UNIVERSITI PUTRA MALAYSIA

WOOD QUALITY OF XYLIA XYLOCARPA AND KHAYA IVORENSIS PLANTED IN SABAH

JAMES JOSUE

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By

JAMES JOSUE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

April 2002

To:
my beloved wife Flosie
&
sons (Neville & Lovink)

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman: Associate Professor Mohd. Hamami Sahri, Ph.D.

Faculty: Forestry

Xylia xylocarpa and *Khaya ivorensis* are two fast-growing trees that are currently planted on trial basis in Sabah. The wood quality of trees grown in Sabah may differ from those grown in other places due to the environmental factors. Five 9-year-old trees of each species were extracted from their respective plots at Luasong, Tawau. Wood specimens were prepared from three height levels; bottom, middle and top, at the inner and outer radial positions. The within-tree and between-tree variations of anatomical, physical and mechanical properties of these species were analysed.

The characteristics of *X. xylocarpa* are comparable to a number of local popular hardwood species, indicating its suitability for heavy construction uses. The mean vessel diameter, ray width, ray height and fibre length are 124 μm, 49.8 μm, 605 μm and 1135 μm, respectively. The basic density, oven-dry density and green moisture content (MC) are 0.72 g/cm^3, 0.78 g/cm^3 and 49.8% respectively. The shrinkage from green to oven-dry conditions

for the radial and tangential directions are 3.35% and 5.76%, respectively. Based on the International Standard Organisation (ISO) standard, the overall means for modulus of rupture (MOR), modulus of elasticity (MOE), compression parallel to grain (Comp), radial shear (Shear-R), tangential shear (Shear-T), radial hardness (Hard-R) and tangential hardness (Hard-T) are 135 N/mm^2, 12861 N/mm^2, 68.3 N/mm^2, 18.95 N/mm^2, 23.38 N/mm^2, 7.86 kN and 7.40 kN, respectively.

The wood properties of *K. ivorensis* are comparable to a number of fast-growing light hardwood species, indicating its potential for general utility timber. The vessel diameter, ray width, ray height and fibre length are 118 μm, 56.6 μm, 306 μm and 1351 μm, respectively. The mean basic density, oven-dry density and green MC are 0.44 g/cm^3, 0.48 g/cm^3 and 55.4%, respectively. The shrinkage from green to oven-dry conditions for the radial and tangential directions are 3.20% and 7.26%, respectively. The overall means for MOR, MOE, Comp, Shear-R, Shear-T, Hard-R and Hard-T are 71.11 N/mm^2, 6873 N/mm^2, 38.21N/mm^2, 9.48 N/mm^2, 13.49 N/mm^2, 2.64 kN and 2.72 kN, respectively.

The trend of within-tree variations for most properties were more consistent in radial rather than vertical direction. This suggests diameter growth to be a more important factor contributing to the variations compared to height. Samples from the outer part of the stem were found to have higher density, shrinkage and mechanical strengths. The between-trees variations of some wood properties were found to be significantly different, probably due to genetic and micro-environmental factors.

Significant correlation was recorded among the physical properties of both species. The regression analysis indicated that the density of *X. xylocarpa* could be best predicted based on fibre length and vessel diameter ($R^2 = 0.56$), and the best single predictor is fibre length ($R^2 = 0.51$). The vessel diameter was found to be the main predictor for the density of *K. ivorensis*. The density was also the best predictor for all mechanical properties, irrespective of the tree species.

The true potential of *X. xylocarpa* and *K. ivorensis* for their respective end-uses would be enhanced by further research such as the study on properties of wood from different sites and other properties like durability, seasoning, processing and machining characteristics.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KUALITI KAYU *XYLIA XYLOCARPA* DAN *KHAYA IVORENSIS* YANG DITANAM DI SABAH

Oleh

JAMES JOSUE

April 2002

Pengerusi: Profesor Madya Mohd. Hamami Sahri, Ph.D.

