UNIVERSITI PUTRA MALAYSIA

STUDIES ON GERMINATION AND SEEDLING GROWTH OF NEOBALANOCARPUS HEIMII (KING) ASHTON

SITI RUBIAH ZAINUDIN

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By

SITI RUBIAH ZAINUDIN

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LIST OF ABBREVIATIONS

a.s.l	=	Above Sea Level
FAA	=	Formalin Acetic Acid
FRIM	=	Forest Research Institute of Malaysia
IRGA	=	Infra-Red Gas Analyser
PAR	=	Photosynthetic Active Radiation
RGR	=	Relative Growth Rate
RLI	=	Relative Light Intensity

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Supervisor : Dr. Lim Meng Tsai

Faculty : Forestry

Neobalanocarpus heimii (King) Ashton locally known as chengal is endemic to Southern Thailand and Peninsular Malaysia. It is an important genera as it produces wood that has become the standard by which many others are compared. It is fairly widely distributed but found in scattered occurrence and at low numbers. This project focuses on the germination, seedling growth, presence of mycorrhiza and photosynthetic rates under different light conditions. Soil analysis and field observation of seedling distribution around the parent tree were also conducted. Germination of chengal was more rapid at lower light intensities than at higher light intensities. The germination percentage is also influenced by seed size i.e., the bigger the seed the better the germination. Treatment means for plant height and leaves showed no significant difference among treatments. However, the number of nodes was significant in all treatments. Seed weight was positively correlated to height, number of leaves, number of nodes and collar diameter at all light intensities. The biomass and total area of leaves per plant were highest at 55% RLI. Chengal grows on sandy loam soil with very low organic carbon content and low pH. Ectomycorrhiza was found in roots at the age of 2 months. The highest photosynthetic rate of 4.37 micro mol $m^{-2}s^{-1}$ was attained by plant grown at 55% RLI at the saturating photon flux of 400 micro mol $m^{-2}s^{-1}$. Plants grown at higher and lower light intensities had lower photosynthetic rates of 1.30 micro mol $m^{-2}s^{-1}$ and became saturated at 100 micro mol $m^{-2}s^{-1}$. After a seed fall, the number of seeds and seedlings around the parent tree is high. However,there is correspondingly a high mortality rate with high density; the number falling to one quarter the total number after a year. This study shows that the germination of chengal was best at 25% RLI and optimum growth of seedlings was attained at 55% RLI.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

KAJIAN MENGENAI PERCAMBAHAN DAN PERTUMBUHAN ANAK BENIH <u>NEOBALANOCARPUS HEIMII</u> (KING) ASHTON

OLEH

SITI RUBIAH ZAINUDIN

June 1990

Penyelia : Dr. Lim Meng Tsai

Fakulti : Perhutanan

<u>Neobalanocapus heimii</u> (King) Ashton dikenali sebagai chengal adalah endemik kepada Selatan Thailand dan Semenanjung Malaysia. Ia merupakan salah satu kayu yang menjadi satu piawai untuk perbandingan spesies kayu keras lain. Projek ini membentangkan kajian ke atas percambahan, pertumbuhan anak benih, kehadiran mikoriza dan kadar fotosintesis di bawah keadaan cahaya yang berbeza. Analisis tanah dan pemerhatian di lapangan terhadap taburan anak benih di sekeliling pokok induk juga dijalankan. Percambahan daripada chengal adalah lebih cepat pada intensiti cahaya yang rendah iaitu 25% RLI berbanding dengan intensiti cahaya yang tinggi. Peratus percambahan juga dipengaruhi oleh saiz biji benih iaitu biji benih yang lebih besar memberikan percambahan yang lebih baik. Purata rawatan untuk ketinggian

pokok dan daun menunjukkan tiada perbezaan bererti di antara rawatan. Walau bagaimanapun, bilangan nod adalah bererti di antara semua rawatan cahaya. Berat biji benih menunjukkan perhubungan positif dengan ketinggian, bilangan daun, bilangan nod dan garispusat kolar pada semua rawatan cahaya. Biomas dan jumlah keluasan daun per pokok adalah paling tinggi pada 55% RLI. Chengal tumbuh di tanah liat berpasir dengan kandungan organik karbon dan pH yang rendah. Ektomikoriza di dapati didalam akar pada umur 2 bulan. Kadar fotosintesis yang paling tinggi, 4.37 micro mol $m^{-2}s^{-1}$ dicapai oleh tumbuhan pada 55% RLI pada keamatan ketepuan foton fluk 400 micro mol $m^{-2}s^{-1}$. Tumbuhan pada intensiti cahaya yang lebih tinggi dan rendah mempunyai kadar fotosintesis yang rendah iaitu 1.30 micro mol $m^{-2}s^{-1}$ dan menjadi tepu pada 100 micro mol $m^{-2}s^{-1}$. Selepas biji benih gugur, terdapat banyak biji dan benih benih yang tumbuh mengelilingi pokok induk. Bilangan anak benih menurun dengan cepat dengan kenaikan jarak dari pokok induk. Terdapat kadar kematian yang tinggi bilamana ketumpatan adalah sangat tinggi. Oleh itu bilangan berkurangan kepada satu perempat selepas setahun. Kajian ini menunjukkan percambahan biji benih chengal adalah paling baik pada 25% RLI dan anak benih chengal memerlukan keamatan cahaya 55% RLI untuk pertumbuhan yang optimum.

