

## 学 位 論 文 要 旨

Studies on variation of wood properties in plantation-grown teak (*Tectona grandis* L.f.) in Indonesia  
インドネシアにおけるチーク (*Tectona grandis* L.f.) 植林木の木材性質の変異に関する研究

環境資源共生科学専攻 森林資源物質科学大講座

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Teak (*Tectona grandis* L.f.) is an important commercial plantation species. The demand of teak wood is increasing in Indonesia. However, the total wood production of this species is decreasing, because teak wood resources have declined and the productivity of the plantations is still low. Therefore, tree breeding programs have been developed to produce more productive teak forests in Indonesia. Under the tree breeding programs, clonal test sites and seed provenances test sites have been established. In the present study, the growth characteristics and wood properties variation were investigated among clones and seed provenances of teak trees.

The variation of growth characteristics ( $D$ , TH, and  $V$ ), SWV, and  $P$  among 15 clones, their repeatability, interaction between genotype and environment, and correlations between measured characteristics were clarified for 12-year-old teak trees planted at two different sites in Indonesia. Significant differences of all measured characteristics were found among 15 clones at both sites. Their repeatability showed relatively moderate to high values in both sites. These results indicate that these characteristics are closely related to genetic factors. Significant interaction between genotype and environment was found in all measured characteristics, suggesting that interaction between genotype and environment should be considered when the teak plantations are established in Indonesia. In addition, SWV and  $P$  showed lower interaction between genotype and environment than growth characteristics. Highly positive significant correlations were found among growth characteristics ( $D$ , TH, and  $V$ ). These results indicate that growth characteristics are closely related with each other in teak clones. Thus,  $D$  is one of suitable criteria in tree breeding programs of teak for selecting plus trees with good diameter and height growth, and high bole volume. No significant correlation was found between growth characteristics and SWV, suggesting that SWV is independent of growth characteristics of teak trees. Based on these results, wood properties and growth characteristics of teak trees can be improved by application of an appropriate tree breeding program.

Total of 155 trees derived from 21 seed provenances of 24-year-old teak trees planted in Indonesia was used to

clarify the variation of growth characteristics ( $D$ ,  $TH$ , and  $V$ ),  $SWV$ , and  $P$  among seed provenances. Repeatability value and correlations between the measured characteristics were also determined. Significant differences for all measured characteristics were observed among provenances, indicating that these characteristics are genetically controlled. Repeatability of growth characteristics,  $SWV$ , and  $P$  are moderate values. These results indicate potential for improving growth characteristics and wood properties of teak trees with the help of breeding programs. No significant correlations were observed between the growth characteristics and  $SWV$ , indicating that they are independent. It is concluded that mechanical properties are also important criteria for selecting plus trees in tree breeding programs. Principal component analysis revealed that seed provenances from Indonesia (Bangilan, Deling, and Randublatung) and India (Malabar and Central Province) have high scores of growth characteristics and  $SWV$ .

The variation of anatomical characteristics and wood properties among nine clones of 12-year-old teak trees planted in Indonesia were clarified. Their repeatability and relationships among characteristics were also clarified. Significant differences among the nine clones were found in vessel element length ( $VEL$ ), basic density ( $BD$ ), and compressive strength ( $CS$ ). Moderate to high values of repeatability were obtained for fiber diameter ( $FD$ ),  $VEL$ ,  $BD$ , and  $CS$ , indicating that these characteristics are genetically controlled. A significant positive correlation was found between  $BD$  and fiber wall thickness ( $FWT$ ).  $CS$  was also correlated with  $BD$  and  $FWT$ . These results indicate that  $FWT$  is strongly correlated with  $BD$  in teak. Radial variations of  $VD$ ,  $FWT$ ,  $VEL$ , and wood fiber length ( $FL$ ) gradually increased from pith to bark. On the other hand,  $FD$  slightly increased near the pith and then became constant outward. Radial variation of  $BD$  also showed a gradual increase from pith to bark. In addition, radial variation of  $CS$  varied little and slightly increased from pith to bark. Radial variation of  $FL$  with respect to relative distance from the pith showed almost the same pattern for the two radial growth rate categories, suggesting that xylem maturation depends on cambial age rather than stem diameter in teak trees. Therefore, it is considered that after forming the mature wood, intensive silvicultural practices should be applied to produce as much mature wood as possible in teak trees.

The variation of decay resistance, heartwood color, and extractive contents among nine clones, repeatability value, and relationships between mass loss and other characteristics were investigated for 12-year-old teak trees planted in Indonesia. Significant differences among clones were found in mass loss by *Trametes versicolor* and heartwood color ( $L^*$  and  $a^*$  values). Moderate to high value of repeatability was obtained for these characteristics; therefore, it is suggested that these characteristics are genetically controlled in teak trees. No significant differences were found in  $b^*$  value of heartwood, and extractives contents. In addition, low to moderate value of repeatability was found in extractives contents. Furthermore, negatively significant correlation was found between mass loss by *T. versicolor* and 2-(Hydroxymethyl)anthraquinone, suggesting that this compound might be related to decay resistance of teak. Based on these results, decay resistance, heartwood color and 2-(Hydroxymethyl)anthraquinone are important factors to improve the wood durability in teak breeding programs.

In the present study, the growth characteristics and wood properties of teak were varied among clones and seed provenance, suggesting that growth characteristics and wood quality can be improved by application of an appropriate tree breeding programs. In addition, it is considered that using a selection index integrating more than a single property would be effective rather than a single property in teak trees. From based on the results in the present study, it is concluded that the use of better planting material from breeding programs and intensive silvicultural practices brings establishing the more productive teak plantation with high wood quality in Indonesia.