UNIVERSITI PUTRA MALAYSIA

WOOD QUALITY OF TEN-YEAR-OLD SENTANG (*Azadirachta excelsa*) GROWN FROM SEEDLINGS AND ROOTED CUTTINGS

NORDAHLIA BINTI ABDULLAH SIAM

WOOD QUALITY OF TEN-YEAR-OLD SENTANG (*Azadirachta excelsa*) GROWN FROM SEEDLINGS AND ROOTED CUTTINGS

By

NORDAHLIA BINTI ABDULLAH SIAM

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

January 2009

Specially dedicated to:

My beloved father Abdullah Siam b. Alias and mother Hamidah bt. A.R. Hassan

Your love always in my heart

My beloved husband Khairul Iman b. Khairuddin

Your love has kept me going on

My beloved father and mother in law Khairuddin b. Kamaruddin and Mariam bt. Din

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

WOOD QUALITY OF TEN-YEAR-OLD SENTANG (*Azadirachta excelsa*) GROWN FROM SEEDLINGS AND ROOTED CUTTINGS

By

NORDAHLIA BINTI ABDULLAH SIAM

2009

Chairman: Associate Professor Zaidon Ashaari, PhD

Faculty: Forestry

Seeds of sentang were exhibit recalcitrant and cannot be stored for a long period of time. So efforts have been made to propagate this species vegetatively via rooted cuttings technique. It is envisaged that for the technique to be deemed successful, the quality of wood that it produces should be comparable with or better than the wood extracted from the natural forest or established plantation via seedlings. The main objective of this study was to determine and compare the wood qualities of the trees grown from seedlings and rooted cuttings and to study the property variations within the tree. The specific objectives of these studies were to evaluate the macroscopic features, anatomical, physical, mechanical properties and resistance to fungal decay of sentang which grown from these two propagation techniques. Correlations between anatomical, physical and mechanical properties of the wood were also analysed. The studies of both types of wood were done at three different height levels, i.e bottom, middle and top and also in the sapwood and heartwood

portion. Data were subjected to Analysis of Variance (ANOVA) and further analysed using Least Significant Difference (LSD) at $p \leq 0.05$.

The barks of both types of wood were smooth and pinkish grey. There was significant difference in colour of sapwood and heartwood between these two propagation techniques where the sapwood from seedling trees was lighter than those from rooted-cutting trees. However, the heartwood of the latter was darker. The mean percentage of sapwood-heartwood ratio was not significantly different between these two types of wood and the amount of sapwood-heartwood ratio increased towards the top. The anatomical structure in both types of wood is similar with typical sentang. Vessels are diffuse, solitary or multiple, round to oval shaped and filled with dark-coloured dried extractives deposits in the heartwood. Apotracheal and paratracheal parenchyma are present in both types of wood. Tangential section shows multiseriate rays which mostly 2-3 cells wide and heterocellular rays were observed in the radial section in both types of wood. The rooted-cutting wood showed higher value in fibre dimensions, vessel diameter and proportion of vessels, whereas vessel density and proportion of fibre were higher in the seedling wood and proportion of rays was not significantly different between both types of wood. Both the seedling and rooted-cutting wood showed a decreasing trend towards the top in fibre dimensions, vessel diameter and proportion of rays. Increasing trend was observed in vessel density and proportions of vessels and fibres. The sapwood exhibited higher value in fibre dimensions, proportion of rays and larger vessel diameter but lower value in vessel density and proportions of vessels and fibres than the heartwood in the seedling wood.

However, in the rooted-cutting wood there was no significant difference between sapwood and heartwood in proportion of rays, vessels and fibres.

Both types of wood were not significantly different in basic density. Moisture content at green condition and shrinkages in green to air-dry and green to oven-dry conditions were higher in the rooted-cutting wood, but tangential and radial shrinkages from green to oven-dry conditions showed no significant difference between both types of wood. The physical properties of both types of wood showed a decreasing trend from the bottom to the middle of the tree and then a slight increasing trend towards the top. Basic density was higher in the sapwood but moisture content and shrinkages in both conditions were higher in the heartwood.

