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Site Influence on Growth and Phenotype of Teak (*Tectona grandis* Linn. f.) in Natural Forests of Myanmar

Cuvillier Verlag Göttingen

Site Influence on Growth and Phenotype of Teak (*Tectona grandis* Linn. f.) in Natural Forests of Myanmar

Dissertation

zur Erlangung des Doktorgrades
der Fakultät für Forstwissenschaften und Waldökologie
der Georg-August-Universität Göttingen

vorgelegt von
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geboren in Yangon, Myanmar

Göttingen 2003

Gedruckt mit Unterstützung des Deutschen Akademischen Austauschdienstes

D7

1. Berichterstatter: PD Dr. R. Mitlöhner
2. Berichterstatter: Prof. Dr. G. Gravenhorst
Tag der mündlichen Prüfung: 18.06.2003

(Cover photo by Teaknet)

Acknowledgements

I am first indebted to Prof. Dr. Hans–Joachim Weidelt, PD Dr. Ralph Mitlöhner, Institute of Silviculture, Section II: Tropical Silviculture, University of Göttingen, Prof. U Aung Kyin, Advisor at the Institute of Forestry, Yezin, Myanmar, and Frau Dr. Christa Klaus, Director, German Academic Exchange Service (DAAD), Bonn, for their tireless effort in giving me an opportunity to do doctoral study in Germany. I also extend my deep appreciation to U Shwe Kyaw, Director-General of Forest Department and U Than Swe, Director-General of Planning and Statistics Department, Ministry of Forestry for accommodating the requirements of PhD study.

I would like to express my deep sense of gratitude to PD Dr. Ralph Mitlöhner for his kind encouragement and supervision on my work throughout my study period in Germany. My sincere thanks go to Prof. Dr. Gode Gravenhorst, Institute of Bioclimatology, and Prof. Dr. Frantisek Hapla, Institute of Wood Biology and Wood Technology, for having examined and reviewed my doctoral thesis and for their criticism and good advice. I am especially grateful to PD Dr. Martin Worbes, Institute of Tropical Agronomy (formerly from Institute of Forest Botany), who provided many useful suggestions and wise comments on dendrochronological analysis on teak. My sincere thanks are also due to Dr. Jochen Schöngart and Ms. Esther Naumer, PhD student, for their help in carrying out the growth-ring analysis at the laboratory and the many hours they spent assisting me.

This study would not have been possible without the financial support and close cooperation of the German Academic Exchange Service (DAAD), for which I am very much indebted. I wish to express my personal thanks to U Win Kyi (2), Pro-Rector of Institute of Forestry, former Director of Forest Research Institute, Yezin, and U Saw Eh Dah, Coordinator of Teaknet, Asia-Pacific Region, for their institutional support during the fieldwork in Myanmar.

I would like to place on record my sincere thanks to Prof. Dr. Kyaw Tint, Retired Director-General of Forest Department, Myanmar, for his valuable suggestion and advice from his wide experience on growth and yield study. I wish to acknowledge with

many thanks the enthusiastic help of Uncle U Ye Myint and U Tin Hla, both of whom are Retired Director-Generals of Forest Department as well as Advisors at the Ministry of Forestry, Yangon, Myanmar, in the search of the earlier literatures. The help rendered heartily by many people from the Forest Department, Planning and Statistics Department, and Myanma Timber Enterprise during my field research in Myanmar is also gratefully acknowledged. It will not be possible for me to express every one of them by name, but this in no way belittles my gratitude to them.

My deep gratitude is extended to all colleagues at the Institute of Silviculture in Göttingen for their friendly understanding, supporting and assisting me during my study in Göttingen. My great thanks go in particular to PD Dr. Ralph Mitlöhner, Ms. Ilse Bechtold, Ms. Marlies Friedrich, Mr. Reinhard Köpp, Dr. Uwe Muuß, Ms. Wibke Himmelsbach, Mr. Frank Brodbeck, Prof. Dr. Dieter Murach, all of them helped me in various ways throughout my stay in Germany. They have engraved themselves in my mind as representatives of wise and kind German people forever.

