UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCE AND ECONOMIC EVALUATION OF ACACIA MANGIUM WILLD. PLANTED AT DIFFERENT SPACINGS

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By

SINHSAMOUTH PHOUTHAVONG

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Dedicated to
My Beloved Father Simounthone Phouthavong
and Mother Khampheungchai Phouthavong,
Whose dream comes true.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
B/C Ratio	Benefit/Cost Ratio
CFPP	Compensatory Forest Plantation Project
Dbh	Diameter at Breast Height
IRR	Internal Rate of Return
MPTS	Multipurpose Tree Species
NPV	Net Present Value
PNG	Papua New Guinea
RCBD	Randomized Complete Block Design
SAFODA	Sabah Forest Development Authority
SFI	Sabah Forest Industries
SSSB	Sabah Softwood Sdn. Bhd.
UNDP	United Nations Development Programme
UPM	Universiti Putra Malaysia

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: Professor Nik Muhamad bin Nik Ab. Majid, Ph. D.

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Acacia mangium Willd. is one of the fast-growing timber species planted widely in Malaysia to overcome the expected timber deficit for the wood based industries. However, comprehensive studies on planting distance and economic evaluation of *A. mangium* planted at different spacings have not been well documented.

A trial plot at Universiti Putra Malaysia Serdang, Malaysia planted with *A. mangium* at five different spacings; namely S_1 (2.0 m x 2.0 m), S_2 (2.5 m x 2.5 m), S_3 (3.0 m x 3.0 m), S_4 (3.5 m x 3.5 m) and S_5 (4.0 m x 4.0 m) was investigated to determine specifically the survival percentage, total height, diameter at breast height, volume, growth and yield prediction up to 15 years, soil physical and chemical properties, and relationship between tree growth and soil properties. Economic

analysis of each spacing (with project) vs. 3.0 m x 3.7 m spacing (without project) was also conducted.

The experimental results indicate that spacing S_2 achieved the best survival percentage (81%) and the best mean total height growth (20.40 m). The biggest mean diameter at breast height growth (21.46 cm) was recorded for spacing S_5. The analysis of variance indicated that spacing does not affect total height growth, but affects diameter at breast height. The highest mean volume (0.407 m^3) was found in spacing S_5 and the highest wood volume per hectare (585.12 m^3) was for spacing S_1 at 70 months old. The growth prediction using Gompertz model showed that spacing S_2 recorded the highest mean total height value (24.77 m) and spacing S_5 had the biggest mean diameter at breast height (26.20 cm). The highest predicted mean merchantable volume (0.581 m^3) was for spacing S_5. The yield prediction showed that spacing S_1 produced the highest wood volume (211.44 m^3) per hectare at year 15.

The analysis of variance showed that the soil chemical properties only differed significantly in carbon and iron. The correlation analysis showed that tree growth was not significantly correlated with most of the soil properties.

The results of economic analysis indicated that spacing S_1 was the most viable and profitable activities using IRR (14.01%). The sensitivity analysis showed that the changes in costs and benefits have low impact on the NPV, B/C ratio and IRR of S_1. Therefore, S_1 (2.0 m x 2.0 m) could be the most promising spacing in terms of wood production and economic returns.

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

PRESTASI PERTUMBUHAN DAN PENILAIAN EKONOMI BAGI *ACACIA MANGIUM* WILLD. PADA JARAK PENANAMAN YANG BERBEZA

Oleh

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September 1998

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Acacia mangium Willd. adalah salah satu spesis pokok yang cepat tumbuh yang ditanam secara meluas di Malaysia untuk mengatasi kekurangan bekalan kayu balak bagi industri berasaskan kayu. Bagaimanapun, kajian yang terperinci ke atas jarak tanaman dan penilaian ekonomi bagi *A. mangium* pada jarak berbeza masih belum direkodkan sepenuhnya.

Satu plot percubaan di Universiti Putra Malaysia, Serdang, Malaysia yang merangkumi penanaman *A. mangium* pada lima jarak penanaman yang berbeza; iaitu S_1 (2.0 m x 2.0 m), S_2 (2.5 m x 2.5 m), S_3 (3.0 m x 3.0 m), S_4 (3.5 m x 3.5 m) dan S_5 (4.0 m x 4.0 m) telah dijalankan bagi menentukan peratus kemandiran, tinggi pukal, diameter pada paras dada, isipadu, pertumbuhan dan jangkaan hasil sehingga 15 tahun, ciri fizikal dan kimia tanah, dan perkaitan antara pertumbuhan pokok dan ciri

tanah. Analisa ekonomi bagi setiap jarak (dengan projek) vs. jarak 3.0 m x 3.7 m (tanpa projek) turut dijalankan.

