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VARIATION AND RELATIONSHIP OF SELECTED WOOD PROPERTIES IN PLANTED KELEMPAYAN (NEOLAMARCKIA CADAMBA (ROXB.) BOSSER)

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VARIATION AND RELATIONSHIP OF SELECTED WOOD PROPERTIES IN PLANTED KELEMPAYAN (*Neolamarckia cadamba* (Roxb.) Bosser)

By

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LIST OF ABBREVIATIONS

SG - Specific Gravity

GMC - Green Moisture Content

MC - Moisture Content

ST - Tangential Shrinkage

SR - Radial Shrinkage

SL - Longitudinal Shrinkage

SV - Volumetric Shrinkage

MPa - Megapascal

μm - Micron(s)

MOE - Modulus of Elasticity

MOR - Modulus of Rupture

SAS - Statistical Analysis System

ANOVA - Analysis of Variance

LSD - Least Significant Different

dbh - Diameter at Breast Height

DIP - Digital Image Processor

CCD - Charged Coupled Device

FL - Fibre Lumen

FLU - Fibre Lumen Diameter

R - Ray

CW - Cell Wall

VD - Vessel Diameter

Ves - Vessel

FD - Fibre Diameter

FWT - Fibre Wall Thickness

magn. - Magnification

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Chairman : Assoc. Prof. Mohd. Zin Jusoh

Faculty : Forestry

The tall and straight bole of Kelempayan (*Neolamarckia cadamba* (Roxb.) Bosser), a fast-growing indigenous species, has the potential to be used for forest plantation species. This study was carried out to evaluate the inherent properties of the wood. Six planted trees under similar site conditions were sampled along their radii and at five different height levels to evaluate the inherent variation of wood and the influence of anatomical properties on its specific gravity (SG) and bending strength. Overall means for SG was 0.36, green moisture content 174.83 percent (%), tangential shrinkage 6.46%, radial shrinkage 3.28% and volumetric shrinkage 9.90%. The overall means for modulus of elasticity (MOE) and modulus of rupture (MOR) were 7667 and 71 megapascal (MPa), respectively. Vessel comprised 16.69% of wood, ray 11.96% and fibre 71.41%. Fibre length averaged 1.38 millimeter, fibre diameter 35.01 microns, fibre lumen diameter 24.82 microns and fibre wall thickness 5.11

microns. These physical and mechanical properties are similar to many other light hardwoods species, indicating the suitability of wood for general utility timber.

Significant between-tree variations of wood properties were attributed to genetic and micro-environmental factors, thus enabling selection of genetically superior progeny. Within-tree variations were more consistent in radial than in vertical directions, suggesting that age is a more important factor contributing to the variations than height. Middlewood was more stable dimensionally than innerwood and outerwood.

Significant correlations were recorded among the physical properties, tissue proportions and fibre characteristics. Regression analysis indicated that SG could best be predicted in terms of cell wall proportion, fibre diameter and fibre wall thickness, but the best single predictor was fibre lumen diameter. Bending MOE and MOR were found to be heavily dependent on SG. MOE could best be predicted as a function of SG and ray proportion, whereas the main variables influencing MOR were SG, fibre length and fibre lumen diameter.

The suitability of Kelempayan as general utility timber, established in this study, would be enhanced by further research on its seasoning, processing and machining characteristics.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

VARIASI DAN PERHUBUNGAN SIFAT KAYU TERPILIH DALAM KELEMPAYAN (*Neolamarckia cadamba* (Roxb.) Bosser) YANG DITANAM.

Oleh

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Kelampayan (*Neolamarckia cadamba* (Roxb.) Bosser) adalah spesies tempatan yang cepat tumbuh, mempunyai batang yang lurus serta tinggi, berpotensi untuk digunakan sebagai spesies ladang hutan. Kajian ini dijalankan untuk menilai sifat semulajadi kayunya. Enam pokok yang telah ditanam disampel sepanjang jejari dan pada lima ketinggian yang berbeza untuk menilai variasi sifat semulajadi dan pengaruh ciri anatomi terhadap graviti spesifik (SG) dan kekuatan lentur. Pada keseluruhannya min untuk SG ialah 0.36, kandungan lembapan basah 174.83 peratus (%), kecutan tangen 6.46%, kecutan jejari 3.28% dan 9.90% untuk kecutan volumetrik. Min keseluruhan untuk modulus kekenyalan (MOE) dan modulus pecah (MOR) masing-masingnya ialah 7667 dan 71 megapaskal (MPa). Vesel meliputi 16.69% dari keseluruhan kayu, ruji 11.96% dan gentian 71.41%. Purata panjang gentian ialah 1.38 milimeter, diameter gentian 35.01 mikron, diameter lumen gentian 24.82 mikron dan tebal

dinding gentian ialah 5.11 mikron. Sifat fizikal dan mekanikal ini adalah sama dengan kebanyakan spesis kayu keras ringan, menunjukkan kesesuaian kayu ini untuk pelbagai kegunaan am.

Terdapat variasi sifat kayu yang bererti di antara pokok yang disebabkan oleh faktor-faktor genetik dan mikro-persekitaran; dengan ini membolehkan pemilihan progeni yang mempunyai genetik yang baik dibuat. Variasi pada arah jejari dalam sesama pokok adalah lebih konsisten daripada arah tegak, menunjukkan bahawa umur adalah faktor penting yang menyebabkan variasi daripada ketinggian. Dimensi kayutengah adalah lebih stabil daripada kayudalam dan kayuluar.