This thesis is dedicated to my parents U Kyaw Din and Daw Khin Lay Oo for their love and inspiration to me to be a forester.

Last but not least, I would like to express my heartfelt gratitude to my beloved wife Khin Than Win and two sons, Yan Naing Aung and Kyaw Myo Thant, for their moral support and encouragement to me, without their understanding and patience during my absence in Myanmar this work would never have been accomplished.

Abbreviations

AAC	Annual Allowable Cut
CAI	Current Annual Increment (m^3)
CEC	Cation Exchange Capacity
D	SIMPSON's Index
DANIDA	Danish Agency for Development Assistance
DBH	Diameter at Breast Height (cm)
E (%)	SHANNON's Evenness
FAO	Food and Agriculture Organization of the United Nations
GBH	Girth at Breast Height (ft)
Glk.	Coefficient of parallel variation (*Gleichläufigkeit*)
H'	SHANNON diversity Index
HSWC	Hardwood (non-teak commercial) Supply Working Circle
IF	Improvement felling
IUFRO	International Union of Forest Research Organizations
IVI	Importance Value Index
K/d	ratio of crown diameter (m) to stem diameter (cm)
K_G	Coefficient of Similarity based on basal area
K_i	Bark increment coefficient
K_S	Coefficient of Similarity based on species occurrence
LSWC	Local supply Working Circle
MAI	Mean Annual Increment (m^3)
nWP	Internal negative water potential
TSAP	Time Series Analysis and Presentation
TSWC	Teak Selection Working Circle

Contents

1 Introduction

1.1 Teak in Myanmar

Teak (*Tectona grandis* LINN. f.), a species of world wide reputation as paragon among timber trees, belongs to the family Verbenaceae and is distributed predominantly in tropical and subtropical regions. It is indigenous to only four countries in South and South-East Asia, and dense natural forests with big and beautiful admiralty quality teak have degraded and shrunk so rapidly that at present they are confined only to Myanmar and to some extent to India (GYI and TINT 1998). Thus, natural grown teak has now almost become an endangered species.

Teak is one of the most important hardwood species planted extensively in several countries in the Asia-Pacific region. Being indigenous to the region, substantial experience has been gained in the management of natural and man-made stands of teak. The reasons for the relatively wide use of teak, where quality hardwoods are planted, are its ease of propagation, establishment and management, as well as its excellent wood quality. It is one of the most valuable multi-purpose timbers of the world. Its properties include:

- attractiveness in colour and texture
- strength with lightness
- durability
- dimensional stability
- non-corrosion
- ease of working and seasoning and
- termite, fungus and weather resistance.

A number of teak provenances of different girth sizes, stem forms, phenological characters and timber properties are found in different parts of India, Myanmar, Thailand, Laos and Indonesia (TEWARI 1992). These differences were tested through an international network of provenance trials, which probably provides the best

available information on general provenance variation. Early international trials in evaluation of teak provenances are described by KEIDING and KEMP (1977), WHITE (1991), who recommended the provenances Konni (India), Bangari (Indonesia), and Ban Chan Pui (Thailand). Reports on provenance trials from India, Thailand and Indonesia indicated that national provenances performed best. Myanmar provenances were not included in those series of international provenance trials implemented by DANIDA, and Myanmar trials have been examined in one country trial.

Even though teak once covered a large percentage of India, Thailand and Myanmar and a small area of Laos, there is now a very restricted distribution in each of these countries except Myanmar. In Myanmar, natural teak forests have been managed for many years with sustained timber production as the primary objective. Myanmar is the only country producing large teak logs from natural forest, which attract a price advantage compared with smaller logs from plantations and which is likely to continue in the foreseeable future. However, the area and quality of teak forests are declining with the increase in population and greater pressure on forested land for conversion to agricultural land and illicit cutting. Forest resources, which are replenishable, should be managed so as to be in line with the current situation. Therefore, the management system needs to be modified in order to suit the present status of stand structure, composition, and growth of teak forests. The study is intended to provide information to designate as a portion for future sustainable management of natural teak forests of Myanmar.

