UNIVERSITI PUTRA MALAYSIA

THREE YEAR GROWTH PERFORMANCE OF ACACIA CRASSICARPA PROVENANCES AT SERDANG, MALAYSIA

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THREE YEAR GROWTH PERFORMANCE OF *ACACIA CRASSICARPA* PROVENANCES AT SERDANG, MALAYSIA

By

BOUNHOM THEPPHAVONG

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Forestry Universiti Putra Malaysia

October 1997

Dedicated to Lao People's Revolutionary Party

and Government

for their Support

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to Assoc. Prof. Dr. Kamis Awang, the chairman of my supervisory committee, for his constant guidance, suggestions and encouragement throughout the preparation of this thesis. I am highly indebted to Assoc. Prof. Dr. Lim Meng Tsai and Assoc. Prof. Dr. Nor Aini Abd Shukor for their invaluable suggestions and comments.

I would like also to take this opportunity to express my thanks to the Faculty of Forestry, Universiti Putra Malaysia for the permission given to undertake this study. My sincere appreciation goes to all lecturers of Faculty of Forestry for their help during the study period. Thanks are also extended to Messrs. Latib, Salim, Zakaria, Razak for their help in the field work.

I am greatly thankful to Mr. Kampheuane Kingsada, Director General of Lao Department of Forestry, Lao People's Revolutionary Party and Lao Government, for granting me study leave and SIDA for the scholarship to pursue this programme.

I would like to thank my wife, Somphone Thepphavong and my children, Alounya and Anouda Thepphavong for their continuous support and patience during the entire study period. Lastly, I express my gratitude to my parents and God, the invisible power, for providing me continuous flow of energy to undertake this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
ANOVA	Analysis of variance
ATSC	Australian Tree Seed Centre
CFPP	Compensatory Forest Plantation Project
CSIRO	Commonwealth Scientific and Industrial Research Organization
Dbh	Diameter at breast height
FAO	Food and Agriculture Organization of the United Nations
ITTO	International Tropical Timber Organization
IND	Indonesia
MAI	Mean Annual Increment
MPTS	Multipurpose Tree Species
NT	Northern Territory
PNG	Papua New Guinea
QLD	Queensland
SAFODA	Sabah Forest Development Authority
SFI	Sabah Forest Industries
VOB	Volume Over Bark
VUB	Volume Under Bark
UPM	Universiti Putra Malaysia
USA	United States of America

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

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October 1997

Chairman: Associate Professor Kamis Awang, Ph.D.

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A trial at Universiti Putra Malaysia (UPM) Serdang, Malaysia consisting of eight provenances of *A. crassicarpa* Cunn. ex. Benth. was measured at three years for survival, height, diameter, tree form, specific gravity, biomass of components, volume, form factor, and leaf area. One provenance was from Irian Jaya, Indonesia, four were from Papua New Guinea, and three were from northern Queensland. All provenances survived well (>94.7 %), but they differed significantly (P<0.05) in their growth performance. Provenances from Samlleberr, Irian Jaya, Indonesia, Olive River, Queensland, Limal Malam, Papua New Guinea were found to be most promising in terms of mean height, diameter, tree form, biomass, volume, and leaf area growth.

Equations to predict total biomass (both over and under bark) of eight provenances of *A. crassicarpa* were derived using data from 30 trees from each provenance. Regressions based on logarithmic transformations of both dependent and

independent variables were found to give the best estimates of biomass components. Log Dbh was found to be a good predictor of biomass components and was used as the independent variable.

$$\log T1 = -0.76749 + 2.30116 . \log Dbh$$
$$\log T2 = -0.87307 + 2.30627 . \log Dbh$$

The highest dry total biomass over and under bark of 66.1 and 50.8 tonnes/ha was recorded by the Samlleberr provenance from Irian Jaya, Indonesia.

