UNIVERSITI PUTRA MALAYSIA

SOME ECOLOGICAL STUDIES ON HOPEA ODORATA ROXB. AND HOPEA PUBESCENS RIDL. SEEDLINGS

SAYSAMONE PHOTHISAT

SOME ECOLOGICAL STUDIES ON *HOPEA ODORATA* ROXB. AND *HOPEA PUBESCENS* RIDL. SEEDLINGS

BY

SAYSAMONE PHOTHISAT

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LIST OF ABBREVIATIONS

asl.	=	above sea level
CGP	=	Cumulative Germination Percentage
dbh	=	diameter at breast height
FRIM	=	Forest Research Institute Malaysia
ha	=	hectare
Lao PDR	=	Lao People Democratic Republic
MAID	=	mean annual increment in diameter
MAIH	=	mean annual increment in height
RG	=	Relative Growth
RLI	=	Relative Light Intensity
S/R ratio	=	shoot:root ratio
UPM	=	Universiti Putra Malaysia
Vietnam SR	=	Vietnam Socialist Republic

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March 1998

Chairman: Associate Professor Lim Meng Tsai, Ph. D.

Faculty: Forestry

In Malaysia, *Hopea odorata* Roxb. and *Hopea pubescens* Ridl. have the local names of Merawan siput jantan and Merawan bunga, respectively; while in Laos, their local names are Mai khen heua and Mai khen respectively. *H. odorata* is fairly widely distributed in evergreen forests from mainland Southeast Asia to the Andamand Islands, Borneo and the Philippine Islands, while *H. pubescens* is only endemic to Peninsular Malaysia. Both species belong to the Dipterocarpaceae, and are commercially important timbers.

This project initially focused on the density, distribution, response to light of seedlings under forest canopy, seedling mortality and growth of *H. pubescens*. The project then focused on the influence of seed size on cumulative percentage germination and early growth of *H. odorata* seedlings under different light regimes in the nursery.

The highest seedling density of *H. pubescens* was found to be 130 trees/subplot (of 25 m^2) and the highest density of saplings was 68 trees/subplot. The distribution of seedlings and saplings was most abundant within 10m around the parent tree and no seedlings and saplings were found beyond 25m. The light intensity in the forest fluctuated according to the canopy opening. The highest light intensity recorded in the forest was 45.8%RLI and lowest at 3.0%RLI. The mortality of seedlings and saplings was quite high up to 12.9% and 5.3%, respectively and high mortality occurred in areas of high seedling density and where the light was low. In Plot 1, the mean annual increment in diameter (MAID) of all saplings was 0.37±0.2mm and the mean annual increment in height (MAIH) was 2.36±3.2cm. In Plot 2, the MAID of all saplings was 0.22±0.18mm and the MAIH was 3.02±4.29cm. Height and diameter increments of saplings in the forest were lower than increments recorded in the nursery.

H. odorata seeds were smaller and lighter than most other species of dipterocarps. The mean weight of seeds was 0.14±0.04g. The mean length of seeds was 8.18±0.06mm. 88% of the seeds germinated after sowing 25 days. The germination percentage was influenced by seed size. The highest germination rates were recorded by seeds in the 0.125-0.149g weight class and over 9.95mm in length.

The early growth of *H. odorata* seedlings was highest at 30% relative light intensity (RLI) and lowest at full sunlight. The relative growth (RG) of collar diameter, number of leaves and number of nodes of the seedlings in both batches were significantly different. However, the RG of number of leaves of young seedlings were not significantly different between treatments. The biomass of seedling components was

significantly higher at 30%RLI whereas leaf areas were not significantly different. The shoot:root (S/R) ratio of the young seedlings was highest at 50% RLI, while the S/R ratio of old seedlings was highest at full light. Biomass of seedling components and of the whole seedlings was related to the collar diameter, and correlation coefficients were generally high suggesting that the regression equations can be used for estimating biomass of the whole seedlings. The relationship between leaf area and collar diameter was relatively poorer.

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

BEBERAPA KAJIAN EKOLOGI TERHADAP ANAK BENIH *HOPEA ODORATA* ROXB. DAN *HOPEA PUBESCENS* RIDL.