Myanmar, a country with a total area of 676,577 km^2, is situated in Continental South East Asia, lies between 9° 53′ N and 28° 25′ N latitudes and 92° 10′E and 101° 10′E longitudes. Approximately 75% of the country lies within the tropics. Consequently, it has a wide range of temperature and rainfall, which is distributed over 5 months of the year, ranges from less than 700 mm to over 5000 mm. All these contribute towards a wide variety of environmental condition and diversity in the types of forests that exist within the country.

Myanmar has a forest cover of about 33 million hectares, which is almost half of its total land surface area. The forest cover consists mainly of natural forests, about 45% of

which are teak bearing forests. The forest resources, though scientifically managed since 1856, have been decreasing gradually both in extent and quality due to increased population pressure and consequent rising demands for timber for domestic and foreign uses. Annual production of teak is estimated to be about 450,000 m^3 (1991-2000 average) in the form of logs and sawn timber, of which are mostly from natural forests. About one-quarter of the total foreign exchange earning of Myanmar comes from export of timber, about 90% of which is derived from teak (HTUN and HLAING 2001).

Although there were plenty of teak trees in the natural forests in various densities, teak plantations were established in a compensatory way up to 1962. Starting from early 1970s, block plantations were formed in the areas with degraded forests and poor stocking of teak and other valuable commercial species. Up to 2000, 293,782 ha of teak plantations have been established, i.e. 41% of total plantations formed in Myanmar.

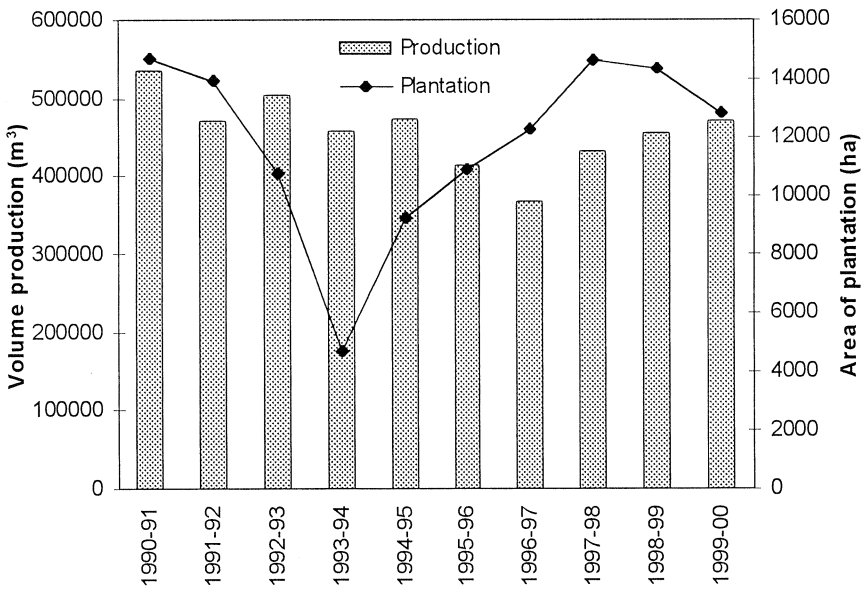

Figure 1.1 The annual production and plantation establishment of teak in Myanmar (FOREST DEPARTMENT 2000; HTUN and HLAING 2001)

In 1997, the Forest Department has launched a special teak plantation programme, which incorporates new features such as adoption of 40-year rotation, participation of interested and relevant communities with increased inputs, etc.

1.2 A brief retrospect of Myanmar teak forests

Consciousness of forestry practice and forest management in Myanmar date back to the Dynasty of King ALAUNGPAYA. He declared all teak trees as Royal property in 1752 and levied royalties for their extraction. The pre-colonial state played a central role in the teak trade and also attempted to regulate teak extraction from the forest itself. A technique of killing commercially mature trees known as girdling was central to this endeavour:

> Girdling consists in cutting through the bark and sapwood till the darker-coloured heartwood is entered about an inch below the surface. The effect of this operation is to check the possibility of sap rising from the root system. Deprived of food supplies the leaves wither and the tree dies. A process of natural seasoning on the stock them follows... the seasoned stem being ready for felling and extraction in two years and more.

