UNIVERSITI PUTRA MALAYSIA

NUTRITIONAL ASPECTS OF ACACIA MANGIUM WILLD. PLANTATION IN PENINSULAR MALAYSIA

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NUTRITIONAL ASPECTS OF *ACACIA MANGIUM* WILLD. PLANTATION IN PENINSULAR MALAYSIA

BY

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

August 1995

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to Prof. Dr. Nik Muhamad Majid, the chairman of my supervisory committee for his constant guidance, suggestions and encouragement throughout the preparation of this thesis. I am highly indebted to Assoc. Prof. Dr. Kamis Awang and Dr. Faridah Hanum Ibrahim for their invaluable suggestions and comments.

I take this opportunity to express my thanks to the Forestry Department Peninsular Malaysia and Universiti Pertanian Malaysia for the permission given to conduct the study in the forest reserves and the University farm, respectively. My sincere appreciation goes to Mr. Jinis from Kerling Forest Reserve, Selangor; Mr. Ziauddin in Kemasul Forest Reserve, Pahang and Mr. Amri Mahmood in Universiti Pertanian Malaysia experimental farm, Puchong for their help during the study period. Thanks are also extended to Muzamal, Mohd. Talib, Zulkifly, Ibrahim Idahm and Yusri for their help in the field work.

I am greatly thankful to the Tribhuvan University, Institute of Forestry, Nepal for granting my study leave. The financial support from Universiti Pertanian Malaysia through the Intensification of Research in Priority Areas (IRPA) grant is highly appreciated.

I would like to thank my wife and three children for their continued support and patience during the entire study period. Lastly, I express my gratitude to God, the invisible power, for providing me incessant flow of energy to undertake this study.

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Acacia mangium Willd. is one of the fast-growing timber species planted widely in Malaysia to overcome the expected timber deficit for the domestic consumption purposes. However, nutrient requirements of this species are not adequately known. There is also no proper foliar sampling guideline although foliar diagnosis is the most widely used method to determine nutrient deficiencies in trees in temperate and subtropical countries. There are few studies conducted on these aspects in the tropics and research guidelines are lacking in the case of *A. mangium* plantation in Malaysia.

The objective of the study was to evaluate the nutritional aspects of *A. mangium* stands. Three methods were used for this purpose: soil analysis, pot culture and foliar analysis. The results of soil analysis showed that phosphorus was the element highly deficient on all the three sites chosen, followed by nitrogen. In the pot trial, 800 kg/ha of urea and 800 kg/ha of P_2O_5 with 100 kg/ha of K_2O was effective in promoting the growth of *A. mangium* seedlings. The results showed that the optimum foliar nutrient concentration in the pot culture should be between 2.35-2.46 percent for nitrogen, 0.20-0.26 percent for phosphorus and 0.70-0.73 percent for potassium. Under field conditions, the optimum foliar concentrations of these nutrients could range between 1.84-2.10 percent for N, 0.11-0.16 percent for P and 0.80-0.88 percent for K.

The results of the present study clearly indicate that the combined effects of N, P and K, P on height and diameter growth in the field were comparatively higher than the effects of P alone. The highly significant synergistic relationship observed between foliar N, K; P, K; P, Mg and N, P in Kemasul; between N, K; P, K and N, P in Puchong and between N, Ca; K, Ca with antagonistic relationship between between N and Mg in Kerling shows the necessity of further research on P, N, Mg and Ca nutrition. The results also indicate that 800 kg/ha of P_2O_5 and 100 kg/ha of K_2O should be sufficient for increasing tree growth.

The foliar sampling experiment demonstrated that foliar nutrient concentrations and nutrient variability were influenced by season and sample

position in the crown. Minimum nutrient variability was observed during the dry season and maximum during the wet season. The case for foliar nutrient concentration was otherwise. Thus, the dry season is the most appropriate time for foliar sampling purposes. On the basis of low nutrient variability, sampling should be carried out from the lower crown for N, K, Ca, Fe and Cu and from the upper crown for P, Mg, Zn and Mn.

Both field fertilizer trials showed a significant relationship between tree height, diameter and foliar P levels and P:K ratio. However, the results showed that tree growth parameters were highly related to P:K ratio than to foliar P level alone on all the three sites. The present study showed no correlation between height, diameter and most of the soil properties measured. However, there was significant and positive interaction between N, P, K and Mg in the soil and trees.

The present study demonstrated that the combination of soil analysis, pot culture and foliar analysis from field fertilizer trials could be a useful technique for assessing nutritional aspects of *A. mangium* stands in Peninsular Malaysia and should serve as a guideline for evaluating nutritional status of other fast-growing plantation species in the tropics.

Abstrak disertasi yang dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi keperluan Ijazah Doktor Falsafah.