Equations to predict total volume (both over and under bark) of eight provenances of *A. crassicarpa* were derived using data from 30 trees from each provenance. Regressions using $(Dbh)^2.H$ as the independent variables were found to give the best estimate of volume.

$$VOB = 0.001708 + 0.357034.(Dbh)^2.H$$
$$VUB = 0.007400 + 0.302753.(Dbh)^2.H$$

Samlleberr, Irian Jaya, Indonesia provenance recorded the highest volume over and under bark of 95.5 and 80.2 m^3/ha, form factor of 0.47 and leaf area of 33,551 m^2/ha. For further plantation trials, the provenances from Samlleberr Irian Jaya, Indonesia, Olive River, Queensland and Limal Malam, Papua New Guinea have been identified to be promising for further testing in the different environmental conditions.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi syarat keperluan untuk ijizah Master Sains.

PRESTASI PERTUMBUHAN PADA TIGA TAHUN BAGI PROVENANS *ACACIA CRASSICARPA* DI SERDANG, MALAYSIA

Oleh

BOUNHOM THEPPHAVONG

October 1997

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Satu ujian di Universiti Putra Malaysia (UPM) Serdang, Malaysia yang melibatkan lapan provenans *A. crassicarpa* Cunn. ex. Benth telah diukur pada tiga tahun untuk tahap kemandirian, ketinggian, diameter, bentuk pokok, ketumpatan bandingan, komponen biomass, isipadu, faktor bentuk dan luas daun. Satu provenans adalah dari Irian Jaya, Indonesia, empat dari Papua New Guinea, dan tiga adalah dari utara Queensland. Kesemua lapan provenans mempunyai tahap kemandirian yang baik iaitu melibihi 94.7 %, tetapi mempunyai perbezaan yang bereti pada ($P<0.05$) bagi prestasi pertumbuhan mereka. Provenans Samlleberr Irian Jaya, Indonesia, Olive River, Queensland, Limal Malam, Papua New Guinea mempunyai potensi kadar yang baik dari segi nilai min ketinggian, diameter, bentuk pokok, biomass, isipadu dan luas daun.

Persamaan untuk meramalkan jumlah biomass (luar dan dalam kulit) bagi semua lapan provenans *A. crassicapa* diperolehi dengan menggunakan data dari 30 pokok dari setiap provenan. Regresi transformasi logaritma menghasilkan anggaran terbaik untuk komponen biomass bagi keseluruhan blok. Log Dbh (diameter paras dada) didapati boleh menjadi penganggaran yang baik untuk komponen biojisim dan telah digunakan sebagai angkubah bebas. Paras tertinggi jumlah biomass kering bagi dalam dan luar kulit adah 66.1 dan 50.8 tan/ha masing-masing telah direkodkan oleh provenan Samlleberr, Irian jaya, Indonesia.

log T1 = - 0.76749+2.30116.log Dbh
log T2 = - 0.87307+2.30627.log Dbh

Persamaan untuk meramalkan jumlah isipadu (luar dan dalam kulit) bagi kesemua lapan pronenan *A. crassicapa* adalah diperolehi dengan menggunakan data daripada 30 pokok untuk setiap provenan. Regresi yang menggunakan $(Dbh)^2$.H sebagai angkubah bebas didapati menghasilkan anggaran isipadu yang terbaik bagi keseluruhan blok

VOB = 0.001708+0.357034.$(Dbh)^2$.H
VUB = 0.007400+0.302753.$(Dbh)^2$.H

Provenans Samlleberr Irian Jaya, Indonesia telah mencatatkan isipadu luar dan di dalam kulit yang tertingi iaitu 95.5 dan 80.2 m^3/ha, 0.47 bagi faktor bentuk dan 33.551 m^2/ha bagi luas daun. Bagi percubaan ladang yang seterusnya, provenans Samlleberr Irian Jaya, Indonesia, Olive River, Queensland, dan Limal Malam, Papua New Guinea telah dikenalpasti mempunyai potensi untuk di gunakan dalan ujikaji selanjutnya yang melibatkan pelbagai keadaan persekitaran.