(Conservator JOHN NISBET, Burma under British rule, vol. II, p.52, 1901)

This process facilitated dragging and floating operations such that girdled teak was easier to extract from the forest than ungirdled, the so called "green teak". Teak girdling was also a useful means of state control.

Myanmar's reputation as a major source of teak was known to the British since the eighteenth century. The British fought three successive wars against Myanmar, finally annexing the whole country.

After the first Anglo-Myanmar war (1824-26), the British transformed the newly acquired territory of Tanintharyi from an economic backwater into a major regional centre. A prosperous timber and shipbuilding industry developed at the principal town of Mawlamyine based on exploitation of local teak forests. Teak as a versatile timber, which contained an oil prevented metal corrosion, was especially sought for

construction of naval vessels. Teak proved superior to oak for shipbuilding. The acquisition of the Tanintharyi teak forests in 1826 was crucial to wider British imperial interests.

Between 1829 and 1857, private firms in Tanintharyi were essentially free to extract teak as they wished. Forest rules were few in number, and limited in scope. By the 1850s, the depletion of Tanintharyi teak forests made state intervention and seemed the only realistic option if the teak forests of Bago, annexed after the Second Anglo-Myanmar war (1852), were to avoid a similar fate (BRYANT 1996).

Between 1852 and 1855, the British introduced preliminary measures to regulate Bago teak forests. Bago's first Superintendent of Forests and predecessor to BRANDIS, the British physician JOHN McCLELLAND, examined the teak bearing Bago Yoma, documented the incidence of teak and warned of the perils of unregulated private extraction.

Dr. DIETRICH BRANDIS, a German botanist-turned forester, was recruited by DALHOUSIE, Governor-General of India to replace McCLELLAND in 1856 (Lower Myanmar was governed as a province of India after Second Anglo-Myanmar war). The Forest Department was established so as to permit the introduction of scientific forest management in the Bago teak forests. BRANDIS started work in Bago forests to know characteristics of the teak tree, making estimation of the annual allowable cut. He recognised the importance of the frequency distribution of trees by girth classes, the need to estimate diameter growth from ring counts over the life of the tree, and the estimation of survival and mortality. These quantitative factors are still the basis of sound forest management everywhere.

The initial enumerations were improved by stratification of permanent transects along contours to enable the lines to be re-located and re-measured. The quantitative setting of yields was supplemented by silvicultural rules to take account of the findings of the inventories and growth estimates. Over hundred working plans based on these principles were developed and implemented in Myanmar from 1857 to 1967.

A reforestation technique known as *Taungya* forestry was implemented in the latter half of the nineteenth century. First attempted with Karen, one of the major ethnic groups of Myanmar, in Pyay District in 1856, this scheme was base on the idea that, if cultivators planted teak with their rice and other crops on the same land, the Forest Department would be left with young teak plantations once these cultivators had moved to new fields.

Following the Third Anglo-Myanmar war (1885-86) the British controlled all of Myanmar forests. By the early 1890s, the Upper Myanmar forest administration was established on the model of that in Lower Myanmar. The Burma Forest Act (1881) established a complex procedure for the creation of reserved forests. Most of the best teak forests of Bago Yoma were reserved and growing stable under forest administration in the early twentieth century. Forest management under the Burma Forest Act (1902) became an ever more rigorous attempt to promote long-term commercial timber production in reserves according to scientific principles. In 1907 Lower Myanmar forests except Taungoo forests opened to private enterprise as a part of a major reorganisation of teak extraction. Teak production rose steadily during 1900-24 with an amount of 66,058 tons (119,000 m^3) per annum. Output increased most rapidly during and after the First World War (BLANFORD 1936).