CHAPTER ONE

GENERAL INTRODUCTION

Status of Forestry in Malaysia

For the past three decades, tropical forests dominated by dipterocarps have been exploited on an increasing scale due to popular world demand for hardwood. Malaysia has 17.37 million hectares of dipterocarp forests which contributed significantly to industrial development, earning of foreign exchange and socio-economic changes (Thang, 1986). In view of the rapid depletion of the forest resources, efforts to meet future demand for timber has forced the Forestry Department of Peninsular Malaysia to embark on a Compensatory Plantation Programme in which fast growing soft hardwood species such as *Acacia mangium* and *Gmelina arborea* have been successfully planted.

In an attempt to pursue a sustainable yield policy, dipterocarp forests have to be regenerated after logging with dipterocarps, either naturally or artifically by enrichment planting. Natural regeneration of hill dipterocarp forest is generally poor (Wyatt-Smith, 1963; Burgess, 1976). This is due to the variability of terrain and stocking of economic species. Efforts to improve the regeneration status of these forests by extending the natural distribution range of the more productive species through planting have not been very successful (Tang and Wadley, 1976). This could be due to the limited understanding of the ecophysiology of the species.

Neobalanocarpus heimii (King) Ashton is listed as one of the ten endangered species in Malaysia (Kiew et al., 1985). Due to its strength and durability it is of great economic importance and demand for chengal locally is high (Maskayu, Vol 1, Jan, 1989). It produces a strong and naturally durable wood used for power-line posts, building boats, carriage-bodies for lorries and buses and frames for doors and windows.

Growth measurements of 319 planted chengal trees at Forest Research Institute Malaysia at 22 years old has a mean girth of 37 cm and a mean annual increment of 1.70 cm. Measurement of 5370 trees in Negeri Sembilan and Pahang gave annual increment of 1.0 cm , so that in its natural state, it probably takes about 80 years to reach a girth of 153 cm, and 120 years to reach a girth measurement of 230 cm (Edwards, 1930).

In the natural environment big trees of chengal are usually found with a marked lack of suitable representation of small and intermediate sizes (Symington, 1943). To ensure successful regeneration of chengal, there is a need for information on its distribution and requirements for growth. These would help in the management and manipulation of the forest to favour the regeneration of chengal in accordance to its tolerance.

Objective of Study

The unusual distribution of chengal suggest that the ecological requirements for growth and regeneration may be very specific. As a result of this, these studies were conducted to explain how chengal establishes itself. Parameters include the response of chengal seedlings to light, measurement of photosynthetic rates, presence of mycorhizza and soil analysis.

