites
The location of this study is in Compartment 17, KHDTK Wanagama, Gunungkidul, Special Region of Yogyakarta. Data was taken two times on March 2018 and 2019, based on the peak season of teak flowering is on December until March [3][4].

The material of this research is teak provenance trial plantation PPGM-T73-88, located in Compartment 17, made in 5 blocks, 4 tree plots, and 4 m x 4 m spacing. The plantation consists of provenances from Indonesia (Cepu, Muna, Ponorogo, Gundih, Deling, Java, Blora, Randublatung, Soe (West Timor), Bangilan/streaked teak/doreng, Ngliiron/smooth-stem teak, and Margasari/knotted-stem teak), India (Malabar, Central Province, and Godavari), Thailand, Laos (Kay/gray teak, Kouoc/white teak, and Kouai/brown teak), and Burma/Myanmar (Figure 1).

Provenance:
1. Cepu
2. Bangilan
3. Muna
4. Ngliiron
5. Margasari
6. Ponorogo
7. Gundih
8. Deling
9. Java
10. Blora
11. Pati
12. Randublatung
13. Malabar
14. Central Province
15. Godavari
16. Thailand
17. Kay
18. Kouoc
19. Kouai
20. Burma
21. Soe

Figure 1. Teak provenance trial PPGM– T73 – 88, Compartment 17, KHDTK Wanagama
2.2. Research Procedures

2.2.1. Survival Rate. Survival rate was measured to know how many each provenance and total trees remaining in the plantation.

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\text{Survival rate each provenance (\%) } = \frac{\text{Remaining trees of each provenance}}{\text{Trees planted}} \times 100\%
\]

\[
\text{Total survival rate (\%)} = \frac{\text{Remaining trees total}}{\text{Trees planted}} \times 100\%
\]

2.2.2. Height and Diameter Measurement. Measurement of tree heights with hagameter started from soil surface until the highest apical meristematic on trees crown. Diameters at Breast Height (DBH) were measured with phi band on the 1.3 m stem height.

2.2.3. Analysis of Variance. Analysis of variance (Anova) was done for height and diameter characteristics. If the analysis result showing significant difference, then Duncan Multiple Range Test (DMRT) is needed [5].

3. Results and Discussion

3.1. Survival Rate
In this provenance trial, out 225 of total 420 trees (54%) were survived. There are 10 provenances that have survival rate more than average. Malabar and Central province have the highest survival rate (90%) (Figure 2).

![Figure 2. Survival rate](image)

3.2. Height and Diameter
The provenances have significant difference of height and diameter at confidence level 95%. Duncan Multiple Range Test has conducted to measure the variation and ranking of the provenance based on height and diameter (Table 1 and 2).

Average height and diameter are 11.67 m and 26.00 cm, respectively. Kouai, Deling, and Bangilan provenances are the highest provenance, while Deling, Malabar, and Kouai have the biggest tree.
diameter. Soe provenance is the lowest on both characteristics. Variations on the height and diameter showed that genetic factor takes role in it.

Deling and Kouai are provenances that placed on the top three of height and diameter characteristics. Other studies on this plantation have conducted at 10-months-old [6] and 13-years-old [2] teak. These studies proven that provenances have inconsistency of height and diameter ranking in different ages. Out of 21 provenances, Bangilan is the only provenance that remains on the top three of height characteristic while Soe is on the lowest ranking.

Table 1. DMRT result of height characteristic.

| Provenance | DMRT | Height (m) |
|------------|------|------------|
| Kouai      | a    | 14.58      |
| Deling     | a b  | 13.86      |
| Bangilan   | a b c| 13.52      |
| Cepu       | a b c d| 13.10     |
| Godavari   | a b c d| 13.05     |
| Muna       | b c d e| 12.19     |
| Gundih     | b c d e| 12.03     |
| Ngliron    | b c d e| 12.03     |
| Pati       | b c d e| 12.00     |
| Central Prov. | b c d e| 11.98     |
| Burma      | b c d e| 11.93     |
| Blora      | b c d e| 11.89     |
| Ponorogo   | c d e f| 11.49     |
| Randublatung | c d e f g| 11.27  |
| Kay        | c d e f g| 11.20    |
| Malabar    | c d e f g| 11.18    |
| Java       | d e f g | 11.04     |
| Margasari  | e f g   | 10.25      |
| Kouoc      | e f g   | 9.96       |
| Thailand   | f g     | 9.58       |
| Soe        | g       | 9.02       |
| Average    |         | 11.67      |

Table 2. DMRT result of diameter characteristic.

| Provenance | DMRT | Diameter (cm) |
|------------|------|---------------|
| Deling     | a    | 34.73         |
| Malabar    | a b  | 32.71         |
| Kouai      | a    | 31.95         |
| Randublatung | a b c| 31.14     |
| Gundih     | a b c| 31.12         |
| Bangilan   | a b c d| 29.17     |
| Central Prov. | a b c d e| 28.09  |
| Muna       | a b c d e| 27.73     |
| Blora      | a b c d e| 27.63     |
| Cepu       | a b c d e| 26.68     |
| Margasari  | a b c d e f| 25.97    |
| Pati       | a b c d e f| 24.99    |
| Thailand   | a b c d e f| 24.86    |
| Kouoc      | a b c d e f| 24.60    |
| Burma      | a b c d e f| 24.59    |
| Godavari   | b c d e f| 24.21        |
| Ponorogo   | c d e f | 21.48        |
| Java       | d e f   | 20.69        |
| Kay        | d e f   | 18.99        |
| Ngliron    | e f     | 18.80        |
| Soe        | f       | 15.98        |
| Average    |         | 26.00        |

Note: same alphabets show insignificance

This 31-years-old provenance trial has the average of height and diameter 11.67 m and 26.00 cm, respectively. The average of height is lower than 28-years-old provenance trials in Ghana, West Africa, which are located in 2 plantations with different rainfall rate. The average height is 23.3 m in Pra Anum (1,650 mm) and 20.2 m in Tain II (1,140 mm) [7]. Beside, study of 30-years-old provenance trial in Tanzania has 27.4 m of height and 27.9 cm of diameter [8]. Within the same age, 16 m difference of height is very significant. It might occurred due to the low fertility of soil in Wanagama. In the opposite, the plantation has normal diameter, so the spacing is considered sufficient for teak provenance trial.

Theoretically, evaluation on teak provenance trial should be compared based on environmental condition of provenances origin and its new location. However, environmental conditions were not able to be compared for this plantation because the seeds collected for plantation were actually
brought from the first generation of provenance trial in KPH Bojonegoro. Hence, the provenances seeds are the second generation of the parent trees in each of their origin. They might have had crossed mating in open pollination. There were also lack of information of the seed sources in each provenances, whether they were collected from the single tree or more. There is a high possibility that they have been adapted in KPH Bojonegoro environmental condition. Beside, environmental factors donot always give consistent results. Evaluation on teak provenance trial [9][10] showed that provenance from a given location, did not always performed the same result when planted in other location with the same environmental condition.

Seed from provenances which have good phenotype could be used by local people in their agroforestry directly or as planting materials for developing a new provenance seed stand. Other characteristics evaluation such as stem form, health condition, and wood quality should be done for this plantation. So, we could also get this plantation to be certified.

4. Conclusion

This study concluded that Kouai and Deling provenances are the most adaptive provenance for height and diameter characteristics. Respectively, the heights of both provenances are 14.58 m and 13.86 m, and the diameters are 31.95 cm and 34.73 cm.

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