Fakulti: Perhutanan

Xylia xylocarpa dan *Khaya ivorensis* merupakan pokok cepat tumbuh yang sedang ditanam secara percubaan di Sabah. Kualiti kayu bagi pokok-pokok yang ditanam di Sabah mungkin berbeza dengan pokok-pokok yang ditanam di tempat yang lain oleh sebab faktor alam sekitar. Lima pokok yang berusia sembilan tahun dari setiap spesis telah diperolehi dari plot masing-masing di Luasong, Tawau. Sampel diambil daripada tiga paras ketinggian iaitu, bawah, tengah dan atas dan daripada dua kedudukan jejari iaitu, bahagian dalaman dan luaran untuk mendapatkan spesimen bagi kajian variasi ciri-ciri anatomi, fizikal dan mekanikal di dalam dan di antara pokok-pokok.

X. xylocarpa mempunyai ciri-ciri kayu yang setanding dengan beberapa spesis kayu keras berat tempatan yang terkenal, menggambarkan kesesuaiannya untuk digunakan dalam industri benaan. Purata garispusat vesel, lebar ruji, ketinggian ruji dan panjang gentian masing-masing ialah 124 μm, 49.8 μm, 605 μm dan 1135 μm. Ketumpatan asas, ketumpatan kering

ketuhar dan kandungan lembapan segar masing-masing adalah 0.72 g/cm^3, 0.78 g/cm^3 dan 49.82%. Kadar pengecutan dari keadaan segar hingga kering ketuhar pada arah jejari dan tangen masing-masing ialah 3.35% dan 5.76%. Berdasarkan piawaian International Standard Organisation (ISO), purata modulus kepecahan (MOR), modulus kekenyalan (MOE), mampatan selari dengan ira (Comp), kekuatan ricih radial (Shear-R), kekuatan ricih tangen (Shear-T), nilai kekerasan radial (Hard-R) dan nilai kekerasan tangen (Hard-T) masing-masing adalah 135 N/mm^2, 12861 N/mm^2, 68.30 N/mm^2, 18.95 N/mm^2, 23.38 N/mm^2, 7.86 kN dan 7.40 kN.

K. ivorensis mempunyai ciri-ciri kayu yang setanding dengan beberapa spesis kayu keras ringan jenis cepat tumbuh, menggambarkan kesesuaiannya untuk pelbagai kegunaan am. Purata garispusat vesel, lebar ruji, ketinggian ruji dan panjang gentian masing-masing ialah 118 μm, 56.6 μm, 306 μm dan 1351 μm. Ketumpatan asas, ketumpatan kering ketuhar dan kandungan lembapan segar masing-masing adalah 0.45 g/cm^3, 0.48 g/cm^3 dan 55.45%. Kadar pengecutan dari keadaan segar hingga kering ketuhar pada arah jejari dan tangen masing-masing ialah 3.20% dan 7.26%. Purata MOR, MOE, Comp, Shear-R, Shear-T, Hard-R dan Hard-T masing-masing adalah 71.11 N/mm^2, 6873 N/mm^2, 38.21 N/mm^2, 9.48 N/mm^2, 13.49 N/mm^2, 2.64 kN dan 2.72 kN.

Variasi di dalam pokok bagi kebanyakan ciri-ciri kayu adalah lebih konsisten pada arah jejari atau mendatar berbanding dengan arah menegak. Ini menggambarkan pertumbuhan diameter pokok adalah faktor yang lebih penting kepada variasi, berbanding ketinggian. Sampel daripada bahagian luaran didapati mempunyai ketumpatan, kadar pengecutan dan

kekuatan mekanikal yang lebih tinggi. Variasi di antara pokok-pokok bagi beberapa ciri-ciri kayu didapati mempunyai perbezaan yang bererti, mungkin disebabkan faktor genetik dan alam sekitar.

Perkaitan yang bererti telah diperolehi di antara ciri-ciri fizikal kedua-dua spesis. Analisa regresi menunjukkan bahawa ketumpatan *X. xylocarpa* boleh diramal dengan baik oleh faktor panjang gentian dan garispusat vesel ($R^2 = 0.56$), dan panjang gentian ($R^2 = 0.51$) merupakan faktor tunggal yang terbaik untuk meramal nilai ketumpatan. Garispusat vesel didapati sebagai peramal utama ketumpatan *K. ivorensis*. Ketumpatan juga menjadi peramal terbaik untuk semua ciri-ciri mekanikal kedua-dua spesis.