Literature Review

Chengal Distribution and Regeneration

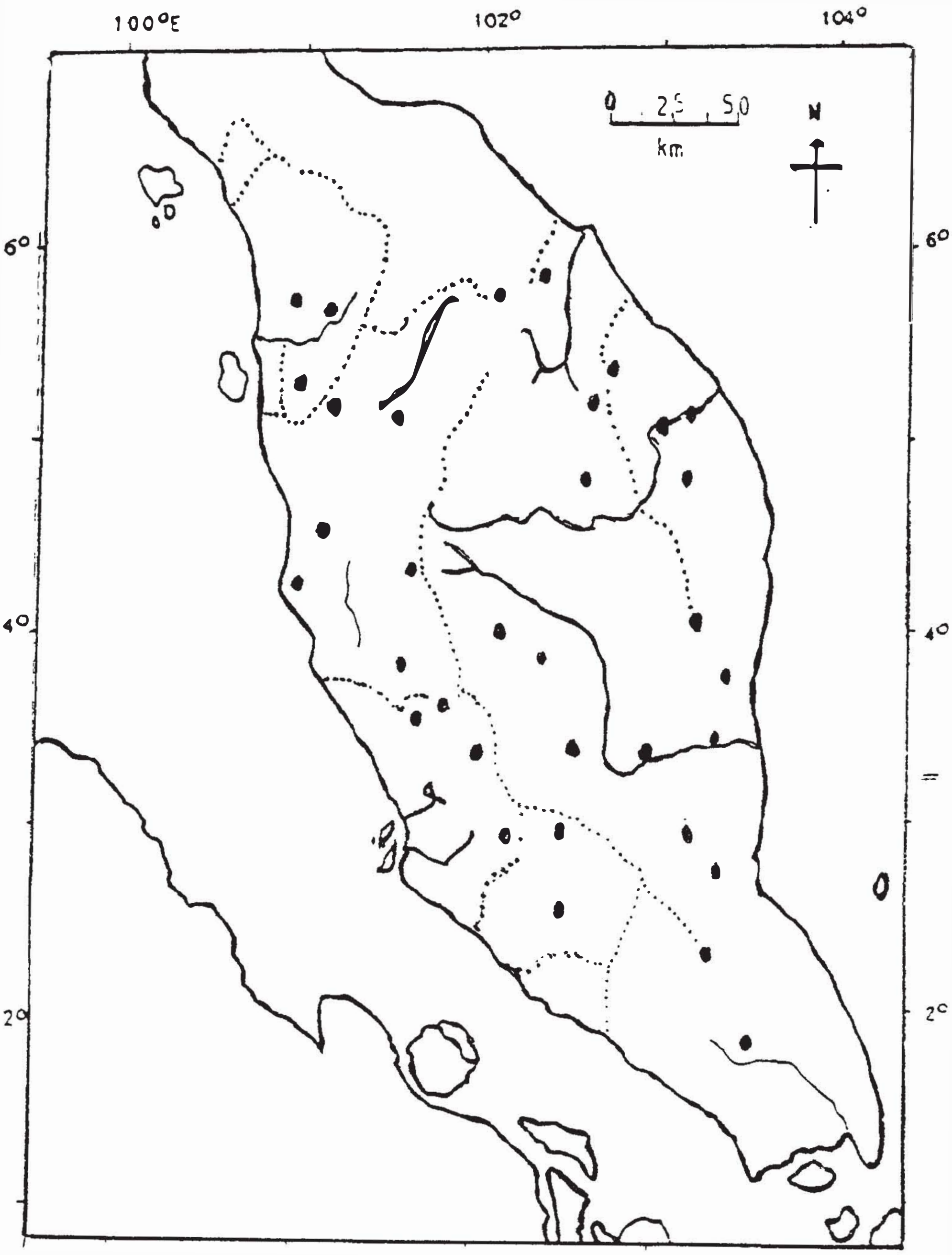
Chengal is found throughout Peninsular Malaysia except for Perlis and Malacca (Symington, 1943) (Figure 1). It is found in the lowland forests below 600m a.s.l and seems to prefer sandy soil with little laterite. It is also found in low densities, i.e less than 5 trees/ha (Symington, 1943). According to Symington (1943), numerous seedlings and saplings can sometimes be found beneath the parent tree. Chengal is a large tree that can attain a diameter of up to 4 metres and height of 42 metres to the first branch. Reported to be slow growing, it does not achieve a maximum rate of growth until it is about 75 cm in girth. However, measurements of certain plants have indicated that under favourable conditions growth may be greater than mentioned above (Symington, 1943).

According to the Forest Research Institute of Malaysia Phenology Reports (1989) chengal flowers and fruits every year. Flowering does not seem to occur in mast with flowering of other species of Dipterocarps (Ng, Pers. comm., 1989). It begins to bear flowers and fruits while still young, and planted trees have been known to bear fruits at less than ten years old (Symington, 1943).

Chengal seeds are heavy and wingless and hence dispersal is restricted. Seeds are dispersed by animals and by rolling down hill slopes. Because of its limited dispersal mechanism seedlings are usually found in high densities beneath the parent trees (Symington, 1943). According to Symington (1943), although these seedlings are able to survive for long periods under dense shade, light is still required for better growth.

Seed Germination

Seeds of many forest trees of the humid tropics germinate soon after dispersal. Germination of dipterocarps seeds is rapid and Ng (1978) concludes that rapid germination gives the plants the advantage of escaping seed predation. For example,



Key
● = Chengal

Figure 1 Distribution of <u>Neobalanocarpus</u> <u>heimii</u> (Chengal) in Peninsular Malaysia

Dryobalanops aromatica germinates within 1-2 weeks while Hopea odorata, Shorea materialis, Shorea maxima and Parashorea lucida within 1-3 weeks.