By the early 1920s, forests were managed much more intensively than had been the case in the late nineteenth century. The working plans epitomised the more intensive style of forest management and the first modern working plan was prepared by Deputy Conservator J. W. OLIVER in Thonze Reserve (Tharyarwady District). This plan sub-divided the Reserve into blocks and compartments, which were to be harvested on a rotation basis. OLIVER's plan signalled the formal adoption of a teak selection system in Myanmar (BRYANT 1996).

The Forest Department had created an extensive network of reserved forests, in which intensive management was being practised and it had effectively achieved its goal of a system on sustained-yield basis in Myanmar.

1.3 Current status of natural teak forests

Historically forests in India, Myanmar, and Thailand have been the most important source of teak wood (GYI and TINT 1998). However, with the drastic decline in the area of teak forests, at present Myanmar is the only country that still relies on the natural forests for its teak wood production (NAIR and SOUVANNAVONG 2000).

Myanmar has about 16.5 million ha of natural teak bearing forests, constituting 59% of the total extent. Globally, natural teak forests represent a relatively limited area and their share in teak wood production is likely to continue to decrease relative to the production from planted teak forests. Consequently, the focus on production from the remaining natural teak forests is generally decreasing in favour of environmental protection and conservation of biodiversity (NAIR and SOUVANNAVONG 2000). Policies and legislation ban or severely restrict harvesting in natural forests in most of the countries within teak's natural range: all industrial harvesting in the natural forests of Thailand has been banned since 1989; in India, clear-felling of teak has been stopped in most teak-growing provinces since 1986; teak harvesting in the Lao People's Democratic Republic has been largely prohibited since 1989 (PANDEY and BROWN 2000). However, in Myanmar, natural forests still contribute an important part of teak production. As a result of Myanmar's long experience with harvesting under Myanmar Selection System, teak management is generally well regarded in terms of environmental sustainability (WINT 1998).

1.4 Objectives of the study

The study is focused on the natural forests where teak occurs as a dominant species. The main objective is to provide vital information on the growth of teak in different type of forests.

The major objectives of this study are:

1) To describe the different types of teak bearing forests in Myanmar with their silvicultural stand structure analysis
2) To assess the phenotypic characteristics of teak stands in different ecotypes
3) To analyse the growth-climate relationship of teak with reference to existing records
4) To investigate the stand growth characteristics by annual growth ring analysis
5) To measure the plant internal water balance of teak in respective localities to estimate the adaptability on periodical minimum factor of water

2 Biological and ecological characteristics of teak and its management systems

2.1 Distribution of natural teak forests

Teak occurs naturally in the South and Southeast Asian regions covering the range of latitudes between 9°-25°30′ N and longitudes between 73°-104°30′ E (KAOSA-ARD 1986). Within these limits the occurrence is discontinuous, the teak forests being separated by mountain ranges, plains, farmland and other types of forest. There are many localities throughout its range where no teak occurs due to unfavourable growth conditions. The main teak resources are in central and south western India, where in places it accounts for the bulk of the crop, and in throughout the greater part of Myanmar, hills of the northern Thailand and western part of Laos. In Indonesia, teak is also well established on the islands of Java and Muna, but it is believed to be introduced from India by the Hindus in the 14th century. Thereafter, it regenerated and was distributed naturally throughout the areas (KAOSA-ARD 1977, 1986). The total area of the natural teak forests has been estimated at about 27.9 million hectares as shown in Table 2.1.

Table 2.1: Extent of natural teak forests in South and South-East Asia (GYI and TINT 1998)

Country	Teak forest area (ha)	% of total teak forest area
India	8,900,000	31.86
Lao PDR	16,000	0.06
Myanmar	16,517,700	59.13
Thailand	2,500,000	8.95
Total	27,933,700	100.00

CHAMPION and GRIFFITH (1960) noted that in considering the discontinuous distribution of teak, the eastern or Myanmar form is easily distinguished from the western or Indian form and that there is further differentiation within the western form.