UNIVERSITI PUTRA MALAYSIA

FERTILIZER REQUIREMENTS AND NUTRIENT DYNAMICS OF TEAK (TECTONA GRANDIS L.F.) PLANTATIONS IN PENINSULAR MALAYSIA

MUHAMMAD TAHIR SIDDIQUI

FERTILIZER REQUIREMENTS AND NUTRIENT DYNAMICS OF TEAK (*TECTONA GRANDIS* L.f.) PLANTATIONS IN PENINSULAR MALAYSIA

MUHAMMAD TAHIR SIDDIQUI

DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA
1998

FERTILIZER REQUIREMENTS AND NUTRIENT DYNAMICS OF TEAK (*TECTONA GRANDIS* L.f.) PLANTATIONS IN PENINSULAR MALAYSIA

BY

MUHAMMAD TAHIR SIDDIQUI

Dissertation Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Forestry Universiti Putra Malaysia.

February 1998

Dedicated to My Beloved Father

(Late) **HAJI MUHAMMAD ISHAQUE SIDDIQUI**

whose dream comes true.

ACKNOWLEDGEMENTS

All praise to Allah S.W.T whose countless blessings enabled me to accomplish this study. I wish to express my deep gratitude to my supervisor Assoc. Prof. Dr. Haji Sheikh Ali Abod for his unflagging interest, concern and inspiration throughout the period of this study. His discreet assistance of many kinds has helped me to steer uphill, especially during the write-up. I gratefully acknowledge my indebtedness to my co-supervisors Prof. Dr. Azizah Hashim and Dr. Amir Husni Mohd. Shariff who furnished invaluable comments and suggestions which significantly improved the thesis. Thanks are also due to Dr. Mohammad Idrees Ahmad for his help in statistical analyses and my friends for their help and encourgement.

I take this opportunity to express my thanks to Forest Research Institute Malaysia (FRIM) for the permission given to conduct the study in its sub-station at Mata Ayer, Perlis and also to the field staff for their help in the field work and data collection.

I gratefully acknowledge the financial support from the Public Services Department Malaysia and University of Agriculture, Faisalabad- Pakistan for granting study leave.

Special thanks are due to my brothers, sisters and relatives for their encouragement and support throughout the period of this study. I would like to express my profound appreciation to my wife Shagufta Shaheen and my lovely daughters Wajeeha Siddiqui and Zanira Siddiqui for their sacrifices, patience and moral support that enabled me to successfully carry out this research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATES

ABSTRACT

Abstract of thesis submitted to the Senate of the Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy.

FERTILIZER REQUIREMENTS AND NUTRIENT DYNAMICS OF TEAK (*TECTONA GRANDIS* L.f.) PLANTATIONS IN PENINSULAR MALAYSIA

By

MUHAMMAD TAHIR SIDDIQUI

February, 1998

Chairman: Associate Professor Dr. Haji Sheikh Ali Abod

Faculty: Forestry

Teak (*Tectona grandis* L.f) is one of the highly sought after timbers of the world. It is not indigenous to Malaysia and was introduced as plantation species in the northern states of Kedah and Perlis in early 1950's. To-date, 1100 ha of teak plantation has been established in Malaysia and more acreage are planned in the future. However, comprehensive fertilizer requirements of this species are not adequately known.

The objective of the present study was to determine the fertilizer requirements of *T. grandis* and their effects on the nutrient dynamics in the trees. Three

experiments were conducted for this purpose: pot trial, field trial and destructive sampling of various aged trees. Soil and plant analyses were carried out to determine the effects of fertilizer application and age on the nutrient concentrations in the trees. Results of the pot trial revealed that 564 kg/ha of ammonium sulphate and 300 kg/ha of P_2O_5 with 75 kg/ha of K_2O promoted the growth of *T. grandis* seedlings. The results of field experiment clearly indicated that N and P are equally important and act additively to boost the growth of teak seedlings. It was found that 200 kg/ha ammonium sulphate and 300 kg/ha triple superphosphate gave maximum height and diameter of the teak seedlings. The disparity in fertilizer dosages is due to large number of plants per ha in pot experiment.

Application of fertilizers increased the N, P, K, Ca, Mn and Zn concentrations in the leaves of teak trees. Magnesium and Cu concentrations were however, reduced as a result of fertilizer application. This is attributed as antagonism process. Nutrient concentrations i.e. N, P and K in the leaves reduced as the tree advanced in age whereas Ca, Mg, Mn, Zn and Cu concentrations increased with increase in tree age.

The foliar sampling experiment revealed that nutrient concentrations were influenced by the position in the crown. On the basis of low nutrient variability, the results showed that sampling should be carried out in the morning and from the upper or middle crown for N, P, K, and from the lower crown for Ca, Mg, Mn and Cu.