The viability of seeds is affected by various factors. Amongst them are the method of collection, stage of seed maturation, infestation by pests, moisture content of seeds and storage conditions. Yap (1981) compared seeds of Shorea assamica collected from the ground with those from the tree and found little difference in germination percentage. Tang (1971) has also indicated that selected good seeds of Shorea curtisii from ground collection are just as viable as those from trees. However, ground collected seeds of unknown duration can show very low viablity (Yap, 1981).

The viability of seeds is also affected by the different stages of maturation. Barnard (1950) found that seeds with green seed coats and brown wings germinate better than seeds with brown seed coats. A slightly higher germination percentage was observed in the fruits of Shorea materialis with brown wings over those with partially brown wings (Yap, 1981). In Shorea sumatrana, fruits with green pericarps germinated better than those with brown pericarps.

The establishment of certain dipterocarp species is critical where the production of viable seeds is very low. The major pests of seeds while still on trees are weevils

(Alcidodes spp. and Nanophytes spp.) while Scolitid beetles (Poeciilips spp.) infest fallen seeds (Daljeet-Singh, 1974). Their infestation on Shorea curtisii reduces viable seeds to as low as 1.6% of the total seeds produced (Burgess, 1972).

Mature dipterocarp seeds are rich in moisture and quickly die when dehydrated (Jansen, 1971; Tang, 1971; Tang and Tamari, 1973; Sasaki, 1980; Yap, 1981). These are typical recalcitrant seeds which die quickly through dehydration and can only be stored wet (Roberts, 1973). Moisture is essential for germination and seed can become non-viable in seven days if allowed to dry. Corbineau and Come (1986) found that seeds of Shorea roxburghii and Hopea odorata are typical recalcitrant seeds. The seeds cannot tolerate desiccation and die when their mean moisture content drop by 20% (dry weight basis).

Shorea roxburghii and Shorea ovalis seeds lose viability at 20% moisture content (Sasaki, 1980) while the seeds of Dryobanalops aromatica are damaged at a moisture content below 35% (Tamari, 1976).

Yap (1981) proved that stored fruits of dipterocarps also lose their viability rapidly, and different species responded to different storage conditions. It was found that Dipterocarpus baudii fruits with intact wings stored in closed bags at 14^{o}C for 17 days was able to retain viability of over 60% while fruits with wings removed germinated poorly after storage in the same condition. Dipterocarpus oblongifolius however, was only able to retain viability of over 60% when stored in bags with the air replaced with nitrogen for 60 days at room temperature. Seeds of Shorea roxburghii and Hopea odorata germinate very easily at high temperatures with optimal temperature close to $30^{o}C$ or $35^{o}C$. According to Corbineau and Come (1986), germination was possible at $40^{o}C$, but this temperature did not allow seedlings growth. Hopea odorata seeds however, germinated perfectly down to $15^{o}C$, whereas those of Shorea roxburghii germinated very poorly at temperature below $15^{o}C$ (Corbineau and Come, 1986).

Species found in closed shaded habitats of moist temperate and tropical environment are found to have larger seeds than those that regenerate in open, secondary habitats (Foster, 1986). It is generally considered that large seeds enhance seedlings survival at low light intensities.

Large seeds may have nutrients, energy and water reserves to accommodate metabolic requirements during periods of dormancy. These reserves could allow seed survival until conditions of germination and growth of seedlings are favourable (Foster, 1986). Large seeds contain large amounts of secondary compounds that are used in the defence of the seeds and seedlings. Freeland and Janzen (1974) found that some seeds contain secondary compounds like amino acid analogues, alkaloids and phenolic compounds of up to 10% of its dry mass. Seeds of the shade-tolerant neotropical nutmeg, Virola surinamensis contain 15.4% dry mass of soluble tannin (Howe and Vande Kerckhove, 1981).

Large seeds also provide energy and nutrients necessary for growth. Grime and Jeffrey (1965) found a strong positive correlation between seed size and maximum height of seedlings in nine temperate zone tree species which germinated under shade. Similar results were obtained by Howe and Richter (1982) and Howe et al., (1985) for the shade-tolerant neotropical nutmeg, Virola surinamensis.

Seedling Growth

Shade is an important prerequisite for dipterocarp establishment (Whitmore, 1984). Several species such as Shorea leprosula , Parashorea tomentella and Dipterocarpus stellatus require some shade for seedlings establishment (Nicholson, 1960).

Generally, most species produce a large population of seedlings after a mass fruiting although there is high mortality in the first few months. Liew and Wong (1973) in their study on Parashorea tomentella in Sabah, found that seedling survival rates declined from 41.95% in the first year to 16.90% in the fourth year. The survival of dipterocarp seedlings, however, can differ considerably between species