Oleh

SAYSAMONE PHOTHISAT

Mac 1998

Pengerusi: Profesor Madya Lim Meng Tsai, Ph. D.

Fakulti: Perhutanan

Di Malaysia, *Hopea odorata* Roxb. dan *Hopea pubescens* Ridl. dikenali sebagai Merawan siput jantan dan Merawan bunga, manakala di Laos, nama tempatannya adalah Mai Khen heua dan Mai Khen. *H. odorata,* tersebar secara luas di hutan malar hijau dari tanah besar Asia Tenggara kepada Pulau Andaman, Borneo dan Filipina, manakala *H. pubescens* adalah endemik kepada Semenanjung Malaysia. Kedua-dua spesis adalah daripada famili Dipterokarpa dan adalah kayu balak komersil yang penting.

Pada permulaannya, projek ini tertumpu kepada kepadatan, penyebaran, kesan cahaya kepada anak pokok di bawah kanopi hutan, kadar kematian anak pokok dan kadar pertumbuhan *H. pubescens.* Selepas itu, projek ini tertumpu kepada pengaruh saiz

biji benih kepada peratusan kadar pertumbuhan kumulatif dan pertumbuhan awal anak pokok *H. odorata* di bawah kadar cahaya yang berlainan di tapak semaian.

Kepadatan anak benih tertinggi bagi *H. pubesens* adalah 130 pokok/subplot (bagi 25 m^2) dan kepadatan tertinggi anak pokok adalah 68 pokok/subplot. Penyebaran anak benih adalah banyak pada sekitaran 10m dari pokok ibu dan tiada anak benih pada jarak lebih daripada 25m. Keamatan cahaya di dalam hutan tidak sekata berdasarkan kepada pembukaan kanopi. Keamatan cahaya tertinggi direkodkan adalah 45.8% keamatan cahaya relatif (RLI) dan terendah adalah 3.0% RLI. Kadar kematian anak benih dan anak pokok adalah tinggi 12.9% hingga 5.3%, masing dan kadar kematian yang tinggi berlaku di kawasan di mana terdapat kepadatan anak benih yang tinggi dan cahaya yang rendah. Di Plot 1, purata tambahan perepang tahunan (MAID) bagi semua anak pokok adalah 0.37±0.2mm dan putara tambahan ketinggian tahunan (MAIH) adalah 2.36±3.2cm. Di Plot 2, MAID bagi semua anak pokok adalah 0.22±0.18mm dan MAIH adalah 3.02±4.29cm. Bacaan pertambahan ketinggian dan perepang bagi anak pokok di hutan adalah lebih rendah berbanding dengan bacaan yang diambil di tapak semaian.

Biji benih *Hopea odorata* adalah kecil dan ringan berbanding dengan spesis dipterokarp yang lain. Purata berat biji benih tersebut ialah 0.14±0.04g manakala purata panjang biji benihnya adalah 8.18±0.06cm. 88% dari biji benih ini bercambah selepas 25 hari disemai. Peratusan percambahan ini dipengaruhi oleh saiz biji benih. Kadar percambahan tertinggi yang direkodkan oleh biji benih dari kelas berat 0.125-0.149g dan mempunyai panjang melebihi 9.95mm.

Pada pertumbuhan awal anak benih *H. odorata,* kadar pertumbuhan adalah tertinggi pada 30% RLI dan terendah pada cahaya penuh. Pertumbuhan Relatif (RG) bagi perepang kolar, jumlah daun dan jumlah tunas anak benih bagi kedua-dua adalah berbeza secara signifikan. Walaubagaimanapun, RG bagi jumlah daun anak benih muda tidak berbeza secara signifikan di antara awatan tersebut. Komponen biomass anak benih adalah lebih tinggi pada 30% RLI manakala jumlah luas daun tidak berbeza secara signifikan. Kadar pucuk:akar (S/R) bagi anak benih muda adalah tinggi pada 50%RLI, manakala kadar S/R bagi anak benih matang adalah tinggi pada cahaya penuh. Komponen biomass anak benih dan keseluruhan anak benih menjungai pertalian dengan perepang kolar dan koefisien korelasi yang tinggi menunjukkan bahawa persamaan regressi boleh digunakan untuk menganggarkan biomass keseluruhan pokok. Perhubungan di antara keluasan daun dan perepang kolar tidak memuaskan.