Potensi kegunaan-akhir sebenar *X. xylocarpa* dan *K. ivorensis* akan menjadi lebih jelas melalui penyelidikan susulan seperti kajian ke atas ciri-ciri kayu dari tempat yang berbeza, dan kajian ciri-ciri yang lain seperti ketahanan semulajadi, pengeringan, pemprosesan dan pemesinan.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Varianve
Comp.	Compression Parallel to Grain
DBH	Diameter Breast Height
EMC	Equilibrium Moisture Content
FL	Fibre Length
FRC	Forest Research Centre
FRIM	Forest Research Institute Malaysia
FSP	Fibre Saturation Point
Hard-R	Radial Hardness
Hard-T	Tangential Hardness
ISO	International Standard Organisation
LFC	Luasong Forestry Centre
MAI	Mean Annual Increment
MC	Moisture Content
MOR	Modulus of Rupture
MOE	Modulus of Elasticity
R-W	Ray Width
R-H	Ray Height
SAFODA	Sabah Forestry Development Authority
SD	Standard Deviation
SFI	Sabah Forest Industries Sdn Bhd.
Shear-R	Radial Shear
Shear-T	Tangential Shear
TAPPI	Technical Association of Pulp and Paper
V	Vessel Diameter

CHAPTER I

INTRODUCTION

Sabah is one of the 13 states in Malaysia. It extends between latitudes of 4^{o} 7' and 7^{o} 23' north of the equator and between longitudes of 115^{o} 7' and 119^{o} 17' east of Greenwich, covering an area of 7, 394,191 hectares or approximately 22 percent of the total area of Malaysia. The forestry sector has always been the backbone of Sabah's economy. During the period of 1980-1997, forestry contributed an average of about RM2.69 billion per year in terms of foreign exchange earnings through the export of forest products, while revenue from forest resources was at an average of RM717.5 million annually (Anon., 1997). However, past exploitation of the forest resource has reduced the production capacity of the natural forest. Major commercial timber resources are dwindling and the timber processing industry is desperately searching for additional and alternative raw materials.

In light of this, forest plantation or man-made forest has been gaining importance, not only for the supply of raw materials, but also to sustain the existing timber resources. The state policy on forest plantations emphasises on long term strategy to switch the production base from natural forest to plantation forest which shall provide the bulk of the production capacity. The long term target is to produce at least 6 million m^3 of planted woods annually without compromising the tendency to substitute natural forest with plantation forests (Anon., 1997). Accordingly, there has been a dramatic increase in the area of plantation forests in Sabah. At the end of 1999, plantation forest for timber supply covered approximately 138,400 hectares of

the total planted area which include 23,600 hectares of rattan, established mainly by the private sectors (Anuar, 1997).

The importance of forest plantations in the state is also reflected by the establishment of a number of new agencies which are involved in the research and development of forest plantation. Initially, most of the development of commercial forest plantation were carried out by Sabah Softwood Sdn. Bhd. (SSSB), Sabah Forestry Development Authority (SAFODA) and Sabah Forest Industries Sdn. Bhd. (SFI). However, the late 1980's and early 1990's witnessed the participation of other privately owned companies and individuals such as Luasong Forestry Centre (LFC), Sejati Sdn. Bhd., Koprosa Sdn. Bhd., Boonrich Sdn. Bhd and KTS (Plantation) Sdn. Bhd..

The preferred species for planting are mostly exotic species like *Acacia mangium*, *Paraserianthes falcataria*, *Gmelina arborea*, *Eucalyptus* spp., *Araucaria* spp. and *Pinus* spp. mainly due to their fast growing characteristic and their ability to produce quality timber or at least timber for general purposes. Of late, many new private companies have shown keen interest to venture into plantations of *Tectona grandis* (teak) and *Azadiractha excelsa* (sentang) which are being intensively promoted in Malaysia.

Obviously, the existence of many promising fast-growing exotic species has or may have provided the wood-based industry with new resources of raw material. However, technical issues relating to species choice and utilisation potential need further research and development work. The ever increasing demand of forest produces globally would need to