Compression and shear parallel to the grain were higher in the seedling wood, however MOE was higher in the rooted-cutting wood and MOR showed no significant difference between the seedling and rooted-cutting wood. Mechanical properties showed increasing trend towards the top and higher values in the heartwood in both types of wood. All the mechanical properties in the seedling and rooted-cutting wood were significantly related with vessel diameter, proportion of fibres and volumetric shrinkage with small correlation. Basic density was weakly correlated with mechanical properties in this present study. Both types of wood were classified as resistant with rooted-cutting wood being more resistance to white rot fungus (*Lentinus sajor-caju*) than the seedling wood. The resistance of the wood to fungal decay decreased towards the top and higher resistance was shown in the heartwood than the sapwood portion.

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

KUALITI KAYU SENTANG (*Azadirachta excelsa*) BERUMUR SEPULUH TAHUN YANG DITANAM SECARA BIJI BENIH DAN KERATAN PENGAKAR

Oleh

NORDAHLIA BINTI ABDULLAH SIAM

2009

Pengerusi: Profesor Madya Zaidon Ashaari, PhD

Fakulti: Perhutanan

Biji benih sentang adalah rekalsitran dan tidak boleh disimpan dalam jangka masa yang lama. Oleh itu, usaha telah diambil untuk menanam spesies ini secara vegetatif menggunakan teknik keratan pengakar. Teknik ini dijangka akan berjaya di mana kualiti kayu yang dihasilkan seharusnya sama atau lebih baik daripada kayu yang diambil dari hutan asli atau dari perladangan yang ditanam secara biji benih. Objektif utama kajian ini adalah untuk menentukan dan membandingkan kualiti kayu pada pokok yang ditanam secara biji benih dan keratan pengakar dan untuk melihat variasi sifat kayu pada pokok tersebut. Objektif spesifik penyelidikan adalah untuk mengenalpasti sifat makroskopik, anatomi, fizikal, mekanikal dan ketahanan kayu terhadap kulat pereput bagi pokok sentang dari dua teknik penanaman ini. Kajian terhadap korelasi di antara sifat-sifat anatomi, fizikal dan mekanikal juga dijalankan. Kajian bagi kedua-dua jenis kayu dijalankan pada tiga paras ketinggian yang berbeza iaitu bahagian bawah, tengah dan atas serta pada gubal dan teras kayu. Data dianalisis

menggunakan analisis varian (ANOVA) dan seterusnya dianalisis menggunakan perbezaan minimum yang ketara (LSD) pada $p \leq 0.05$.

Kulit pokok bagi kedua-dua jenis kayu adalah licin dan berwarna kelabu kemerah muda. Terdapat perbezaan bererti bagi warna pada kayu gubal dan kayu teras bagi kedua-dua teknik penanaman ini. Kayu gubal pada kayu anak benih adalah lebih cerah berbanding kayu keratan pengakar. Manakala, kayu teras lebih gelap pada kayu keratan pegakar. Purata peratus kayu gubal tiada perbezaan bererti antara kedua-dua teknik penanaman ini dan meningkat ke bahagian atas pokok. Struktur anatomi pada kedua-dua jenis kayu adalah menyamai dengan sentang tipikal. Sel salur adalah tunggal, beganda, berbentuk bulat atau oval, dipenuhi dengan ekstraktif pada bahagian kayu teras. Terdapat parenkima apotrakeal dan paratrakeal pada kedua-dua jenis kayu. Bahagian tangen menunjukkan ruji multiseriat yang lazimnya mengandungi 2-3 sel dan ruji heterosel didapati di bahagian radial pada kedua-dua jenis kayu. Kayu keratan pengakar menunjukkan nilai yang tinggi dalam sifat gentian, diameter sel salur dan peratusan sel salur, manakala ketumpatan sel salur dan peratusan gentian adalah tinggi bagi kayu biji benih dan peratusan ruji mununjukkan nilai yang tidak bererti diantara kedua-dua teknik ini. Keputusan dari sifat anatomi didapati kayu biji benih dan kayu keratan pengakar menunjukkan penurunan ke bahagian atas bagi sifat gentian, diameter sel salur dan peratusan ruji, manakala ketumpatan sel salur, peratusan sel salur dan gentian meningkat ke bahagian atas. Sifat gentian, diameter sel salur, peratusan ruji adalah tinggi di bahagian kayu gubal, manakala ketumpatan sel salur, peratusan sel salur dan gentian adalah tinggi di bahagian kayu teras pada kayu biji benih. Manakala, pada kayu keratan pengakar,

tiada perbezaan bererti antara bahagian kayu gubal dan kayu teras bagi peratusan ruji, sel salur dan gentian.

