UNIVERSITI PUTRA MALAYSIA

DIAMETER CLASS DISTRIBUTION, GROWTH AND VOLUME OF Dryobalanops aromatica C.F. Gaertn. PLANTED IN KENABOI FOREST RESERVE, JELEBU, NEGERI SEMBILAN

SETIA BINTI MAJURI

FH 2016 65

DIAMETER CLASS DISTRIBUTION, GROWTH AND VOLUME OF *Dryobalanops aromatica* C.F. Gaertn. PLANTED IN KENABOI FOREST RESERVE, JELEBU, NEGERI SEMBILAN

By

SETIA BINTI MAJURI

A Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Forestry Science in the
Faculty of Forestry
Universiti Putra Malaysia

2016

DEDICATION

Specially dedicated to……..

My beloved father and mother...

My lovely brothers and sisters…

For their encouragement, inspiration, understanding and

always be with me so that I can finish my degree.

May Allah S.W.T will bless you all. Thank you…..

ABSTRACT

Dryobalanops aromatica C.F.Gaertn. was identified as a quality timber in Peninsular Malaysia and had an economic value. *Dryobalanops aromatica* were found productive for plantation programs where the programs is an alternative for a long-term timber production strategy in Peninsular Malaysia. A study was conducted in 1-ha area at Compartment 106, Kenaboi Forest Reserve, Jelebu, Negeri Sembilan to investigate the distribution of diameter class for *Dryobalanops aromatica* that are planted 45 years ago. A total ten plots, measuring in 50 m in length and 20 m in width were made in belt-transect method. The trees were categorized into diameter class and the number of the trees were recorded. Result shows that 116 trees was recorded and can be classified into four dbh classes which are dbh classes of 15 - 29.99 cm, 30 -44.99 cm, 45 - 59.99 cm and ≥ 60 cm. The number of individuals for dbh classes of 15 - 29.99 cm, 30 - 44.99 cm and 45 - 59.99 cm shows 12 individual (10.3%), 59 individual (50.9%) and 40 individual (34.5%) respectively. The dbh classes of ≥ 60 cm is the lowest with five individuals that only occupy only 4.3% of the area. Plot 2 shows the highest density of individuals with total 18 individual which consists all of dbh classes while Plot 6 shows the lowest number of individual with represent only eight individual. Mean dbh for the *D. aromatica* planted in Kenaboi FR is 41.73 cm. The MAI for the stands is ranging from 0.36 to 1.6 cm/yr. Total basal area for 1-ha area is 16.89 m^2 with total volume is 221.77 m^3 ha^{-1}. The stands in the area shows the positively interaction between basal area (m^2) and volume (m^3) with $y = 0.0623x + 0.071$. The present study considered that the distribution of dbh classes in this area is poor because the number of survive trees is low compared to the number of planted trees in 1971.

