



UNIVERSITI PUTRA MALAYSIA

**THE POTENTIAL OF UTILIZING THE ARBUSCULAR
MYCORRHIZA (AM) IN THE REHABILITATION OF SANDY
TAILINGS WITH ACACIA MANGIUM WILLD.**

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TAILINGS WITH *ACACIA MANGIUM* WILLD.**

By

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**Dissertation Submitted in Fulfilment of the Requirements for the Degree
of Doctor of Philosophy in the Faculty of Forestry,
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LIST OF ABBREVIATIONS

μm	micrometer
cm	centimeter
cmole	centimole
Diam.	Diameter
DMRT	Duncan's Multiple Range Test
F0	chemical fertiliser at 0.15 g (NPK 15:15:15)/kg soil
F1-F4	organic fertiliser at 0.5 g, 1.0 g, 1.5 g and 2.0 g/kg soil
g	gram
H1-H6	Harvest 1 to 6 done 4 weekly
ha	hectare
hr	hour
Ht.	Height
Inftn.	Infection
kg	kilogram
kg	kilogram
+M	with mycorrhiza inoculation
-M	without mycorrhiza inoculation
m	meter
min	minute
MIP	Mycorrhiza Inoculum Potential
mm	milimeter
MPN	Most Probable Number
nm	nanometer
Nod.	Nodule
ppm	part per million
RDW	Root Dry Weight
RFMD	Relative Field Mycorrhiza Dependency
rpm	rotation per minute
s	second
SDW	Shoot Dry Weight
VAM	Arbuscular Mycorrhiza



Abstract of dissertation submitted to the Senate of Universiti Pertanian Malaysia in fulfilment of the requirement of degree of Doctor of Philosophy.

**THE POTENTIAL OF UTILISING ARBUSCULAR MYCORRHIZA
(AM) IN THE REHABILITATION OF SANDY TAILINGS WITH *ACACIA
MANGIUM* WILLD.**

By

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APRIL 1997

Chairman: Prof. Dr. Nik Muhamad Majid

Faculty : Forestry

This study examined the potential of utilising the AM fungi and an organic fertiliser in improving the plant growth and soil fertility status of sandy tailings.

The AM fungal spore and Most Probable Number (MPN) count and root infection ratings were determined in barren sandy tailings and sandy tailings under a five and seven year old *A. mangium* stands. The results indicate very slow build up of the AM propagules over a seven year period of rehabilitation. *Glomus* spp. was more widely distributed as compared to *Gigaspora* spp.



Under the propagation trials, the pot culture method using *Setaria* spp. as the host was found to be most suitable for production of large scale inoculum. *S. calospora*, an introduced species was found to be the most effective with maximum 55% infection in the *A. mangium* roots.

In a subsequent glasshouse trial, inoculation using *S. calospora* in combination with a chemical fertiliser (0.15 g NPK 15:15:15/kg soil) vs four levels (0.5, 1.0, 1.5 and 2 g/kg soil) of an organic fertiliser resulted in superior growth from AM inoculated plants at low level of organic fertiliser application. The higher increase in tissue P as compared to soil P indicates the importance of AM in direct P uptake. Increased P uptake was found to parallel uptake of N, K, Ca and Mg. Other effects include higher rate of photosynthesis, intercellular CO₂ concentration, stomatal conductance and the leaf area index and lower stomatal resistance. The increase in mycorrhizosphere bacterial population may be the key factor in enhancing soil NO₃-N and NH₄-N. Using the image analyser, there was also significant improvement in organic matter and pore diameter size of $\leq 1.2 \mu\text{m}$ distribution.

Utilisation of effective AM at low level of organic fertilizer therefore, could have a great potential in the rehabilitation of marginal lands such as the sandy tailings.



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**POTENSI PENGGUNAAN MIKORIZA ARBUSKULAR (MA)
DALAM PEMULIHARAAN TANAH BERPASIR BEKAS LOMBONG
YANG DITANAMI *ACACIA MANGIUM* WILLD.**

oleh

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APRIL 1997

Pengerusi: Prof. Dr. Nik Muhamad Majid

Fakulti : Perhutanan

Kajian ini meneliti keupayaan penggunaan kulat AM dan baja organan bagi meningkatkan pertumbuhan pokok dan status kesuburan tanah bekas lombong.

Bilangan spora dan nombor paling bangkai propagul AM dan juga tahap jangkitan akar ditentukan bagi tanah bekas lombong yang belum ditumbuhi pokok, dan yang telah ditanami *A. mangium* berumur lima dan tujuh tahun. Keputusan menunjukkan amat sedikit sekali peningkatan propagul AM selama



tujuh tahun tempuh pemuliharaan. Species *Glomus* didapati tersibar lebih meluas berbanding species *Gigaspora*.

Dalam kajian propagasi, kaedah kultur pasu menggunakan species *Setaria* sebagai perumah didapati paling sesuai untuk menghasilkan jumlah besar inokulum. *Scutellospora calospora*, suatu species yang diperkenalkan merupakan suatu species yang paling efektif dengan 55% infeksi maximum pada akar *A. mangium*.