CHAPTER I

INTRODUCTION

General Introduction

Forest and forestry play an important role in the world, due to their value in scientific research, socio-economic development and also their role in environmental protection, nature conservation and other aspects. In Malaysia, forests (including Plantation Forests) cover 19.2 million hectares or 58.4% of the total land area. Of this, 16.7 million hectares are Dipterocarp Forests while the remaining 1.9 million hectares and 0.6 million hectares are Swamp and Mangrove Forests respectively (Anon, 1993). The Dipterocarp forests contributed significantly to industrial development, foreign exchange and other developmental activities (Tang, 1986).

In Laos, the current forest area is 11.2 million hectares or 47% of the total land area. Mixed Deciduous Forests cover 8.3 million ha, Dry Evergreen Forests cover 1.2 million hectares, while of the remaining 1.7 million hectares, 1.2 million ha are under Dry Dipterocarp Forests and 0.5 million ha are under Gallery, Coniferous and Mixed Coniferous/Broad Leaf Forests (0.087 million ha, 0.132 million ha and 0.281 million ha, respectively). Based on regional distribution, 3.6 million ha are found in the Northern region, 3.7 million ha in the Central and 3.9 million ha in the Southern region (Manivong and Sandewall, 1992).

The tropical forests in Southeast Asia, which are dominated by Dipterocarps, have been exploited as important sources of hardwood in the world. The demand for tropical hardwood has increased tremendously over the last twenty years and resulted in serious degradation of the forests due to over-logging and high impact logging techniques, which seriously affect the tree regeneration of these forests. In general, the extent of tropical rain forest and especially, the Dipterocarp forests, has also decreased rapidly due to the rapid destruction by exploitation of forest and conversion to other uses, and loss due to shifting cultivation and forest fire (Rochadi, *et al.*, 1991). In Laos, the natural forest has been degraded by over logging, illegal logging, land clearing for shifting cultivation and forest fire, and deforested by hydropower construction programs, reservoirs for irrigation and others.

The realization of the important roles of forest resources in the socio-economic development has prompted many South East Asian countries to legislate policies for the sustainable management of natural forests, and undertake efforts to regenerate the forest after logging with dipterocarp and other commercially important species. Among the strategy is to enhance regeneration of the forest by enrichment planting as the natural regeneration of some forests such as the hill dipterocarp forest is very poor (Wyatt-Smith, 1963; Burgess, 1976). Efforts to improve the regeneration status of these forests by extending the natural distribution range of the more productive species through planting, however, have not been very successful (Tang and Wadley, 1976). Burgess (1972) reported that successful natural regeneration of the forests after timber exploitation is dependent on the presence of adequate dipterocarp regeneration on the forest floor before felling commences. Hence, information on the periodicity, season,

and relationship of flowering to recorded meteorological phenomena is of fundamental importance to enable seed fall and felling to be synchronised. Regeneration of forest should be part of ecologically sustainable forest management.

The ecological study of forests containing *Hopea odorata* Roxb. and *Hopea pubescens* Ridl. is of special interest for two reasons. Firstly, *Hopea* is an important timber species in the lowland and hill dipterocarp forests in Malaysia as well as in Laos, Myanmar and Cambodia. Secondly, *Hopea* is commercially important, especially in Laos, and there is relatively little research on this genus compared to other dipterocarp genera. Adequate and successful regeneration of this species depends on a number of factors, such as adequate seed fall, successful germination, survival and completed tree growth with suitable conditions. Some species of dipterocarp trees are already successfully planted in forest plantations (Smitinand and Santisuk, 1981).

The species *H.odorata* and *H.pubescens* occur at altitudes below 300m in tropical lowland evergreen rain forest and they mainly belong to the Lowland Dipterocarp Forest zone (Symington, 1941). *H. odorata* regenerates freely along the rivers in the North of Peninsular Malaysia, while *H. pubescens* is widely distributed in flat well drained land, and low hills. These species are also markedly gregarious species of the main canopy and can dominate stands over large areas.