ABSTRAK

Dryobalanops aromatica C.F.Gaertn. dikenal pasti sebagai spesis yang menghasilkan kayu yang berkualiti di Semenanjung Malaysia dan mempunyai nilai ekonomi. *Dryobalanops aromatica* ditemui sangat produktif untuk program perladangan dimana program ini adalah alternatif kepada strategi pengeluaran kayu jangka panjang di Semenanjung Malaysia. Satu kajian telah dijalankan di dalam 1-ha kawasan bagi Kompartmen 106, Hutan Simpan Kenaboi, Jelebu, Negeri Sembilan untuk menyiasat taburan kelas diameter bagi pokok *Dryobalanops aromatica* yang ditanam 45 tahun lalu. Sepuluh plot, berukuran 50 m panjang dan 20 m lebar telah dibuat dalam reka bentuk tali pinggang-transek. Pokok-pokok dikategorikan ke dalam diameter kelas di mana taburan dan bilangan pokok-pokok direkodkan. Keputusan menunjukkan bahawa pengagihan dbh kelas daripada pokok *Dryobalanops aromatica* boleh dikelaskan kepada empat kelas iaitu kelas 15 - 29.99 cm, 30 - 44.99 cm, 45 - 59.99 cm dan ≥ 60 cm. Bilangan individu untuk dbh kelas 15 - 29.99 cm, 30 - 44 .99 cm dan 45 - 59.99 cm menunjukkan 12 individu (10.3%), 59 individu (50.9%) dan 40 individu (34.5%) bagi kelas masing-masing. Dbh kelas bagi ≥ 60 cm adalah yang paling rendah dengan hanya lima individu yang hanya mewakili 4.3% daripada kawasan itu. Plot 2 menunjukkan kepadatan individu yang paling tinggi, dengan 18 individu yang terdiri daripada semua kelas dbh, manakala Plot 6 menunjukkan bilangan individu yang paling rendah dengan hanya lapan individu dicatatkan di dalam plot tersebut. Purata dbh untuk pokok *D. aromatica* yang ditanam di Kenaboi FR adalah 41.73 cm. Purata pertambahan diameter tahunan (MAI) untuk pokok *D. aromatica* adalah antara 0.36 to 1.6 cm/yr. Jumlah basal area untuk 1-ha kawasan ialah 16.89 m^2 dengan jumlah isipadu, 221.77 m^3 ha^{-1}. Pokok-pokok di kawasan ini menunjukkan interaksi positif antara basal area (m^2) dan isipadu (m^3) dengan persamaan y = 0.0623x + 0.071. Kajian ini dianggap bahawa pengagihan kelas dbh di kawasan ini sangat miskin kerana bilangan pokok yang hidup selepas 45 tahun adalah sangat sedikit daripada jumlah yang ditanam pada 1971.

ACKNOWLEDGEMENT

Alhamdulillah, praise to Allah S.W.T for giving me an opportunity, health and encouragement to completing this project paper. I would like to express great appreciation to my supervisor, Assoc. Prof. Dr. Mohamad Azani bin Alias for his support, patience, constant guidance, time, encouragement and constructive criticism throughout this study until the completion of this paper. Special thanks to Assoc. Prof. Dr. Mohd Nazre Saleh for his suggestions and criticisms in the completing this project paper.

Special thanks to Mr. Nor Zaidi Jusoh from Department of Forestry, Negeri Sembilan for his permission to conduct this study in Kenaboi Forest Reserve. My sincere appreciation to all staffs from Phenology Mantin, Negeri Sembilan for their help and guidance in collecting the data in Kenaboi Forest Reserve.

To my beloved family, thanks for giving me full support and encourage me all the time. Deeply thanks to my friends Nur Razanah Ahmad, Fatin Norliyana, Mohd Hasrol Syah, Asyraf, Nasrullah and Azren Putra for their willingness to help me in the data collection and also to Nor Fazlina, Norhidayah, Nor Nasuha and kak Rodziah with their moral support to completing this project paper.

APPROVAL SHEET

I certify that this research project report entitled “Diameter Class Distribution, Growth and Volume of *Dryobalanops aromatica* C.F. Gaertn. Planted in Kenaboi Forest Reserve, Jelebu, Negeri Sembilan” by Setia Bt Majuri has been examined and approved as a partial fulfillment of the requirements for the degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

Approved by:

_____

Assoc. Prof. Dr. Mohamad Azani Bin Alias
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

_____

Prof. Dr. Mohamed Zakaria Bin Hussin
Dean
Faculty of Forestry
Universiti Putra Malaysia

Date: 23 June 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BA	Basal area
DBH	Diameter at breast Height
FR	Forest Reserve
FRIM	Forest Research Institute Malaysia
Ha	Hectare
Km	Kilometer
m	Meter
Max.	Maximum
Min.	Minimum
yr	Year

CHAPTER 1

INTRODUCTION

1.1 General

The genus of *Dryobalanops* C.F. Gaertn. is prominent genus with total of seven species that well defined. There are only two species from this genus are found outside the island of Borneo, which is *Dryobalanops aromatica* C.F.Gaertn. and *Dryobalanops oblongifolia* Dyer. *D. aromatica* was found in a well –drained soils while *D. oblongifolia* can be found on poorly drained soils along streams. *D. aromatica* is one of seven species that well defined in the genus of *Dryobalanops* (Ashton, 1964). The substance that obtained from the Kapur trees (crystalline camphor) was traded in seventh century among Europe, the Malacca port and other port in the west coast.