CHAPTER I

INTRODUCTION

General Background

Forests are fundamental and vital components of the ecosystems. Forests provide enormous social services to the society in the form of shelter, timber, food and raw material. They play a vital role in providing clean water for drinking and irrigation. They protect our watershed and regulate the supply of water for industrial uses. Tropical forests cover approximately 40 % of the total land area of the world. Tropical forest resources have the potential to make a substantial contribution to development by meeting some of the basic needs of rural populations, contributing to food security, supporting industrial growth, maintaining environmental quality, providing habitats for wildlife, wood, and many other products.

The essential links between forests and human are now receiving renewed attention, and there is increasing awareness of the value of forest to life on earth. The rapid increase in the world population, especially in the developing countries and the shrinkage in the area of forest land, increases the demand for diversified products. There is a growing awareness by the people of a shrinking resource base. Forests are under alarming pressure due to many major factors including logging, shifting cultivation, floods and forest fire (Kamis Awang, 1995).

The world's demand for wood continues to increase while deforestation continues to threaten both the ecological balance and future timber supply. According to Food and Agriculyure Organization of the United Nations (FAO) estimates for the Asia-Pacific region, the rate of annual deforestation for the last 10 years was close to 4.7 million ha per year (FAO, 1993). One of the challenges we now face is to get new sources of timber to meet this escalating demand. Forest plantation appears to be one of the most promising solutions.

The production of tropical sawn and veneer logs in International Tropical Timber Organization (ITTO) producer member countries totalled 123.8 million m^3 in 1995. The top four tropical log producing countries (Malaysia, Indonesia, Brazil and India) contribute to over 83 percent of the production (ITTO, 1996). Establishing forest plantation is one of the most appropriate ways of meeting escalating demands of wood supply at a time when global forest resources are steadily decreasing.

Various species have been selected in the past for tree planting depending on the objectives and areas available. These include teak (*Tectona grandis*), pines (e.g. *Pinus caribaea*, *P. patula*), mahogany (*Swietenia macrophylla*) eucalypts (e.g. *Eucalyptus camaldulensis*, *E. deglupta*), yemane (*Gmelina arborea*), batai (*Paraserianthes falcataria*) and ipil-ipil (*Leucaena leucocephala*) (Evans, 1982).

However, in the last one and half decades, several tropical acacias including *Acacia mangium*, *A. auriculiformis*, *A. aulacocarpa* and *A. crassicarpa*, particularly the first two have been planted on increasingly large scales (Kamis Awang and Taylor, 1992).

In Peninsular Malaysia, establishment of plantation forest was initiated in 1957 with the planting of *T. grandis* (teak) in the northern states of Perlis and Kedah. The aim was to produce high quality timber. To date, about 1,800 ha of such plantation have been established. In 1960's and early 1970's, planting of tropical pines, mainly *P. caribaea*, was carried out in the states of Selangor, Pahang, Johor, Negeri Sembilan for the intended pulp and paper industry. The planting of pines was stopped when the proposed industry was abandoned. About 5,600 ha of pine plantation were establishment (Thai and Mahdan, 1995).

A large-scale forest plantation programme known as the Compensatory Forest Plantation Project was then launched in 1982 with the main objective to supplement the shortage of timber supply from natural forests which was expected to occur between 1996 and 2010 (Mohd Darus and Lokman,1989). The project planned to establish about 82,000 ha of plantations based on 15 year rotation of fast-growing hardwood species such as *A. mangium, G. arborea* and *P. falcataria.* So far almost 55,000 ha of such plantation have been successfully established throughout Peninsular Malaysia (Thai and Mahdan, 1995).

In Sarawak, forest plantation was started in 1979. It involved the rehabilitation of shifting cultivation land. At the end of 1994, the total area planted was about 10,000 ha, mainly with *A. mangium, G. arborea, Shorea macrophylla,* and *Araucaria cunninghamii*.