ASPEK PEMAKANAN LADANG *ACACIA MANGIUM* WILLD. DI SEMENANJUNG MALAYSIA

Oleh

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OGOS 1995

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Acacia mangium Willd. adalah satu daripada spesis pokok hutan cepat membesar yang ditanam secara meluas di Malaysia untuk mengatasi jangkaan kekurangan kayu bagi penggunaan tempatan. Bagaimanapun, pengetahuan berkaitan keperluan nutrien bagi spesis ini belum cukup diketahui. Panduan penyampelan daun yang teratur juga belum wujud walaupun diagnosis daun merupakan cara yang sering digunakan untuk menentukan kekurangan nutrien dalam pokok di negara iklim sederhana dan separa tropika. Terdapat beberapa kajian aspek ini di kawasan tropika tetapi matlumat mengenai perladangan *A. mangium* di Malaysia adalah kurang.

Objektif kajian adalah untuk menilai aspek nutrien *A. mangium*. Tiga cara telah digunakan bagi tujuan ini: analisis tanah, kultur tabung dan analisis daun. Keputusan analisis tanah menunjukkan bahawa fosforus merupakan unsur

yang sangat kurang pada kesemua tiga kawasan yang dipilih, diikuti oleh nitrogen. Dalam percubaan tabung, 800 kg/ha urea dan 800 kg/ha P_2O_5 dengan 100 kg/ha K_2O adalah berkesan bagi meningkatkan tumbesaran anak benih *A. mangium*. Keputusan menunjukkan bahawa kandungan nutrien daun yang optimum adalah di antara 2.35-2.46 peratus bagi nitrogen, 0.20-0.26 peratus bagi fosforus dan 0.70-0.73 peratus bagi kalium. Di ladang, konsentrasi optimum bagi nutrien di dalam daun adalah di antara 1.84-2.10 peratus bagi N, 0.11-0.16 peratus bagi P dan 0.80-0.88 peratus bagi K.

Keputusan ini jelas menunjukkan bahawa kesan gabungan N, P dan K, P terhadap tumbesaran ketinggian dan perepang pokok lebih ketara daripada kesan P sahaja. Perhubungan sinergistik yang sangat bererti telah dikesan di antara N, K; P, K; P, Mg dan N, P di Kemasul; di antara N, K; P, K dan N, P di Puchong dan di antara N, Ca; K, Ca di Kerling dengan perhubungan antagonistik di antara N dan Mg di Kerling. Ini telah menunjukkan perlunya penyelidikan lanjut bagi unsur pemakanan P, N, Mg dan Ca. Keputusan juga menunjukkan bahawa 800 kg/ha bagi P_2O_5 dan 100 kg/ha bagi K_2O mencukupi untuk menambahkan tumbesaran pokok.

Experimen penyampelan daun menunjukkan bahawa kandungan nutrien daun dan perbezaan nutrien adalah dipengaruhi oleh musim dan di bahagian mana sampel diambil. Perbezaan nutrien yang minima telah diperhatikan pada musim kemarau dan maxima pada musim hujan. Oleh itu, musim kemarau adalah merupakan masa yang paling sesuai bagi tujuan penyampelan daun. Berdasarkan kepada perbezaan nutrien yang rendah, penyampelan haruslah

dilakukan daripada bahagian silara bawah bagi N, K, Ca, Fe dan Cu dan daripada silara atas bagi P, Mg, Zn dan Mn.

Kedua-dua percubaan di ladang telah menunjukkan perhubungan bererti diantara ketinggian pokok, perepang dan paras P daun dan nisbah P:K. Bagaimanapun, keputusan jelas menunjukkan bahawa parameter tumbesaran pokok adalah berkait rapat kepada nisbah P:K daripada terhadap paras P dalam daun sahaja di ketiga kawasan. Kajian ini telah menunjukkan tiada korelasi diantara ketinggian, perepang dan kebanyakkan sifat tanah yang telah analisa. Bagaimanapun, terdapat interaksi yang positif dan bererti diantara N, P K dan Mg pada tanah dan pokok.

Kajian ini juga telah menunjukkan bahawa gabungan analisis tanah, kultur tabung dan analisis daun adalah teknik yang sesuai bagi penilaian aspek pemakanan *A. mangium* di Semenanjung Malaysia dan seharusnya digunakan sebagai panduan bagi penilaian status permakanan lain-lain spesis pokok hutan yang cepat membesar di kawasan tropika.

CHAPTER I

INTRODUCTION

Forest nutrition research dates back to the middle of the 18th century when Jean-Baptiste Van Helmont examined the nutrient requirements of a small willow tree (Binkley, 1986). The practice of forest fertilization has now covered many parts of the world. Forest fertilization has now become an accepted management practice in the pine forests of the United States (Bolstad and Allen, 1987). In Australia and New Zealand, over 90 percent of exotic plantations are now fertilized at or soon after planting (Crane, 1982). In countries of the Far East, such as, South Korea, Taiwan and Japan, fertilization of forest plantations is also a common practice (Kawana and Haiwara, 1981).