D. aromatica occur naturally in Sumatra (Angkola Sibolga, Kelasan, Upper Singkil, Bengkalis, Siak and Mursala Island), the Peninsular Malaysia (Johor, Pahang, Selangor and Terengganu), Lingga Archipelago (Lingga and Singkep Island) and Borneo (Sabah, Sarawak and Brunei). In Peninsular Malaysia, this tree is found naturally only in the east coast, south of latitude 5° N, except for small pockets in Rawang, Selangor (Wyatt-Smith, 1963). Burkill (1935) recommended that the tree was introduced from the east coast by traders of crystalline camphor.

The plantation of forest species in Peninsular Malaysia was recorded date back as far as 1880. This is due to the concern over the rapid destruction of

desired species was expressed (Hill, 1900). The concern towards timber destruction started in the Gutta percha era where the *Palaquium gutta* (Nyatoh taban) species heavily felled, and finally very difficult to obtain the wood for railway sleepers. The beginning of hardwood plantation in Malaysia, started when the scheme of plantation was initiated in Sungai Buloh Forest Reserve. In 1898, certain species such as *D. aromatica*, *Casuarina equisetifolia*, *Eugenia grandis*, *Swietenia macrophylla*, *Hevea brasiliensis* and *Fagraea fragrans* was planted around Pekeliling, Kuala Lumpur.

The plantation of *D. aromatica* species became more widely in Peninsular Malaysia through plantation that were conducted by FRIM. *D. aromatica* was planted in various areas such as in FRIM, Tampin, Bukit Lagong Forest Reserve, and Kanching Forest Reserve, Selangor. Besides that, *D. aromatica* species also planted through Taungya System that introduce in Malaysia in early 1950-an. *D. aromatica* have been widely used in enrichment planting and are thought to be among the more promising dipterocarp plantation species due to their relatively fast growth (Wyatt-Smith, 1963; Kollert et al., 1996). This species also is one of the most suitable species for large-scale plantation in Malaysia (Abdul Rahman et al.,1992).

D. aromatica is a fast growing species, comparing with the faster of the red meranti *Shorea* species such as *Shorea acuminata* Dyer and *Shorea leprosula*, that taking about 43 years to reach a girth of 5 feet at breast height (Edwards, 1930). This species also was a shade tolerant species in the young stage. Therefore, it can be planted under a heavy shade. *D. aromatica*

is a good species for planting, especially under some shade, since it recorded a relatively high survival rate of 45% when planted under shade through line planting technique (Mohamad Azani et al., 1998). *D. aromatica* is intolerant to the other species. Therefore, the growth of *D. aromatica* in natural forest is slower than in planted forest due to the competition between species and environmental variables affecting growth (Ahmad Zuhaidi, 2005). This species should be grown in area that less mixed species.

D. aromatica produces wind-dispersed fruit (5 - 7 g fresh weight) with five sepal wings (about 4 - 7 cm long) and one seed (Itoh et al., 1995) to disperse itself easier. This species flowers and fruiting more frequently than the others dipterocarp species. Distribution pattern of flowering or fruiting of *D .aromatica* was observed in a Lowland mixed dipterocarp forest at Lambir Hills National Park every year between 1990 to 1998, except 1995 (Itoh et al., 1997). Considerable *D. aromatica* fruiting occurred only from 1991 to 1992, and from 1996 to 1997, when many other species also fruited heavily after periods of mass flowering (Sakai et al., 1999). Frequent reproduction of *D. aromatica* was also observed in Peninsular Malaysia (Appanah & Weinland, 1993). The study of pattern fruiting individuals In Lowland Mixed Dipterocarp Forest at Lambir Hills National Park shows that from 393 adult trees, 143 (36.4%) individuals was fruited (Itoh et al., 2002).

1.2 Problem Statement

D. aromatica was identified as a quality timber in Peninsular Malaysia and had an economic value. In addition, from the planting trial that conducted by FRIM with several silviculture treatment, *D. aromatica* were found productive for plantation programs where the programs is an alternative for a long-term timber production strategy in Peninsular Malaysia.