The successful introduction of *A. mangium* into Sabah, Malaysia from Australia in 1966, promoted this species to a major fast-growing tree in forest plantation programmes in Asia and the Pacific. As at 1993, over 150,000 ha of *A . mangium* have been planted worldwide, and the area covered is expanding rapidly (Kamis Awang and Taylor,1993). Subsequently, the Sabah Forestry Development Authority (SAFODA) was established in 1976 to afforest 200,000 ha of shifting cultivation areas. In 1980s many more private companies were involved in the programme including the Sabah Forest Industries (SFI) which established the first pulp and paper mill in the country. Until the end of 1994, some 90,000 ha of forest plantation have been established in Sabah (Thai and Mahdan, 1995).

The selection of species for plantation is a multi-stage process which has to satisfy a variety of requirements. Firstly, the species has to grow well in the climatic, soil and environmental conditions of the intended sites. Next the wood must be suitable for the proposed uses. Finally the system must be optimised to provide the maximum amount of high quality products per hectare per year. Two acacias, *A.mangium* and *A. auriculiformis*, have shown good performance in earlier trials. These two species have been introduced into several tropical and sub-tropical countries and are grown as commercial plantations (Kamis Awang and Taylor, 1993; Turnbull and Kamis Awang, 1997).

A. mangium is preferred in Malaysia and Indonesia and *A. auriculiformis* in India and China. In many countries, plantation-grown trees will become increasingly important for the supply of industrial wood. Later species and provenance trials have identified other acacias with good potential for tropical and sub-tropical plantations (Boland *et al.*, 1990). Since acacias may be grown for various uses, it is highly desirable to assess the various properties of these species to determine their suitability.

The importance of forest plantation becomes more significant as they could play a major role in the long-term national timber production strategy. The programme is in line with the International Tropical Timber Organization's (ITTO) 2000 target which requires that all trades of tropical timber and timber products must be produced only from sustainably managed forests. Since 1979, the Australian Tree Seed Centre (ATSC), of CSIRO's Division of Forestry, has been the principal organisation involved in research on seed collection for *A. mangium, A. auriculiformis, A. crassicarpa* and *A. aulacocarpa* from throughout the species natural ranges, collection sites and the selection of the better known provenances. Large areas of land in Southeast Asia are being planted to acacias and eucalypts for timber, paper and pulp production. *A. crassicarpa* is one of them. It is a fast-growing species that is easy to grow as it is adaptable to a wide range of conditions.

In Malaysia, there have been species and provenance trials of various acacias for different purposes (Sim 1992; Nor Aini *et al*., 1992; Kamis Awang *et al*., 1995).

Problem Statements

In the last two decades, vast areas of natural rain forest in Malaysia have been cleared mainly for agricultural development, mining, infrastructure development and exploitation of timber. In 1955, forest constituted about 75 % of the total land of Peninsular Malaysia. This was further reduced to about 55 % in 1970, about 50 % in 1980 and about 48 % in 1990. In view of the general increase in demand for wood, paper and paper products, the pattern does not seem to keep pace with timber demand. It is anticipated that Peninsular Malaysia will face an acute shortage of timber well before the year 2000 (Freezaillah, 1981).

The soil fertility problems associated with the forest clearance are further aggravated by soil degradation, caused by soil erosion and nutrient leaching. There is a need to find suitable tree species which can help to rehabilitate the degraded (e.g. shifting cultivation) soils. Tropical acacias (*A. mangium*, *A. auriculiformis* and *A. crassicarpa*) have the potential to overcome this quandary but the advantages of these acacias have not been widely explored yet under Malaysian conditions.