Dalam kajian rumahkaca seterusnya, inokulasi *S. calospora* dengan penggunaan suatu baja kimia (0.15 g NPK 15:15:15/kg tanah) melawan 4 paras (0.5, 1.0, 1.5 dan 2.0 g/kg tanah) baja organan, menunjukkan bahawa pertumbuhan terbaik adalah dari pokok yang diinokulasi MA pada tahap baja organan paling rendah. Peningkatan P tisu yang lebih tinggi berbanding P tanah menunjukkan kepentingan MA dalam pengambilan P secara langsung. Peningkatan P juga didapati selaras dengan peningkatan N, K, Ca and Mg. Kesan-kesan lain termasuk peningkatan kadar fotosintesis, kepekatan antarsel CO₂, konduktan stomata, dan indeks luas daun dan penurunan rintangan stomata. Peningkatan populasi bakteria mikorhizosfera pula mungkin merupakan faktor utama merangsang peningkatan NO₃-N dan NH₄-N tanah.

Dengan bantuan image analyser, terdapat kemajuan yang significant tentang taburan bahan organan dan saiz liang berdiameter $\leq 1.2 \mu\text{m}$.

Penggunaan MA yang efektif pada tahap baja organan yang rendah mempunyai potensi besar dalam pemeliharaan tanah terbiar seperti tanah berpasir bekas lombong.

CHAPTER 1

INTRODUCTION

Tin mining industry was once the most important contributor to the economic development of Malaysia. Equally important and very significant are the large areas of tin-tailing left behind by the mining activities. These lands are mainly located around the urban areas and estimated to be about 200,000 ha (Ang, 1987) or about 2% of the total land area in Peninsular Malaysia.

Lim et al. (1981) stated that the most problematic tailings are the sandy tailings and consolidated slime tailings. Several problems have been identified in the reclamation of sandy tailings. The main problem being the unequal topography of the resulting tailings. Extensive land leveling and reshaping are hence prerequisite in the reclamation of these lands. From the physical aspects, sandy tailings are prone to excessive drainage, high surface soil temperature (40 - 50°C) and hence high evaporation rate and the absence of soil structure (Mokhtaruddin and Sulaiman, 1990). From the chemical aspects, sandy tailings have very low nutrient and water retention capacity. Shamsuddin et al. (1986) reported that tin mining activities have caused severe siltation in river beds and drainage system and destruction of agricultural land. Sandy tailings have also been shown to be low in organic matter content and hence, microbiologically inert (Vimala et al. 1990; Mokhtaruddin and Sulaiman, 1990).



In Malaysia, several research have been done to improve the physical and chemical characteristics of sandy tailings. Some of which include the addition of inorganic fertilizers, animal and plant wastes, soil conditioners and mulch (Lim et al. 1981) In an effort to rehabilitate an ex-mining land, Majid et al. (1992) planted a fast growing timber species *A. mangium*, supplemented with an inorganic fertilizer. They reported that high level of inorganic fertilizer (300- 400 g NPK) per seedling in the first four month was required to sustain growth. However, due to the limited and high cost of fertilizer doubled with increasing labour shortage, it seemed necessary to develop an alternative approach in the rehabilitation of sandy tailings.

The Arbuscular Mycorrhizal (AM) fungi has been known to improve plant growth under several adverse conditions (Bradley et al., 1981; Nelson, 1987; Danielson, 1985). The improved growth is mainly associated to the improved P uptake of the mycorrhizal plants (Mosse, 1986). However, several other beneficial effects of AM have also been documented as to:

- promote the uptake of other slow mobile elements such as Zn, Mo, Cu, K, S and NH_4^+ (Cooper, 1984)
- increase plant resistance to soil-borne pathogen (Azizah et al. 1990; Sieverding, 1991)
- improve soil aggregation (Tisdall, 1992) and
- improve N fixation (Mosse, 1981).

The use of fertilizer was optimum in the presence of AM (De La Cruz, 1990, Azizah, 1991). Through AM symbiosis, Azizah (1989) found substantial growth increment of Acacia plants within 3 months of sampling time. Darts et al. (1991) have also shown that symbiotic association of Rhizobium with mycorrhiza resulted in improved nutrient uptake of several tropical Acacias. However, information on the full benefit of the mycorrhizal symbiosis is still lacking.

Currently, information on mycorrhizal occurrence in rehabilitated sandy tailing is still lacking and hence, more research need to be done especially on the ecology and types of AM and to the species present in sandy soils so as to enable one to understand its development and application.

The present study carried out comprises four stages. The first stage concentrated on the ecological study of AM under denuded sandy tailings in comparison to tailings under five and seven year old *A. mangium* stands. The second stage emphasized on the isolation and propagation of single AM spores in funnel, pot and organ cultures. The third stage involved screening of the most compatible AM species for *A. mangium* plantation. The fourth stage aimed to evaluate the performance of selected AM species under different fertilizer regimes in the glasshouse. The physiological, morphological, chemical, physical and microbiological changes brought about by AM symbiosis with *A. mangium* seedlings will be recorded. This study comprises 6 sequential harvests, 4 levels of organic fertilizer plus one control and 2 treatments (with or without AM). Each treatment was replicated 5 times. The objectives of the present study are as follows:

- To quantify, using the Most Probable Number (MPN) method and spore count, AM occurrence, distribution and build-up in soil and plant roots under denuded tailings and that of under *A. mangium*