Forest fertilization is designed to accelerate forest productivity which is regulated by a variety of environmental factors; radiation, temperature, water and the availability of nutrients. The availability of nutrients is also affected by these environmental factors, and in most cases forest productivity is directly related to nutrient availability and uptake. As forest managers have little influence on climatic factors, efforts to increase forest productivity have mainly been focused on tree nutrition research.

The practice of forest fertilization differs with the varied nutrient requirements of the many different sites. However, many of the forest stands in the northern hemisphere are considered to be N-deficient (Nambiar, 1984). Similarly, tropical soils are highly weathered, well drained, acidic with low base status and available P (Baligar and Bennett, 1986a).

Fertilization on established stands has become an accepted part of forest management of many countries in Scandinavia, Europe, and North America. In these countries, fertilizers are applied to average or healthy coniferous stands at the time of thinning to produce additional growth of non-juvenile wood (Crane, 1982). There has been little development in such practices in Australia, New Zealand and in most tropical countries. Later-age fertilizer application (that is, after first canopy closure) has been limited almost exclusively to operations aimed at correcting nutritional disorders or treating stagnant or relatively slow-growing stands. Forest fertilization research is still new and as such, very limited literature is available on the subject particularly in the tropics.

Although a leading producer of tropical hardwood, Malaysia is anticipated to face a shortage of timber supply for domestic consumption by the year 2000. To avert this impending crisis, the Federal government has since 1982 embarked on a Compensatory Forest Plantation Project (CFPP). The species currently being planted are *Acacia mangium* Willd., *Gmelina arborea* and *Paraserianthes falcataria* with *A. mangium* as the main species.

Malaysia, being in the tropics, has generally nutrient deficient soils, especially phosphorus (Johari and Chin, 1986). Thus, there has been a routine practice of phosphorus fertilizer application at the time of planting in forest plantation programme. Previous studies on fertilization were primarily centered on pine plantations (Sheikh Ali, 1982). However, forest fertilization in established stands in Peninsular Malaysia is not a common practice and more so with *A. mangium* plantation. In view of the declining wood production trend, rising demand of wood for domestic use and slow regeneration of natural forests, it is imperative that a more concerted effort to enhance growth of forest plantations be made. The growth of *A. mangium* trees has been recorded as more than 5 cm DBH and 5 m in height per year for 2-year-old stand (Racz and Zakaria, 1986); 3.43 cm DBH and 3.38 m height per year for 5-year-old stand (Paudyal and Nik Muhamad, 1992). As better growth performance of *A. mangium* has also been reported elsewhere (Forest Research Institute, 1984, Kamis and Mohd. Amran, 1984) little emphasis has been given to assess the extent of growth that can be enhanced by fertilizer application on established stands.

Before fertilizer application, foliar diagnosis is the most widely used method to determine nutrient deficiencies in temperate and subtropical countries. However, there are some difficulties in foliar analysis techniques, especially with sampling procedures. It has been documented that the chemical composition of plant leaves varies with season, age of foliage, position in the crown and sampling time in experiments with agricultural crops and conifers (White, 1954; Ovington, 1956; Leyton, 1960; Madgwick, 1964).

Reliable information about nutrient deficiencies in the stand can be obtained by standardizing foliar sampling procedures. However, the sampling techniques used in temperate regions may not be applicable to the tropical region where in most parts the climate is non-seasonal and plant growth is continuous throughout the year (Srivastava and Hiew, 1980; Srivastava and Abu Bakar, 1980). Few studies have been conducted on these aspects in the tropics. For example, in Malaysia, Abang Naruddin (1981) tried to address this problem in *Pinus caribaea* plantation. However, no research guidelines have been developed for *A. mangium* plantation in Peninsular Malaysia. This study, therefore, was an attempt to prepare such a guideline.

The study consisted of a pot trial, field foliage sampling trial and field fertilizer trial. All the field trials were performed on three sites; Kemasul in Pahang, Kerling and Puchong in Selangor. The fertilizer trial lasted for one and a half years. The data on pot and field fertilizer trials were statistically analysed by using ANOVA, Duncan's Multiple Range Test, Correlation analysis, Multiple and Stepwise Regression Analysis. For foliar sampling trial, coefficient of variation (CV) approach was employed. This is based on the assumption that the smaller CV values show more stability in nutrient concentrations and is thus more appropriate time for foliar sampling.

The objectives of this study were to:

1. assess the growth response of *A. mangium* stands to fertilization.
2. determine the optimum fertilizer application for *A. mangium* stands.
3. establish a foliar sampling guideline for nutritional assessment of *A. mangium* stands.