A. crassicarpa is one of the fast growing acacia species originated from Australia, Papua New Guinea and Indonesia. Its wood is can be used in the manufacturing of plywood, particle board, pulp, paper and for fuelwood. Since it is a nitrogen fixer, it can help in improving soil fertility, reducing soil erosion and nutrient leaching. Early reports on the evaluation of several *A. crassicarpa* provenances in Thailand (Chittrachumnonk and Sirilak, 1991), Malaysia (Kamis Awang *et al*., 1995), Sri-Lanka (Weerardane and Vivekanandan, 1991), Hainan Island, China (Yang and Zeng, 1991) and Laos (Latsamay, 1991) indicate that their growth is either better or comparable to those of *A. mangium* and *A. auriculiformis*. These provenance trials of *A. crassicarpa* have also demonstrated the superior vigour of provenances from Western Province, Papua New Guinea over those from north Queensland (Thomson, 1994). In Malaysia, the introduction of *A. crassicarpa* has been limited to Sabah (Sim and Gan, 1991). Therefore more research is needed particularly on its genetic improvement and silvicultural aspects.

Research Objectives

The present study aims to evaluate the growth performance of eight *A. crassicarpa* provenances at Universiti Putra Malaysia (UPM), Serdang, Malaysia. The specific objectives of the study were to:

(i) compare the growth performance of eight provenances of *A. crassicarpa* in terms of survival, height, diameter, tree form, specific gravity.

(ii) develop biomass allometric relationships and comparison biomass of eight provenances.

(iii) develop a volume table for *A. crassicarpa* and comparison volume, form factor and leaf area of eight provenances.

CHAPTER II

LITERATURE REVIEW

Introduction

Many of the considerations of species and provenance testing are common to both. Many countries, particularly in the tropics are at an early stage of tree introduction. Initially, this usually involves species and provenance trials. However, the successful implementation of a plantation programme would require efforts in research and development in a number of areas of establishment including the production of high number of quality planting stocks, continuous genetic improvement through breeding and additions to the species being planted. These have to be supplemented by continuous research on the physiological, ecological and silvicultural requirements of growth and out-planting of the species, as well as ways to utilise the various end products.

Tropical Acacias

Acacias in general belong to the family of *Leguminosae* of sub-family *Mimosoidae*. There are about 1,100 species in the genus *Acacia* of which over 850 occur in Australia and neighbouring Papua New Guinea (PNG) and Indonesia. The remainder are endemic largely to Africa and tropical America (Boland *et al.,* 1984).

Many of these acacias are found native to tropical regions such as in Australia, Indonesia, Papua New Guinea and Thailand. Twelve acacia species with potential for more extensive utilization in forestry and agroforestry have been identified (Boland *et al.*, 1984). In forestry, *A. mangium* and *A. auriculiformis* are the most commonly planted species (Pinyopusarerk, 1992). However, in recent years *A. aulacocarpa* and *A. crassicarpa* have been introduced on trial plantings into many countries in the region.

Acacia species was first introduced into Peninsular Malaysia since the early 1930s, through *A. auriculiformis*. In 1958, two species *A. aulacocarpa* and *A. richii* were introduced. In 1966, *A. mangium* was introduced to Sabah as firebreaks. Its good growth created interest and some seeds were brought into Peninsular Malaysia. In addition to these species which were established as plantation trials, *A. confusa* and *A. holosericea* were also introduced as avenue trees for urban areas (Yap, 1986).

Many *Acacia* species, which are exotic to Malaysia, have shown great potential for forestry. Based on species introduction trials and large scale plantings, *A. aulacocarpa*, *A. auriculiformis*, *A. crassicarpa* and *A. mangium* have been identified as best adapted to the humid/subhumid tropics. These species grow fast and are most suited for wood production for chips, pulp and sawn timber (Pinyopusarerk, 1992). They produce seeds easily, and the seeds can be easily processed and stored. They can also be propagated vegetatively. Much of the present forest plantation development in

Malaysia is based on *A. mangium*. However, early plantings used materials of narrow genetic base resulting in a decline in growth over several generations. But better provenances have now been identified and their introduction that could be advantageous (Harwood *et al*., 1994)