Keputusan telah menunjukkan jarak S_2 mempunyai peratus kehidupan (81%) dan pertumbuhan tinggi pukal (20.40 m) yang terbaik. Pertumbuhan diameter paras dada terbaik (21.46 cm) direkod untuk jarak penanaman S_5. Analisa varian menunjukkan jarak penanaman tidak memberi sebarang kesan keatas pertumbuhan tinggi pukal tetapi membawa kesan keatas diameter paras dada. Putara isipadu terbesar (0.407 m^3) ditemui dalam jarak tanaman S_5 dan isipadu kayu per hektar tertinggi (585.12 m^3) pada jarak tanaman S_1 pada usia 70 bulan. Jangkaan pertumbuhan ladang *A. mangium* pada usia menggunakan model Gompertz menunjukkan jarak tanaman S_2 merekodkan nilai purata tinggi pukal tertinggi (24.77 m) dan jarak tanaman S_5 mempunyai purata diameter paras dada terbesar (26.20 cm). Jangkaan purata isipadu jadual dagang (0.581 m^3) didapati pada jarak tanaman S_5. Jangkaan hasil menunjukkan jarak tanaman S_1 menghasilkan isipadu kayu tertinggi (211.44 m^3) per hektar pada usia 15 tahun.

Analisa varian menunjukkan ciri kimia tanah hanya mempunyai perbezaan yang nyata dalam karbon dan besi. Keputusan analisa korelasi menunjukkan pertumbuhan pokok adalah tidak menpunyai perkaitan yang rapat dengan hampir keseluruhan ciri tanah.

Keputusan analisa ekonomi menunjukkan bahawa jarak S_1 adalah aktiviti yang paling boleh-guna dan menguntungkan menggunakan IRR (14.01%). Keputusan analisa sensitiviti menunjukkan perubahan dalam kos dan keuntungan mempunyai pengaruh yang rendah ke atas NPV, nisbah B/C dan IRR bagi S_1. Oleh demikian, S_1 (2.0 m x 2.0 m) mungkin menjadi jarak tanaman yang terbaik untuk penghasilan kayu dan pulangan ekonomi.

CHAPTER I

INTRODUCTION

General Background

The world's demand for wood is increasing as the population grows, while the natural forest resources are depleting, particularly in the tropical developing countries. In most tropical countries, large portions of these natural forests have been converted to other alternative land uses, particularly for agricultural development. The conversion of forestlands is also attributed to other activities such as shifting cultivation, development of dam for hydroelectric generation and reservoir, encroachment and illegal logging. These factors led to deforestation, which in turns affect future timber supply and ecological balance.

The World Bank has estimated that the tropical forest areas are cleared at a rate of 15 to 20 million hectares per year. At the level of demand prevailing then, the remaining tropical forest would disappear in 60 to 80 years (Evans *et al*., 1992). According to Food and Agriculture Organization estimates for the Asia-Pacific region, the rate of annual deforestation for the last 10 years was close to 4.7 million hectares per year (FAO, 1993). The FAO State of the World's Forest reported that during 1991-1995 there was an estimated net loss of 56.3 million hectares worldwide. The annual rate of loss in developing countries remains high at 0.65 percent; tropical Asia-Oceania has the highest rate at 0.98 percent. However, a comparison of the annual loss of natural forests for the periods 1980-90 and 1990-95 with estimates of 15.5 million hectares and 13.7 million hectares per annum, respectively, indicates that the rate may be slowing (Prebble, 1997). One of the challenges that the world faces today is to sustain future timber supply to meet escalating demand. Therefore, it appears that rehabilitation and reforestation are one of the most promising solutions to solve this problem.

In Malaysia, plantation forestry began as early as in 1950's with the planting of *Tectona grandis* (Teak) in the northern states of Perlis and Kedah. The aim was to produce high quality timber. To date, there are about 1,800 hectares of such plantations being established. Then various trial plots were established with the main objective of selecting suitable tree species for the production of high quality timber and pulpwood on degraded sites (Barnard and Beveridge, 1957). However, in the 1960's, research was focused on the establishment of softwood plantations for the production of pulp and paper industry. The com-mercial plantation began in 1973 in Sabah with the establishment of 60,000 hectares of tropical pines; in 1979 in Sarawak about 10,000 hectares of fast-growing hard-wood species and in Peninsular Malaysia in 1960 about 5,600 hectares of tropical pines.

The first pilot softwood plantation programme was initiated in Peninsular Malaysia in 1967 with the assistance of the United Nations Development Programme

(UNDP), an executing agency for the Food and Agriculture Organisation of the United Nations (Freezailah, 1967). The purpose of the project was to demonstrate suitable techniques for the establishment and management of large-scale softwood planta-tions for pulpwood production. The Ulu Sedili Forest Reserve in Johore and Kemasul Forest Reserve in Pahang were selected for this large-scale forest plantation project. About 5,600 hectares of the softwood plantations were established in these two forest reserves, planted mainly with *Pinus caribeaea* (Johari and Chin, 1986).

