UNIVERSITI PUTRA MALAYSIA

EFFECTS OF THINNING ON GROWTH AND SAP FLOW IN NINE-YEAR-OLD *AZADIRACHTA EXCELSA* (JACK) IN MERLIMAU, MELAKA, MALAYSIA

ROSDI KOTER

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By

ROSDI KOTER

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

July 2007

To My Wife, Patahayah Mansor and Children, Hafidz, Haziq, Hakeem, Haris and Nureen Asiah

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

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July 2007

Chairman : Associate Professor Ahmad Ainuddin Nuruddin, PhD

Faculty : Forestry

Since 1997, the forest plantation in Malaysia has gained further momentum with the inclusion of selected indigenous species for forest plantation development. Considering the size of plantations being established, the need for studies on silvicultural operation is widely recognized. Until now, except for *Acacia mangium*, there was no specific model on silviculture and maintenance of each species being planted in Malaysia. The objectives of this study were to quantify the effects of thinning regime on the diameter growth, stand volume and crown structure and to determine the effect of sap flow of thinned and unthinned *A. excelsa* stands.

The study was conducted in the, Sime Darby Estates, Merlimau, Melaka. The *A.excelsa* stands were planted at an initial spacing of 3 x 4 m (833 stem ha^{-1}) over 2 hectares in May 1995. There were two treatments used for this study; unthinned as control and moderate thinning, where 50% of the stand

were felled systematic according to lines. In addition sap flow velocity of selected trees in both treatments were measured using heat pulse probe connected to data logger.

During the study, the achieved mean diameter at breast height of *A. excelsa* was 14.30 ± 0.81 cm and the mean of the potential final crop trees (300 trees ha^{-1}) of 18.99 ± 0.78 cm. The mean periodic annual diameter increment was 1.87 ± 0.07 cm $year^{-1}$ before thinning and 1.60 ± 0.08 cm $year^{-1}$ 23 months after thinning. The periodical annual diameter increments are not significantly different between plots after 23 months. The diameter increment is still increasing indicating that the growth of the species has not reached the optimum rate.

The response to thinning also includes the effect on the expansion of the crowns. Results presented from this trial have indicated that the thinning has a positive effect on crown development in which thinned *A.excelsa* stand reached up to 6.5 m in length, as compared with the unthined treatment up to 5.0 m. The crown length increment was significantly, being greater by quantify by 30% in the thinned plot. The crown radial of both unthinned and thinned stand varied from 0.2 to 3.6 m and 0.1 to 4.2 m respectively.

The amount of water loss in the thinned stand was significantly higher than those in the unthinned plot, 0.53 liter/hour compared with 0.32 liter/hour respectively. The rate of water loss for *A. excelsa* at thinned stand was higher than those from unthinned stand with a total of 12.02 liters and 10.27

liters over day respectively. Higher soil moisture content was also observed in thinned plot compared to unthinned plot.

This study provides useful information on the growth of *A.*excelsa due to thinning activities by creating the gap opening and the water loss implication after thinning was undertaken. Such information is useful in making long-term growth projections with growth adjusted to variation of microclimate within the stand.

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

KESAN PENJARANGAN KE ATAS PERLADANGAN SENTANG (*Azadirachta excelsa* (Jack).) BERUMUR 9 TAHUN DI MERLIMAU, MELAKA, SEMENANJUNG MALAYSIA

Oleh

ROSDI KOTER

July 2007

Pengerusi : Profesor Madya Ahmad Ainuddin Nuruddin, PhD

Fakulti : Perhutanan

Sejak tahun 1997, perladangan hutan di Malaysia telah berkembang ke peringkat yang lebih intensif. Mengambilkira kepada saiz ladang yang menunjukkan pertambahan dari segi keluasan dan adalah perlu diberikan penekanan terhadap penyelidikan di dalam operasi silvikultur. Hingga kini, masih tiada model silvikultur dan penyelenggaraan yang khusus untuk spesies pokok yang di tanam secara ladang di Malaysia kecuali untuk *Acacia mangium*. Objektif kajian ini dijalankan ialah untuk mengukur kesan penjarangan ke atas pertumbuhan diameter, isipadu dirian, bentuk batang dan struktur dan untuk mengenalpasti kesan penggunaan air di dalam dirian yang dijalankan penjarangan dan tidak dijalankan penjarangan.

Kajian ini telah dijalankan di Estet Sime Darby, Merlimau, Melaka. Dirian ini telah ditanam pada bulan Mei 1995 dengan jarak awal 3 x 4 m (833 pokok /ha) di kawasan seluas 2 ha. Kajian dijalankan untuk menentukan kesan penjarangan ke atas pertumbuhan pokok dan penggunaan air.

Purata pencapaian diameter paras dada ialah 14.30 ± 0.81 cm. Manakala potensi pokok akhir (300 pokok/ha) mencapai purata diameter sebanyak 18.99 ± 0.4 cm. Pertambahan diameter tahunan didapati tidak menunjukkan perbezaan yang bererti antara tahun dan plot dengan purata pertambahan diameter tahunan ialah 1.87 ± 0.07 sm per tahun sebelum penjarangan dan 1.60 ± 0.10 sm per tahun selepas dua tahun penjarangan. Pemerhatian juga menunjukkan pertambahan purata diameter tahunan masih meningkat dan belum lagi mencapai tahap kemuncak.