The strength and durability of the wood makes these two species important constructional timber, and the wood is used for boat building, canoes, frames for doors and windows, railway sleepers and general construction. The bark has a high tannin content and so is suitable for the preparation of certain qualities of leather (Troup,

1921). In Laos, the wood of *H. odorata* is an important wood used for furniture, house building, general construction and it is also exported as sawn timber.

Growth measurements of *H. odorata* planted in Southern Vietnam show that the trees are capable of achieving rather rapid growth. Sixty-year-old trees have diameters of about 45 - 60 cm (Foxwothy, 1932). In Northern Thailand, plantation grown *H. odorata* reached an average girth of 50 cm in 18 years (Smitinand and Santisuk, 1981). Symington (1941) observed that *H. pubescens* in Kemasul, recorded an average annual girth increment of 2 cm and it is suggested that it would take 71 years to reach 150 cm girth.

Aims and Scope of Study

The study aims to better understand the requirements for regeneration and growth as well as the biology and physiology of *H. odorata* and *H. pubescens* to ensure successful regeneration of the species. Studies were conducted to determine natural seedling distribution in the forest and the influence of light and canopy opening on seedling and sapling growth. Studies were also conducted in the laboratory and nursery to investigate, how seed size influence germination and early seedling growth under different light regimes.

CHAPTER II

LITERATURE REVIEW

Botanical Background

Dipterocarpaceae comprise about 515 species in 16 genera in 3 sub-families, which are Dipterocarpoideae, Monotoideae and Pakaraimoideae. The largest sub-family is Dipterocarpoideae, which consists of about 495 species in 13 genera. The genera are *Anisoptera*, *Cotylelobium*, *Dipterocarpus*, *Dryobalanops*, *Hopea*, *Neobalanopcarpus*, *Parashorea*, *Shorea*, *Stemonoporus*, *Upuna*, *Vateria*, *Vateriopsis*, and *Vatica* (Jacobs, 1981).

Many members of the Dipterocarpaceae are unbranched to a considerable height and grow to a large size. The bark, wood and pith contains resin canals (Foxworthy, 1932). Symington (1941) described the shape, leaves, flower, fruits, bark and smell of the fresh cut as useful for identification of some groups of trees.

Sapwood is sometimes present and can be 5 - 15 cm thick, whitish or pale yellow. Heartwood darker yellow and becoming golden or brownish after prolonged exposure to the air. Foxworthy (1932) described that the wood as soft to moderately hard, light to moderately heavy, or heavy, of fine or medium coarse texture, grain straight or twisted, with distinct sapwood and hardwood.

The wood is usually of only moderate durability and is used principally for indoor purposes. Some of it is particularly good for doors and window frames. Troup (1921) described the *Hopea* species as "the most valuable of the Burmese Dipterocarps, having a hard very durable timber much in request for boat building, canoes and construction generally".

Ecological Distribution of Dipterocarpaceae

The Dipterocarpaceae are distributed over a large area of tropical Africa and the Indo-Malayan region from India to New Guinea, embracing territories separated by seas. Borneo and Peninsular Malaysia are the richest in dipterocarp species (Ashton, 1964). Climate is important in determining the distribution of the dipterocarps and limiting the distribution of this family in Southeast Asia (Laos, Vietnam, Cambodia, Thailand, Myanmar and Indo-Malayan) and South Asia (India, Pakistan and Sri Lanka). Some species are found in as far north as Southern China (one *Hopea* in Kwangtung and one *Vatica* in Hainan), while in Pakistan, *Shorea robusta* occurs in the Dry Forests (Symington, 1941). Continental Southeast Asia (Myanmar, Thailand, Laos, Cambodia and Vietnam) is the crossroad of the geographical migration of the dipterocarps (Smitinand and Santisuk, 1981). The dipterocarps are essentially tropical evergreen rain forest trees, adapted to warm and uniformly moist conditions, and so disappear on mountain slopes above altitudes between 900 to 1,200 m above sea level. The high ranges thus form barriers in its natural distribution.