Stem analysis showed that there was lowest nutrient concentrations in the wood especially in the heartwood. Bark contained maximum concentrations of Ca. Fertilizer application increased N, P, K and Ca concentrations in the bark and stemwood. In contrast, Mg and Zn concentrations decreased as a result of fertilizer application. Nitrogen concentration decreased in twigs of fertilized plants. There was a decreasing trend in nutrient concentrations due to increase in age except for Ca which increases with age.

Nutrient concentrations in teak roots were also influenced by fertilizer additions. Macro nutrients were high in fine roots (<2mm) except Mg which was high in control plants. Manganese and Zn also increased as a result of fertilizer addition irrespective of root size. The results also revealed that nutrient concentrations decreased with increase in root diameter class and age.

The results of the present study revealed that the combination of pot and field experiments, analysis of tree components i.e. foliar, stem and root and soil analysis could be a useful technique in determining the fertilizer requirements of *T. grandis* in Peninsular Malaysia. The nutrient concentrations as affected by fertilizer additions and age should also serve as a guideline for evaluating the nutritional status of other quality timber species in the tropics.

ABSTRAK

Abstrak tesis dikemukakan kepada Senat Univesiti Putra Malaysia bagi memenuhi keperluan Ijazah Doktor Falsafah.

KEPERLUAN BAJA DAN DINAMIK NUTRIEN PADA JATI *(TECTONA GRANDIS* L.f.) DI SEMENANJUNG MALAYSIA

Oleh

MUHAMMAD TAHIR SIDDIQUI

Februari, 1998

Pengerusi: Madya Professor Dr.Hj. Sheikh Ali Abod

Fakulti: Perhutanan

Jati (*Tectona grandis* L.f.) merupakan salah satu kayu balak yang sangat penting di dunia. Ia bukan spesis yang asli di Malaysia tetapi telah diperkenalkan sebagai spesis perladangan di negeri-negeri di bahagian utara semenanjung iaitu Kedah dan Perlis pada awal tahun 1950 an. Sehingga kini, terdapat 1100 ha. ladang jati di Malaysia dan keluasan perladangan ini akan diperbesarkan lagi pada masa depan. Walau bagaimanapun, penggunaan baja yang paling sesuai untuk spesis jati belum diketahui lagi.

Objektif kajian ini adalah untuk menentukan baja yang diperlukan oleh *Tectona grandis* dan kesannya ke atas dinamik nutrien di dalam pokok. Tiga ekperimen telah dijalankan iaitu percubaan berpasu, perenbaan di ladang dan persampelan destruktif ke atas pokok pelbagai umur. Analisis tanah dan tanaman telah dijalankan untuk

menentukan kesan pemberian baja dan umur ke atas konsentrasi nutrien di dalam pokok. Keputusan dari percubaan berpasu menunjukkan bahawa 564 kg/ha ammonium sulfat dan 300 kg/ha P_2O_5 dengan 75 kg/ha K_2O menggalakkan pertumbuhan anak benih *T. grandis*. Keputusan dari percubaan ladang menunjukkan dengan jelas bahawa N dan P adalah sama penting dan bertindak secara sinergistik untuk menggalakkan lagi pertumbuhan anak benih pokok jati Ia juga menunjukkan bahawa 200 kg/ha ammonium sulfat dan 300 kg/ha triple superphosphate memberikan ketinggian dan perepang batang yang maksimum kepada anak benih pokok jati.

Pemberian baja meningkatkan kadar N, P, K, Ca, Mg, Mn dan Zn pada daun pokok jati. Walau bagaimanapun, konsentrasi Mg dan Cu berkurangan dengan pemberian baja. Ini adalah disebabkan berlakunya proses antagonisma. Konsentrasi nutrien, contohnya N, P dan K pada daun didapati berkurangan apabila umur pokok meningkat manakala Ca, Mg, Mn, Zn dan Cu pula bertambah.

Ujikaji persampelan daun telah menunjukkan bahawa konsentrasi nutrien dipengaruhi oleh kedudukan daun pada silara pokok. Berasaskan kepada perubahan nutrien yang rendah, keputusan kajian menunjukkan bahawa persampelan hendaklah dibuat pada awal pagi dan sampel diambil dari bahagian atas atau tengah silara pokok untuk analisis N, P, K, dan dari bahagian bawah silara pokok untuk analisis Ca, Mg, Mn dan Cu.

Analisis batang menunjukkan bahawa kayu jati terutamanya di bahagian kayu terasnya mempunyai konsentrasi nutrien yang rendah. Konsentrasi Ca yang maksimum didapati pada bahagian kulit. Pemberian baja telah meningkatkan konsentrasi N, P, K dan Ca pada kulit dan batang kayu. Sebaliknya, konsentrasi Mg dan Zn berkurangan dengan pemberian baja. Konsentrasi nitrogen adalah rendah pada ranting pokok yang telah dibaja. Keputasan turut menunjukkan pengurangan konsentrasi nutrien dengan pertambahan umur pokok kecuali unsur Ca yang didapati meningkat dengan bertambahnya umur pokok.