A. mangium has since been selected as the main species for the Compensatory Forest Plantation Project (CFPP) of the Department of Forestry, Peninsular Malaysia. The programme of CFPP has been developed in order for Perninsular Malaysia to be self-sufficient in timber supply till the year 2010. It involves the conversion of some 188,000 ha into intensively managed forest plantations within 15 years. For the establishment of such plantations suitable land is needed. On steep terrains and slopes, it is environmentally unsound to establish such plantations which involves clear-felling the primary forests. Erosional hazard would be too serious under such conditions. In this respect the CFPP has to be established on land generally suitable also for agriculture. Preliminary examination indicates that there is sufficient land in the proposed Permanent Forest Estate that is suitable for the 15 year plantation programme (Freezaillah, 1981). The annual planting was to be increased progressively from 5,300 ha in the Fourth Malaysia Plan to 12,100 ha during the Fifth Malaysia Plan (Yong, 1985). Four main areas have been selected for plantation establishment, two of which were established with *P. caribaea* in the late 1960s.

Its vigorous growth and hardiness have made *A. auriculiformis* a popular species in soil improvement trials. Besides being used in plantations, *A. auriculiformis* was one of the more common trees used to provide shade in parks and roadsides. *A.*

holosericea has been planted for its ornamental silvery phyllodes while *A. confusa* was selected for its crown shape. Both species are planted only to a limited extent. Owing to its growth rate and abundant phyllodes, *A. mangium* was gradually being used as avenue trees as well.

In many countries, the critical shortage of wood for rural communities, and the need for multipurpose trees to be integrated into agricultural systems has required a reappraisal of tree and shrub species available for planting. Most acacias produce excellent firewood and charcoal, and have the potential to become a component of farming systems providing wood, shade and shelter, and soil improvement.

Acacia crassicarpa

A. crassicarpa Cunn. ex. Benth. is in the informal section *Juliforea* of the sub-family *Mimosoidae*. There is no published record of hybrids with other acacia species. In Papua New Guinea *A. crassicarpa* is typically of moderate stature (10-20 m height), but can reach 30 m in height with a stem diameter of 60 cm on favourable sites in monsoonal forests. It is a vigorous colonizer of abandoned gardens and occupies less fertile soil than *A. aulacocarpa* and *A. mangium*. Single stemmed trees with long straight boles can be found, but the more typical form is bushy with a low, heavy crown (Thomson, 1994).

The habit of *A. crassicarpa* varies considerably in different regions of its natural range. In Papua New Guinea and Irian Jaya it typically occurs in open forest and woodlands. On areas with of impeded drainage it is a small to medium-sized tree (10-15 m in height) with a straight bole and spreading, heavy branching crowns. On more favourable sites, associated with regenerating rainforests, it develops into a straight-boled tree up to 30 m in height with a maximum Dbh of 60 cm. In north Queensland it is typically a short-boled, heavily branched, small tree below 15 m in height, with a maximum Dbh of 45 cm. In field plantings there may also be considerable variations in form. Trees of Papua New Guinea origin typically have rather sinuous boles with a fine to moderately coarse secondary branching habit. Trees of north Queensland origin frequently lack apical dominance, displaying a multi-stemmed habit, or occasionally a semi-horizontal branching habit from near ground level (Thomson, 1994).

In Queensland, the trees seldom exceed 10 m in height, and the form is usually multi-stemmed. The species occurs on poor-quality sites such as coastal sand dunes or as an understory species in dry woodland. In the plantation, *A. crassicarpa* trees are usually heavily branched and the (main) bole is sinuous (Thomson, 1994).

The tree has large, grey-green phyllodes, 11-22 cm long and 1-4 cm broad with 3-7 longitudinal nerves. Inflorescences are bright yellow spikes 4-7 cm long on thick stalks. The outcrossing rate is greater than 90 % in natural populations. The dull-brown seed pods (5-8 cm long by 2-4 cm wide) are oblong, woody and flat. Seeds are black with creamy yellow funicles (Thomson, 1994).