Ketumpatan asas menunjukkan nilai tidak bererti di antara kedua-dua jenis kayu manakala kandungan lembapan pada keadaan basah dan pengecutan bagi keadaan basah ke kering udara dan basah ke kering oven adalah tinggi pada kayu keratan pengakar, tetapi pengecutan tangen dan pengecutan radial dari keadaan basah ke kering oven menunjukkan nilai tidak bererti antara kedua-dua teknik penanaman. Kedua-dua jenis kayu menunjukkan penurunan dari bahagian bawah ke bahagian tengah kemudian meningkat sedikit ke bahagian atas bagi sifat fizikal. Ketumpatan asas tinggi di bahagian kayu gubal, manakala kandungan lembapan dan pengecutan bagi kedua-dua keadaan tinggi di bahagian kayu teras.

Mampatan dan kekuatan ricihan selari ira tinggi pada kayu biji benih, tetapi MOE adalah tinggi pada kayu keratan pengakar dan MOR menunjukkan nilai tidak bererti antara kayu biji benih dan kayu keratan pengakar. Sifat mekanikal menunjukkan peningkatan ke bahagian atas dan nilai yang tinggi di bahagian kayu teras bagi kedua-dua jenis teknik penanaman. Semua sifat mekanikal pada kayu biji benih dan kayu keratan pengakar adalah berkolerasi secara bererti dengan diameter sel salur, peratusan gentian dan pengecutan volumetrik. Ketumpatan adalah berkolerasi sangat rendah dengan sifat mekanikal pada kajian ini. Kedua-dua kayu dikelaskan sebagai rintang dengan kayu dari keratan pengakar lebih rintang terhadap kulat pereput putih. Ketahanan kedua-dua kayu menurun ke bahagian atas dan kerintangannya adalah tingi di bahagian kayu teras berbanding kayu gubal.

ACKNOWLEDGEMENTS

In the Name of Allah, The Most Merciful and The Most Gracious. Praise goes to ALLAH Almighty for I have been blessed with the strength and ardour to finally accomplish this thesis.

First of all, I would like to express my sincere gratitude and appreciation to Associate Professor Dr. Zaidon Ashaari, Chairman of the Supervisory Committee, for his constant guidance, assistance and suggestions throughout the preparation of this thesis. Heartiest thanks are also due to Dr. Ani Sulaiman for her constant support, encouragement and invaluable advice. I would also like to express my profound gratitude to Prof. Dr Mohd Hamami Sahri for his invaluable suggestions and constructive comments.

I am indebted to the Director General of the Forest Research Institute Malaysia (FRIM) Dato' Dr. Abd. Latif Mohmood for the scholarship grants (RA Scheme). Sincere appreciation is also extended to Dr. Mohamad Omar Mohamad Khaidzir, Dr. Salmiah Ujang, Dr. Ahmad Zuhaidi Yahya, Dr. Mohd Khairun Anwar Uyup and Dr Hamdan Husain for their cooperation and constant support in this project. Cooperation from other FRIM staff Mr. Mohd Zahari Mohd Noor, Mrs Norjihan Abu Bakar, Mrs Rohana Idris, Mr Lim S.C, Mr. Sabri Ahmad, Mr Mohd Jamil Abd. Wahab, Mrs Chong Y.T, Mr. Roszalli Mohd, Mr. Abd Karim Nasir, Mr. Abd Ghani Mohamad, Mr. Rosdi Koter, Mr. Kamarul Hizam Hamsan, Mr. Mahat Judin, Mr. Zakaria Yusoff and others is also greatly appreciated.