Kesan penjarangan juga dapat diperhatikan ke atas pertambahan silara. Keputusan menunjukkan bahawa penjarangan telah memebrikan kesan yang positif terhadap perkembangan silara di mana dirian yang dijalankan penjarangan mencapai 6.5 m tinggi silara berbanding dengan dirian tanpa penjarangan yang hanya mencapai 5.0 m tinggi silara. Perbezaan ini menunjukkan terdapat pertambahan sebanyak 30% apabila penjaranagn di jalankan. Jejari silara pula menunjukan nilai dari 0.2 hingga 3.6 m dan 0.1 hingga 4.2 m masing-masing untuk dirian tanpa penjaranagn dan yang dijalankan penjarangan.

Keputusan juga menunjukkan bahawa kadar kehilangan air adalah tinggi iaitu sebanyak 12.024 liter berbanding dengan yang tidak dilakukan penjarangan (kawalan) iaitu dengan kadar 10.273 liter dalam sehari. Kadar purata kehilangan air menunjukkan terdapat perbezaan bererti di mana penggunaannya ialah sebanyak 0.53 liter/sejam bagi petak penjarangan manakala 0.32 liter/sejam bagi petak kawalan. Kandungan kelembapan air

tanah juga didapati tinggi di petak yang dijalankan penjarangan berbanding petak kawalan.

Kajian ini dapat dijadikan asas dalam menyediakan data pertumbuhan sentang kesan dari penjarangan yang mengakibatkan pembentukan ruang hutan dan kadar kehilangan air selepas penjarangan dijalankan. Kesemua maklumat ini amat berguna dalam membuat perancangan masa hadapan melalui unjuran pertumbuhan berasaskan kepada variasi mikro-iklim di dalam dirian.

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Finally, I would like to dedicate this work to my parents, my wife Fatah and my children Hafidz, Haziq, Hakeem, Haris and Nureen, who without their love and devotion, this study would not have been completed. I love you all!

I certify that an Examination Committee has met on 13th of July 2007 to conduct the final examination of Rosdi Koter in his Master of Science thesis entitled "Effect Of Thinning On Nine Years Old *Azadirachta Excelsa* (Jack) Plantation In Merlimau, Melaka, Peninsular Malaysia" in accordance with Universiti Putra Malaysia (Higher Degree) Act 1980 and Universiti Putra Malysia (Higher Degree) Regulations 1981. The Committee recommended that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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

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Date: 13 December 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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ROSDI KOTER

Date: October

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LIST OF ABBREVIATIONS

asl	Above Sea Level
Anon	Anonymous
ANOVA	Analysis of Variance
DBH	Diameter at Breast Height
DMRT	Duncan's Multiple Range Test
FAO	Food Agriculture Organization
FDPM	Forestry Department Peninsular Malaysia
FRIM	Forest Research Institute Malaysia
GLM	Generalized Linear Model
ha	Hectare
PROC	Procedure
SAS	Statistical Analysis System
UPM	Universiti Putra Malaysia
PPFD	Photosynthetic Photon Flux Density

CHAPTER I

INTRODUCTION

General Introduction

Forest plantation in Malaysia-background

The history of forest plantation in Malaysia began in 1800 with the introduction of exotic tree species such as rubber (*Hevea brasiliensis*) and teak (*Tectona grandis*). *H. brasiliensis* was first introduced in Malaysia in 1877 when nine seedlings of rubber were planted at Kuala Kangsar in the state of Perak.

By the early 1900's the demand for natural rubber had increased dramatically as the result of the expansion of car and electrical industries. Introduction of new land regulations also stimulated interests in rubber planting. The suitability of climatic conditions and the liberal government allocation of land, coupled with the availability of cheap labour led to rapid expansion of rubber land in Malaysia. The rubber trees seemed to thrive better in Malaysia than its native habitat in Brazil particularly for being more resistance against natural diseases and pests. By the end of 1999 a total of 1,700 ha of pilot rubber forest plantations had been established in various locations.

Teak, the most notable exotic timber species planted in plantation in this country, was first introduced in Penang in the 1800's and the earliest teak plantation was initiated at Sungai Raya in Langkawi Island around 1915. The

planting of teak was then extended to mainland Kedah and Perlis in 1940s and 1950s. By the end of 2001, the total teak plantation established in Peninsular Malaysia is 3,107 ha.

During the late 1950s and early 1960s, large scale pilot planting of several fast growing exotic species was conducted, particularly *Pinus, Araucaria* and *Eucalyptus species,* mainly in expectation of the establishment of the pulp and paper industry in Peninsular Malaysia. The planting of pine was discontinued in 1980 when the proposal to set up pulp and paper mill in Peninsular Malaysia was cancelled.