The first commercial reforestation project in Peninsular Malaysia, known as the Compensatory Forest Plantation Project (CFPP), was started in 1982 with the main objective of producing general utility sawn timber (Thang and Zulkifli, 1992; Yong, 1985). The sawn-timber produced from this plantation is expected to be comparable to the Light Red Meranti (*Shorea* spp.). In the initial plan, about 188,200 hectares of the unproductive lowland forests had been planned for conversion into forest plantations over a period of 15 years (Harun, 1981; Yong, 1985; Johari, 1987). The project planned to establish about 82,000 hectares of plantations based on 15-year rotation of fast-growing hard-wood species such as *Acacia mangium*, *Gmelina arborea* and *Paraserianthes falcataria*. So far almost 55,000 hectares of such plantations have successfully established throughout Peninsular Malaysia. This was expected to contribute about 35 percent of the total log production of Peninsular Malaysia or about 2.63 million cu m of timber, with the first harvest by 1998 (Johari, 1987).

Initially, five species of fast growing hardwood species, namely *A. mangium* Willd., *Gmelina arborea* Roxb., *Paraserianthes falcataria* Nielsen (synonym with *Albizia falcataria*), *Maesopsis eminii* Engl., and *Eucalytus deglupta* Blume had been proposed for CFPP (Sheik Ali, 1982). Nevertheless, the last two species were not selected due to wood utilization problems. *M. eminii* has inherent growth stress which causes the sawn timber to warp and distort, while *E. deglupta* trees were found to be infected by heart rot fungi that made the logs hollow.

Reforestation projects have also been initiated in Sabah and Sarawak to ameliorate extensive degraded forestland resulting from shifting cultivation and logging activities.

In Sabah, three private and state agencies have participated in the reforestation project. These are Sabah Softwood Sdn. Bhd. (SSSB), Sabah Forestry Develop-ment Authority (SAFODA), and Sabah Forest Industries (SFI). The objectives of the reforestation project vary between agencies. SAFODA was established in 1976 to afforest 200,000 hectares of shifting cultivation areas. The agency was formed for the rehabilitation of degraded lalang grassland and poor forests with fast growing timber trees on west coast of Sabah. At the same time the agency is also responsible for the resettlement of rural population who resides in the project area. SSSB and SFI on the other hand, are companies established for the development of commercial forest plantations for industrial wood production. SSSB started as early as 1973 to establish 60,000 hectares of tropical pines in Tawau. SFI, which establishes the first pulp and paper mill in the country, involved in the reforestation programme in 1980's. The total area of forest plantations established by these three agencies by the end of 1994 was 90,000 hectares (Thai and Mahdan, 1995). Unlike Peninsular Malaysia, forest plantations in Sabah are managed for pulpwood production. As of 1997, the total plantation established in Sabah was about 112,679 hectares, of which 90,026 hectares (79.9 %) are under fast growing species such as *A. mangium,* 2,049 hectares of Teak and 20,602 hectares of Rattan (Lim, 1997).

In Sarawak, about 60,000 ha of natural forest are destroyed annually due to shifting cultivation practices constituting an annual loss of 2.7 million cu m of logs (Lau, 1979). Programmes have been initiated to reforest the degraded forestland in the state with suitable timber species, but forest plantation development in this timber-rich state is rather slow. The reforestation programme which started in 1979 managed to establish about 10,000 hectares of forest plantations until the end of 1996 (Lim, 1997). The species planted were *A. mangium, Araucaria cunninghamii, Gmelina arborea*, *Swietenia macrophylla, Shorea* spp. (illipe nut), and *Durio zibethinus*.

Since the beginning of the plantation programme in Peninsular Malaysia, *A. mangium* has been grown more widely than the other two species, *Gmelina. arborea* and *Parasieranthes falcataria*. This was due of its rapid initial growth rate, less site demanding and competes well with weeds (Tham, 1979; Johari and Chin, 1986). Hence, more than 80 percent of the CFPP area had been planted with this species.

The goal in plantation forestry is often to produce high quality timber in the shortest possible time (Dale and Sonderman, 1984). Since spacing and hence stand density affect both quality and growth of tree, it is important to carry out spacing trials in order to determine the most suitable spacing to be adopted for any species in plantation forestry.

In Peninsular Malaysia *A. mangium* trees are planted at 3.0 m x 3.7 m spacing, which is considered as the most appropriate planting distance. However, different planting distances might be necessary, depending on the kind of timber needed for the manufacture of the final product. For instance, trees planted for pulp would not necessarily require straight bole and may require closer planting distance. However, the trees are planted for sawn timber production, it is necessary that they should have straight bole and produce high volume of wood, which require different planting distance than trees planted for pulp. Thus, the relationship between timber volume and spacing is important to achieve optimum economic returns in the long run.

Despite of its impressive initial growth performance, the planting of *A. mangium* has been based on only one spacing interval, that is 3.0 m x 3.7 m. This planting distance was based on experience in other countries and it might not be the best spacing in Malaysia because of differences in environmental and climatic factors.