Korelasi yang bererti telah didapati di antara sifat fizikal, nisbah tisu dan ciri gentian. Analisis regresi menunjukkan SG dapat diramalkan berdasarkan kepada nisbah dinding sel, diameter gentian dan ketebalan dinding gentian tetapi peramal tunggal yang terbaik ialah diameter lumen gentian. MOE dan MOR telah didapati bergantung kuat kepada SG. MOE dapat diramalakan sebagai fungsi SG dan nisbah ruji sementara pembolehubah utama yang mempengaruhi MOR ialah SG, panjang gentian dan diameter lumen gentian.

Kesesuaian Kelempayan sebagai kayu kegunaan am seperti yang telah dikenalpasti oleh kajian ini akan dapat ditambah lagi dengan penyelidikan lanjut mengenai ciri-ciri pengeringan, pemprosesan dan pemesinan.

CHAPTER I

INTRODUCTION

Problem Statement

Kelempayan (*Neolamarckia cadamba* (Roxb.) Bosser) is a fast growing tropical tree species. It grows very well and gregariously in exploited and denuded areas especially after logging. The straight bole and self-pruning characteristics of the tree has attracted attention to the tree as a potentially useful species for tree plantation. The growth characteristics of this tree suggest that under natural regeneration, a dense even-age stand can be formed making it suitable for management as a plantation. The many uses of this tree make it even more attractive to many countries to include this tree in their plantation or reafforestation programmes. Apart from its natural range, this species is already grown as exotics in countries like Western Samoa, Fiji and Puerto Rico (Palmer *et al.*, 1983; Donaldson, 1984; Lugo and Figueroa, 1985).

In its natural distribution, especially in Burma, India and the Philippines, the tree is used for match sticks, poles, pencil slats, carving, wooden shoes, veneer and plywood manufacturing. It has also been used for making cases, furniture and interior finishing. Research has shown that the tree is suitable for pulping

and papermaking for the production of linerboard, bag, wrapping paper and corrugating medium (Peh, 1970; Phillips *et al.*, 1979 and Logan *et al.*, 1984).

Though this tree is found in abundance in Malaysia, it has yet to make its way into the processing mills. Nevertheless as the supplies of the prime natural forest species become scarce and in view of its multiple uses, the future of this tree as a source of raw material is great. The wood industry is expected to rely on considerable portion of the supply of raw materials from this plantation species. In light of this new wood resource which has different characteristics from the prime species, information regarding its characteristics is vital prior to processing.

This tree species is not being utilized because specific knowledge of their properties is inadequate. Studies on the potential utilization of this species should be carried out to investigate whether the wood is desirable for high value products. It appears that considerable information is available on the anatomy, physical and mechanical properties of Kelempayan wood but there is no detailed study on the variation pattern and the relationship between these properties. This study is the first and probably the most intensive of many studies regarding variability of Kelempayan wood and the

influence of anatomical characteristics to its quality and strength.

Objectives

This study is carried out to examine within- and between-tree property variation of Kelempayan wood. The information regarding the anatomy, physical and mechanical properties should be accurately assessed and their variability and relationship determined in order to promote wider utilization. The specific objectives of this study are;

(1) to describe the physical, mechanical and anatomical properties of Kelempayan wood.

(2) to evaluate the variation and correlation among the properties found above.

(3) to deterime the relationship between specific gravity and anatomical properties; and

(4) to determine the relationship of modulus of elasticity and modulus of rupture on specific gravity and anatomical properties.

It is not the intention of this study to determine the best use(s) of the wood but rather to evaluate the inherent characteristics which will have strong bearing on other hardwood species regarding their wood

variability and the relationship between anatomical properties to its physical properties. The information is useful in allocating various parts of the tree as the future resource to appropriate manufacturing processes. The future utilization of this species will undoubtedly reduce the pressure on the need to extract logs from the invaluable forests. This will also result in slowing down the rate of forest exploitation, thus achieving conservation of forest areas.

CHAPTER II

LITERATURE REVIEW

This chapter first present the nomenclature as well as occurrence and distribution of Kelempayan. It then review physical and mechanical properties of the wood, as reported by various researchers. Finally, authors for the quantification of wood anatomy are discussed.

Nomenclature

The tree of this species is known by a variety of vernacular names in accordance to its region of occurrence. It is known as Kelempayan in Peninsular Malaysia (Corner, 1988), kadam in India (Pearson and Brown, 1932), selimpoh in Sarawak (Anderson, 1973) bangkal in Brunei (Browne, 1955) jabon in Indonesia (Mandang *et al.*, 1987), and kaatoan bangkal in the Philippines (Lopez, 1967). In Malaysia the timber is known as laran.

The Kelempayan has gone through a series of changes in its botanical name. Ridley (1923) described the tree as *A. indicus* A. Rich.. Burkhill (1935) however called it *Anthocephalus cadamba* (Roxb) miq.. Later Backer and Backhuizen (1965) changed it to *A. chinensis* (Lamk.) Rich. ex Walp.. Bosser (1984) found that the genus *Anthocephalus* is invalid and formally introduced new