Meanwhile, the search for potential fast growing hardwood species continues persistently. Several exotics including *Acacia mangium, Paraserianthes falcataria* and *Gmelina arborea* were identified as potential species for the establishment of short-rotation forest plantation, to produce general utility timber. Hence in 1982 the Compensatory Forest Plantation Project (CFPP) was launched in the states of Pahang, Johore, Selangor and Negeri Sembilan with the projected target of 188,000 ha. The project was jointly funded through loans from the Government of Malaysia and the Asian Development Bank. However, in 1992, there was a moratorium imposed on the planting of *A. mangium* due to the widespread occurrence of heart rot disease in most plantation sites.

Concurrently, potential of utilizing local species was also being explored. Species such as Sentang (*Azadirachta excelsa*) has caught the attention of the plantation industry. This species has shown good growth rates in early years and is almost pest free. Planting of *A. excelsa* was initiated by the

State Forestry Departments in 1993 and 1994, including Kelantan and Terengganu (Forest Department Peninsular Malaysia, 1999). Since then the interest to plant *A. excelsa* has increased. A number of smallholders have replanted their rubber with *A. excelsa* especially in the states of Terengganu and Johore. In 1997 the government, through the Forest Research Institute of Malaysia (FRIM) and other forestry agencies started to promote *A. excelsa* for forest plantation (Baskaran, 1997). By 1999 the Forest Department of Peninsular Malaysia had established 1765 ha of *A. excelsa* plantations (Forest Department Peninsular Malaysia, 2000).

In 2001, forest plantations of Peninsular Malaysia covered a total area of 74,804 ha comprising mainly of *A. mangium* and small percentage of *P. falcataria* and *G. arborea.* More than 15 000 ha were planted in 1988 and more than 10 000 ha in 1985. Most of the plantations were established during the first phase of the Compensatory Forest Plantation Programme between 1982 and 1988. Since 1989, an annual planting rate had never exceeded 7 000 ha (Baskaran & Ong, 2003). There was a dramatic drop in planting rate after 1998 due to the economic recession across Southeast Asia since late 1997.

Problem statements

The study of growth and yield of forest stands is a central issue in forestry research and management. In recent years, much emphasis has been placed on the growth and yield of mixed tropical forest and management activities related to.(Lieberman & Lieberman 1987; Vanclay 1989; Yong 1990; Silva *et al.* 1995; Ong & Kleine 1995; Alder 1995; Kohler & Huth 1998) and sub-tropical forests (Rautiainen, Pukkala, T. & Miina 2001). However, a full understanding of the growth and yield of plantation-grown indigenous tropical species such as *A. excelsa* is still lacking. Thus, this study was initiated after recognizing the importance of growth and yield studies of plantation-grown indigenous fast growing species for future forest management decisions, coupled with a general paucity of knowledge on the growth and potential yield of the species planted under plantation condition. The species of *A. excelsa* is regarded among the most promising indigenous species for forest plantation in Peninsular Malaysia and future reforestation works with this species will cover a wide spectrum of land areas including flat, undulating and even sloping topography.

Considering the size of plantation being established, the need for studies on silvicultural operation is more widely recognized. Until now, except for *Acacia mangium*, there was no specific model on silviculture and maintenance of each species being planted in Malaysia. Most of the planting is based on general plantation silviculture and management. Thinning treatment for instance, gives a strong effect on the wood quality and the

yield. Therefore, as each tree species performed differently, the treatment should be modeled accordingly to fit the growth behavior of the species.

Study on the influence of thinning on environmental factors is usually neglected, although the cause of success or failure may be found in changes in these factors brought about by the thinning operation. Studies of environmental changes will not be necessary in all thinning plots. However, sufficient studies should be made to show how much these factors are altered by thinning practices. For example, if it can be shown that changes in water use are most important, thinning should be made that creates optimum conditions.

Only few studies have been made in Malaysia to study the water use in relation to stand density with subjected to natural forest stand conditions only (Siti Aishah, 2004)..Therefore when such management practice need to be developed to a particular species in forest plantation it is important to monitor not only the growth but also water uses which is related to the water budget of the area.

The studies provide an opportunity to generate baseline information for future planting of *A. excelsa* under plantation condition. Information on growth and potential yield of the species can be used in the planning for future establishment and management planning for future *A. excelsa* plantations,while the sapflow study can provide information on how thinning

regimes has the potential on helping the forest to retain water in the soil and evaporation.

In this thesis, the initial goal is to evaluate the growth performance and sap flow within a thinning and adjacent unthinned stand of *Azadirachta excelsa*. The knowledge will assist in establishing the best methods of thinning, and in addition provide information on tree growth due to thinning activities.

Objectives

1. To evaluate and compare growth between thinned and unthinned stand of. *A.excelsa*
2. To evaluate variation of microclimate within a thinned and adjacent unthinned stand.

Hypotheses

H_0: i) There is no significant effect on tree growth due to thinning.

ii) There is no significant effect on water use before and after thinning

H_1: i) There is significant effect on tree growth due to thinning.

ii) There is significant effect on water use before and after thinning