The growth rates of *D. aromatica* in natural forest is much lower compared to monoculture plantation conditions and the products are uniform. Tang and Wan Razali (1981) shows that the mean annual diameter increment (MAI) for dipterocarp species in Labis FR is 0.89 cm/yr. Ng & Tang (1974) shows the result from plantation condition in FRIM, the MAI for *D. aromatica* is ranging from 1.1 – 1.5 cm/yr.

D. aromatica grown in plantation produces stems and crown of good form. Besides that, the yield of wood under plantation condition is estimated at least five times more than in a natural forest (Lim & Faridah Hanum, 1992).

In the plantation conditions of FRIM, the annual increment diameter for *D. aromatica* is ranging from 0.9 to 1.5 cm/year. This differences of the growth increment between natural forest and plantation condition affecting the harvesting time of the *D. aromatica* in the plantation condition because the trees can reach the minimum cutting limit earlier than in a natural forest. Based on the annual increment diameter, the plantation condition can reach the cutting limit in only ≥ 60 years.

The minimum cutting limit for dipterocarp species in natural forest is 50 cm dbh and above. From the previous study of dipterocarp species in Labis Forest Reserve, the periodic diameter mean annual increment for dipterocarp species in that forest is 0.85 cm/year. Therefore, the harvesting time for the dipterocarp species in the natural forest will take time in >70 years before reaching the minimum cutting limit.

Therefore, in order to manage this species in plantation condition, ecological attribute especially the distribution of diameter class should be understood. In order to gain an information about the distribution of diameter class for *D. aromatica* that are planted in Kenaboi Forest Reserve on 1971 without any silviculture treatment, the present study has been carried out based on the belt-transect sampling.

1.3 Objectives

Generally, this study was to determine the distribution of diameter class for 45 years-old *D. aromatica* planted in Kenaboi Forest Reserve, Negeri Sembilan. Therefore, the specific objectives of this study were:

I. To identify the diameter classes, volume, basal area and mean annual diameter increment (MAI) of planted *D. aromatica* in Kenaboi Forest Reserve.

II. To create new growth increment model for *D. aromatica* under plantation in Kenaboi FR.

REFERENCES

Aiba, M. & Nakashizuka, T. (2007). Variation in juvenile survival and related physiological traits among dipterocarp species co-existing in a Bornean forest. *Journal of Vegetation Science*, *18*(3), 379-388.

Appanah, S. & Weinland, G. (1993). Planting quality timber trees in Peninsular Malaysia: A review. Kuala Lumpur: Forest Research Institute Malaysia.

Ashton, P. S. (1968). A manual of the dipterocarp trees of Brunei State and of Sarawak-supplement. *Kuching, Sarawak: Borneo Literature Bureau (for Sarawak Forest Department).*

Awang, K. (1985). Some Agroforestry Practices in Southeast Asia. Occasional Paper No.4. *Faculty of Forestry, University Pertanian Malaysia, Serdang, Selangor.*

Azani, A. M, Zaki, H.M. & Fujiwara, K. (1998). Rehabilitation of tropical rainforests based on potential natural vegetation species for degraded areas in Sarawak, Malaysia. *Tropics*, *7*(3/4), 223-239.

Bosman, M. T., Kort, I. D., van Genderen, M. K. & Baas, P. (1994). Radial variation in wood properties of naturally and plantation grown light red meranti (*Shorea*, Dipterocarpaceae). *IAWA Journal*, *15*(2), 111-120.

Box, E. O. (1995). Factors determining distributions of tree species and plant functional types. In *Global change and terrestrial ecosystems in monsoon Asia* (pp. 101-116). Netherlands Springer.

Burgess, P. F. (1972). Studies on the regeneration of the hill forests of the Malay Peninsula. *Malayan Forester*, *35*(2), 102-123.

Burkill, I. H. (1935). A Dictionary of the economic products of the Malay Peninsula. *Crown Agents for the Colonies, London.*

Connell, J.H. & Lowman, M.D. (1989). Low-diversity tropical rain forests: some possible mechanisms for their existence. *American Naturalist,* 134:88-119.

Corner, E.J.H. (1988) .*Wayside Trees of Malaya* (3rd Ed.). The Malayan Nature Society, Kuala Lumpur.

DaFangliang, H., Legendre, P. & LaFrankie, J. V. (1997). Distribution patterns of tree species in a Malaysian tropical rain forest. *Journal of Vegetation Science*, *8*(1), 105-114.