Konsentrasi nutrien pada akar jati juga dipengaruhi oleh pemberian baja. Nutrien makro adalah tinggi pada akar halus (< 2 mm) kecuali unsur Mg yang didapati rendah pada pokok kawalan. Pemberian baja dengan tidak mengambil kira saiz akar juga telah meningkatkan unsur Mn dan Zn dalam akar. Keputusan yang diperolehi juga menunjukkan bahawa konsentrasi nutrien berkurangan dengan bertambahnya kelas diameter akar dan umur pokok.

Ketiga-tiga kajian yang telah dijalankan boleh digunakan sebagai satu garis panduan yang baik untuk menentukan paras baja yang diperlukan oleh *T. grandis* di Semenanjung Malaysia. Konsentrasi nutrien yang dipengaruhi oleh pemberian baja dan umur pokok boleh digunakan sebagai panduan untuk menilai status nutrien pada spesis balak bermutu di kawasan tropika.

CHAPTER I

INTRODUCTION

Malaysia is blessed with rich natural resources which have brought wealth and prosperity to this nation. The country is recognized as one of the world' s leading exporters of tropical hardwoods. The total forest area in Malaysia is 19.07 million hectares about 58.1 percent of the total land mass of the country. Out of this, 6.19 million hectares are in Peninsular Malaysia whereas 4.44 million hectares and 8.44 million hectares are in Sabah and Sarawak, respectively (Ministry of Primary Industries, 1996). However, the World Bank has estimated that the tropical forest is fast disappearing at a rate of 15-20 million ha per year. At the level of demand prevailing then, the remaining tropical forest would disappear in 60 to 80 years (Evans, 1992). The most extreme pressures lie in countries in the tropics. Malaysia is not an exception in this case.

In Peninsular Malaysia, approximately 360,121 ha of forested lands are being cleared annually in the recent years. Seventy-five percent of the total forest lands cleared were alienated for agricultural and industrial development (Anon, 1979). In addition, there is also a general increase in demand for wood, paper and paper products. The production pattern however, does not seem to keep pace with this timber demand. It is

anticipated that Peninsular Malaysia will experience an acute shortage of timber well before the year 2000 (Freezaillah, 1982)

The present precarious forest situation in Malaysia stems from an apparently nonchalant forest management practice in the past which was influenced by the misconstrued belief that Malaysia's forest resources were inexhaustible. Hence, from the early 1960s onwards, the green gold of Malaysia became the target of exploitation. Several strategies are therefore under way to ensure that this renewable resource is being perpetuated at sustainable levels, one of which is to raise large scale plantations of suitable exotic and indigenous species. It is therefore, safe to conclude that plantation forestry will play an important role in the future. The growing demand for wood, hampered by the low productivity of natural forests, has greatly enhanced the role of plantation forestry. Plantation forestry also enhances the creation of resources to meet the demand for wood and wood products, development of a flexible resource able to yield different kind and size of products for both internal and external markets. Intensive reforestation programme is currently being carried out in P. Malaysia under a programme of Compensatory Forest Plantation (Yong, 1984). However, this project purely stresses on the supply of medium quality timber grown on short rotation to meet the basic requirement of the lower income group. So far there has been no large scale programme to grow high quality timber species which is also expected to be in short supply in the near future (Hashimand Zainudin, 1983).

One of the current high quality timber species greatly appreciated by Malaysians is teak (*Tectona grandis* L.f). Teak occupies a dominant position in the highly sought after timbers in the world. This species originates from countries with tropical monsoon climates, chiefly India, Myanmar, Thailand and Cambodia. The annual pronounced dry season followed by wet weather in these countries concerned imparts a beautiful grain structure to teak (Borota, 1991). At the same time teak wood is characteristically strong, durable and easily workable. Teak rules the world market because of its sterling qualities. It is difficult to find a happy blend of beauty, strength, stability and durability in any other tropical timber. Rightly teak wood is considered to be the best general utility timber with worldwide reputation, being extensively used for ship building, bridges and wharves, railway carriages and wagons, ordnance, shingles, wheels, carving and general carpentry (Appanah and Weinland, 1993). As a result, it is much sought after throughout the world and fetches a high price as compared to other species of wood.

Currently, all teak utilized in Malaysia is imported from Myanmar, Thailand and Indonesia. Owing to a decline in supply from the countries of origin, the price has spiraled over the years. This situation is expected to continue, unless efforts are made to establish large scale plantations of teak in Malaysia.

Teak has been reported to require very specific soil and climatic conditions for optimum growth. It needs well- drained and well- aerated deep alluvial soils for good growth. Griffith and Gupta (1947) observed that a forest of fine teak growth changed to