To my father Mr. Abdullah Siam Alias, my Mother Mrs. Hamidah A. R. Hassan, my grandmother (Mrs Hjh. Sujirah Tasim) my brothers (Mohd Azrai'i and Muhammad A'mmar) and my sister (Nor Dalila Sa'adah), I render my gratitude and thanks for their advices, patience, concern, support and sacrifices. My appreciations also extended to my father and mother in law (Mr. Khairuddin Kamaruddin and Mrs. Mariam Din) and brothers (Khairil Nizam and Muhd Nur Izham) for their encouragement and support. Special thank to my beloved husband Mr. Khairul Iman Khairuddin, who are always concern with my study and have given me support to improve myself, your love has kept me going on.

I certify that an Examination Committee has met on **9th January 2009** to conduct the final examination of Nordahlia binti Abdullah Siam on her Master of Science thesis entitled "Wood Quality of 10-year-old Sentang (*Azadirachta excelsa*) Grown from Seedlings and Rooted Cuttings" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Digree) Regulations 1981. The committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

H'ng Paik San, PhD
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Edi Suhaimi Bakar, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Faizah Abood, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Razak Wahab, PhD
Associate Professor
School of International Tropical Forestry
Universiti Malaysia Sabah
(External Examiner)

_____
HASANAH MOHD. GHAZALI, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Zaidon Ashaari, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Mohd Hamami Sahri, PhD
Professor
Faculty of Forestry
Universiti Putra Malaysia
(Member)

Ani Sulaiman, PhD
Senior Research Officer of Wood Anatomy
Forest Research Institute of Malaysia
(Member)

_____

HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 9 April 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledge. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

NORDAHLIA BINTI ABDULLAH SIAM

Date: 16 March 2009

TABLE OF CONTENTS

Table	LIST OF TABLES	Page

Figure	LIST OF FIGURES	Page

Plate	LIST OF PLATES	Page
2.1	Pseudo-tap roots in 6-year-old jelutong propagated by tissue culture	28
3.1	10-year-old tap root system of seedlings sentang, Plot 48, Bukit Hari, (FRIM)	38
3.2	10-year-old pseudo-tap root system of rooted cuttings sentang, Plot 44, Bukit Hari, (FRIM)	38
4.1	Barks of the 10-year-old sentang grown from (a) seedlings and (b) rooted cuttings	51
4.2	Discs of the 10-year-old sentang grown from (a) seedlings and (b) rooted cuttings	52
4.3	Cross section from the heartwood of the 10-year-old wood cut from the seedling sentang which was similar in anatomical structure to the wood cut from the rooted-cutting sentang and typical wood of sentang (magnification 50X)	56
4.4	Cross section from the sapwood of the 10-year-old wood cut from the seedling sentang which was similar to the anatomical structure with wood cut from the rooted-cutting and typical wood of sentang (magnification 50X)	56
4.5	Tangential section from the heartwood of the 10-year-old wood cut from the rooted cutting sentang which was similar in anatomical structure to the wood cut from the seedling sentang and typical wood of sentang (magnification 50X)	57
4.6	Radial section from the sapwood of the 10-year-old wood cut from the rooted-cutting sentang which was similar in anatomical structure to the wood cut from the seedling sentang and typical wood of sentang (magnification 50X)	57
6.1	Bending test (MOR and MOE)	114
6.2	Compression parallel to the grain test	115
6.3	Shear parallel to the grain test	116
6.4	Compression at the top and splintering tension at the bottom were observed in both types of wood of sentang	125
6.5	Crushing at the top was observed in both types of wood of sentang	126

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASTM	American Standard Testing Method
BS	British Standard
CFFPR	Compensatory Forest Plantation Project
CWT	Fibre Wall Thickness
DBH	Diameter Breast Height
F (%)	Fibre proportion
FD	Fibre diameter
FL	Fibre Length
FRIM	Forest Research Institute Malaysia
HW	Heartwood
L	Longitudinal Shrinkage
LD	Fibre Lumen Diameter
LSD	Least Significant Difference
LVL	Laminated Veneer Lumber
MC	Moisture Content
MOE	Modulus of Elasticity
MOR	Modulus of rupture
MTC	Malaysian Timber Council
MTIB	Malaysia Timber Industry Board
R	Radial Shrinkage
R (%)	Ray proportion
SAS	Statistical Analysis Software