Foxworthy, F.W. (1930). Forest planting in Malay Peninsula. *Staff Conference, Forest Research Institute, Federated Malay States, Kuala Lumpur.*

Hahn-Schilling, B. (1988). *Dryobalanops aromatica* Gaertn. F. and *Shorea parvifolia* Dyer. A silvicultural analysis of planted dipterocarp stands on the Malaysian Peninsula.

Hill, H.C. (1900). Report on the Present System of Forest Administration in the Federated Malay States, with Suggestions for Future Management of the Forest of those States. *Her Majesty's Indian Forest Service. Government Printers, Selangor.*

Hubbell, S. P. (1979). Tree dispersion, abundance, and diversity in a tropical dry forest. *Science*, *203*(4387), 1299-1309.

Ichie, T., Kenzo, T., Kitahashi, Y., Koike, T. & Nakashizuka, T. (2005). How does *Dryobalanops aromatica* supply carbohydrate resources for reproduction in a masting year?.*Trees*, *19*(6), 704-711.

Ishida, A., Toma, T., Matsumoto, Y., Yap, S. K. & Maruyama, Y. (1996). Diurnal changes in leaf gas exchange characteristics in the uppermost canopy of a rain forest tree, *Dryobalanops aromatica* Gaertn. f. *Tree Physiology*, *16*(9), 779-785.

Ishizuka, S., Tanaka, S. Sakurai, K., Hirai, H., Ogino, K., Lee, H.S. & Kendawang, J.J. (1998). Characterisation and distribution of soils at Lambir National Park in Sarawak, Malaysia, with special reference to soil hardness and texture. *Tropics* 8: 31–44.

Itoh, A. (1995). Effects of forest floor environment on germination and seedling establishment of two Bornean rainforest emergent species. *Journal of Tropical Ecology*, *11*(04), 517-527.

Itoh, A., Yamakura, T., Ogino, K., Lee, H. S. & Ashton, P. S. (1995). Population structure and canopy dominance of two emergent dipterocarp species in a tropical rain forest of Sarawak, East Malaysia. *Tropics*, *4*(2/3), 133-141.

Itoh, A., Yamakura, T., Ohkubo, T., Kanzaki, M., Palmiotto, P., Tan, S. & Lee, H. S. (2003). Spatially aggregated fruiting in an emergent Bornean tree. *Journal of Tropical Ecology*, *19*(05), 531-538.

Jalonen, R., Hong, L. T., Lee, S. L., Loo, J. & Snook, L. (2014). Integrating genetic factors into management of tropical Asian production forests: A review of current knowledge. *Forest Ecology and Management*, 315, 191-201.

Krishnapillay, D. B. & Varmola, M. (2002). Case Study of the Tropical Forest Plantations in Malaysia. *Forest Plantations Thematic Papers. Working Paper (FAO)*. *Forest Resources Division.*

Krishnapillay, B. & Tompsett, P. B. (1998). Seed handling. *A review of dipterocarps: taxonomy, ecology and silviculture,* 3-88. Center for International Forestry Research.

Lee, K. S., Wickneswari, R. & Choong, C. Y. (2007). Stand structure and the genetic diversity of Koompassia malaccensis and *Dryobalanops aromatica* in unlogged and logged-over stands. *Sains Malaysiana*, *36*(2), 233-242.

Lee, S. L., Ang, K. C. & Norwati, M. (2000). Genetic diversity of *Dryobalanops aromatica* Gaertn. f. (Dipterocarpaceae) in Peninsular Malaysia and its pertinence to genetic conservation and tree improvement. *Forest Genetics*, *7*(3), 209-217.

Lee, S. L., Wickneswari, R., Mahani, M. C. & Zakri, A. H. (2000). Genetic Diversity of a Tropical Tree Species, *Shorea leprosula* Miq. (Dipterocarpaceae), in Malaysia: Implications for Conservation of Genetic Resources and Tree Improvement1. *Biotropica*, *32*(2), 213-224.

Lee, S. L. (2000). Mating system parameters of *Dryobalanops aromatica* Gaertn. f. (Dipterocarpaceae) in three different forest types and a seed orchard. *Heredity*, *85*(4), 338-345.