In Peninsular Malaysia, the Dipterocarpaceae is the predominant family of timber trees in the Tropical Lowland Rain Forest (Symington, 1941). These forests, in which most of the commercial timber exploitation occurs, constitute the main part of the climatic vegetative formation. The classification of forest types are the *Lowland Dipterocarp Forests*, which cover all primary forests of the plains, undulating land and foot hills up to about 300m above sea level (asl). The *Hill Dipterocarp Forests* is the vegetation of the altitudinal zone immediately above the *Lowland Dipterocarp Forest* occurring at altitudes between 300 and 750m asl. The *Upper Dipterocarp Forest* is a transition zone between the tropical lowland rain forest and the tropical upper montane rain forest of the higher mountains. The *Upper Dipterocarp Forests* are found on the higher mountains at altitudes from 750 - 1,200m (asl) (Symington, 1941).

Most of Laos is below 1,000m and only 2% is above 1,500m (asl). The forest is of the Monsoon type and consists of Dry Dipterocarp Forests, which range in altitude up to 200m; the Upper Mixed Deciduous Forests are found from 200m to 500m. While, the Upper Dry Evergreen Forests from 500 - 1,000m (asl). The Dipterocarpaceae occurs in most forest types, except the Coniferous Forests. They are found mainly in Mixed Deciduous and Dry Evergreen Forest in the Northwest, Central and Southern region of the country (Manivong and Sandewall, 1992).

Ecological Distribution of *Hopea* Roxb.

The genus *Hopea* extends from India and Sri Lanka eastwards through to South China and Hainan and Southeast through Myanmar, Thailand, Laos, Cambodia and

Vietnam and across the archipelago to the Philippines and Papua New Guinea (Symington, 1941; Jacobs, 1981).

In Peninsular Malaysia, *Hopea* is found in most districts and is usually of medium size. About 100 species have been collected, of which about 70 species have been botanically described. There are more than 30 described species that occur throughout the Lowland Forest from the sea level up to 1,200m (asl). Some species are rather rare and sporadic while others, show a distinct gregarious tendency, and may be locally abundant (Symington, 1941).

In Laos, *Hopea* is dominant in most provinces in the whole country from Xayaboury province in Northwest part of the country to Vientiane and other provinces in the Central and most provinces in the Southern region. This genus occurs abundantly in the Evergreen Forest and Mixed Deciduous Forest. *Hopea* extends from lowland evergreen forest up to an altitude of 1,000m (asl) and above.

Ecological Distribution of *Hopea odorata* Roxb. and *Hopea pubescens* Ridl.

In Malaysia, *H. odorata* and *H. pubescens* have the local names of Merawan siput jantan and Merawan bunga , respectively; while the local Laotian names are Mai khen heua and Mai khen, respectively.

H. odorata occurs widely in evergreen forest in most countries of Southeat Asia as well as the Andaman Island, Borneo and the Philippine Islands (Foxworthy, 1932).

H. pubescens however, is an endemic species in Peninsular Malaysia (Symington, 1941).

In Peninsular Malaysia, *H. odorata* is well known in Langkawi, Perlis and Kedah, and the north of Perak, Kelantan and Trengganu. It is essentially a riparian species, rarely occurring far from streams. On the banks of the larger rivers large trees overhang the water. In Kuala Kangsar district in Perak, *H. odorata* is the preferred timber and is also valued by the villagers in Perlis, Kedah and Trengganu. There is little information concerning the uses of *H. odorata* in the other regions in the Peninsular Malaysia. The species is cultivated as a shade tree in villages in Kelantan and Trengganu.While, *H. pubescens* is widely distributed on flat, well-drained land and low hills from Kelantan and Pahang. In parts of the Lipis and Temerloh district, it is quite abundant (Symington, 1941).

H. odorata is found in almost all provinces of Central and Southern Laos, from Xayaboury and Vientiane provinces southwards. They often grow gregariously in dense Mixed Deciduous and Dry Evergreen Forests. The species is of considerable importance as a source of constructional timber. In Thailand, this species is reported to show good growth in plantations (Smitinand and Santisuk, 1981). The tree can tolerate a considerable amount of shade particularly when young. In Vietnam, this species has been planted from the beginning of the 20th century in Hanoi and Ho Chi Minh City.