Leigh Jr, E. G., Davidar, P., Dick, C. W., Puyravaud, J. P., Terborgh, J., ter Steege, H. & Wright, S. J. (2004). Why do some tropical forests have so many species of trees? *Biotropica*, *36*(4), 447-473.

Lim, L. S. & Lee, S. L. (2002). Genetic variation of *Dryobalanops aromatica* Gaertn. F. (Dipterocarpaceae) in Peninsular Malaysia using microsatellite DNA markers. *Forest Genetics*, *9*(2), 125-136.

Lim, M.T. & Faridah Hanum. (1992). Indigenous species for forest plantations: proceedings of a national seminar*. Faculty of Forestry, Universiti Pertanian Malaysia, Serdang, Selangor*, 23-24 Apr 1992, p. 1-7.

Ng, F.S.P. & Tang, H. (1974). Comparative growth rates of Malaysian trees. *Malaysian forester*, 37:2-22.

Okuda, T., Kachi, N., Yap, S. K. & Manokaran, N. (1997). Tree distribution pattern and fate of juveniles in a lowland tropical rain forest–implications for regeneration and maintenance of species diversity. *Plant Ecology*, *131*(2), 155-171.

Plotkin, J. B., Chave, J. & Ashton, P. S. (2002). Cluster analysis of spatial patterns in Malaysian tree species. *The American Naturalist*, *160*(5), 629-644.

Rahman, K. A., Shahrulzaman, I. & Weinland, G. (1996). Growth performance of a naturally regenerated stand of Kapur (*Dryobalanops aromatica* Gaertn. f.) 37 years after a heavy low thinning treatment. In *Tropical Rainforest Research - Current Issues* (pp. 347-355). Netherlands Springer.

Rozas, V. (2003). Regeneration patterns, dendroecology, and forest-use history in an old-growth beech–oak lowland forest in Northern Spain. *Forest Ecology and Management*, *182*(1), 175-194.

Sasaki, S. (2006). Ecology and physiology of Dipterocarpaceae. In *Plantation technology in tropical forest science* (pp. 3-22). Tokyo Springer.

Sass, U., Killmann, W. & Eckstein, D. (1995). Wood formation in two species of Dipterocarpaceae in peninsular Malaysia. *IAWA journal*, *16*(4), 371-384.

Symington, C. F., Ashton, P. S., Appanah, S. & Barlow, H. S. (2004). *Foresters' manual of dipterocarps*. Forest Research Institute Malaysia.

Tang, H.T. & Wan Razali, W.M. (1981). Report on growth and yield studies in inland mixed indigenous forests in Peninsular Malaysia. *Forest Department Peninsular Malaysia, Kuala Lumpur*. 73 pp.

Watson, J. G. (1935). Plantation experiments at Kepong. *Malaysian Forester*, 4, 110-119.

Weinland, G. (1998). Plantation. Pp. 151-172. In: Appanah, S. and Turnbull, J.M. (Eds.). A review of dipterocarps: Taxonomy,ecology and silviculture. *Center for International Forestry Research and Forest Research Institute Malaysia*.

Wyatt-Smith, J. (1949). A note on tropical lowland evergreen rain-forest in Malaya. Malayan Forestre 12: 58-64.

Wyatt - Smith, J. (1963). Manual of malayan silviculture for inland forests. Malayan Forest Record No. 23. *Forest Research Institute, Kepong,Malaysia.*

Yahya, A. Z., Van Gardingen, P. R. & Grace, J. (2004). Diameter growth of naturally regenerated *Dryobalanops aromatica* in peninsular Malaysia. *Journal of Tropical Forest Science*, (16/1), 1-8.

Zimmerman, B. L. & Kormos, C. F. (2012). Prospects for sustainable logging in tropical forests. *BioScience*, *62*(5), 479-487.

Zuhaidi, Y. A. (2006). Modelling tree diameter growth of plantation grown Dryobalanops sumatrensis. *Journal of Tropical Forest Science*, *18*(4), 203-211.

Zuhaidi, Y. A. (2009). Local growth model in modelling the crown diameter of plantation-grown *Dryobalanops aromatica*. *Journal of Tropical Forest Science*, *21*(1), 66-71.