UNIVERSITI PUTRA MALAYSIA

MYCORRHIZAL INOCULATION FOR GROWTH ENHANCEMENT AND IMPROVEMENT OF THE WATER RELATIONS IN MANGOSTEEN (GARCINIA MANGOSTANA L) SEEDLINGS

MASRI BIN MUHAMAD

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By

MASRI BIN MUHAMAD

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"Sesungguhnya Allah tidak akan merubah nasib sesuatu kaum sehingga kaum itu merubah apa yang ada pada diri mereka"

(Al-Ra'd: 11)

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

MYCORRHIZAL INOCULATION FOR GROWTH ENHANCEMENT AND IMPROVEMENT OF THE WATER RELATIONS IN MANGOSTEEN (*GARCINIA MANGOSTANA* L.) SEEDLINGS

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Chairman: Associate Professor Dr. Azizah Hashim

Faculty: Agriculture

Mangosteen (*Garcinia*

delicious fruits of Malaysia and has great potential for commercial development. However, the long juvenile period resulting from the extremely slow growth of the seedlings renders itself an unattractive proposition for cultivation on a large scale. Accelerating the growth rate of mangosteen seedlings is therefore an important prerequisite for the extensive commercialisation of this crop. Poorly developed root system characterised by unbranched, coarse and lack of laterals strongly correlated to the slow growth. Such root characteristics offer great opportunity for colonisation by arbuscular mycorrhizas (AM). The main objective of this study is therefore, to promote seedling growth through symbiotic associations between AM fungi and mangosteen roots.

Results of inoculation studies have shown that mangosteen seedlings responded to AM infection with more than 60% of the total root length being infected. Introduced AM fungi caused tremendous improvements in the plant growth. Total dry biomass was 40%-64% and net assimilation rate was 30%-40% higher than the uninoculated seedlings. AM inoculated plants also had 20%-40% more leaves that give 35%-65% greater leaf area compared to the uninoculated seedlings. Stomatal resistance, transpiration rates and chlorophyll content were also significantly improved by mycorrhizal infection.

Improvements in plant growth were primarily due to greater uptake of immobile nutrients, particularly phosphorus (P), zinc (Zn) and copper (Cu). Phosphorus, Zn and Cu uptakes by mycorrhizal plants were 67%-88%, 50%-93% and 53%-59% greater than the uninoculated plants, respectively. Colonisation significantly induced greater root length density (RLD), root branching density (RBD) and number of root tips with RLD, RBD and number of root tips of AM plants ranged 58%-87%, 20%-30% and 22%-25% respectively greater compared to the uninoculated seedlings. Mycorrhizal mangosteens were also more tolerant to water stress. They could maintain higher stomatal conductance and photosynthesis at lower moisture status suggesting lower leaf water potentials at which stomata closes. Such ability indicates a more efficient stomatal regulation by AM plants. Recovery of AM plant was more rapid and complete compared to the uninoculated controls

upon the relief of water stress. The complete and rapid recovery of the inoculated seedlings was related to their greater water extraction abilities. Inoculated seedlings also established faster and grow more vigorous after field planting which was related to their greater root regeneration capacity.

These investigations clearly indicate the benefits of inoculating mangosteen seedlings with AM fungi. These associations not only stimulate rapid seedling growth but also improved the overall quality of planting stock. It is suggested that inoculation with AM fungi be considered as an important component in the nursery production of mangosteen seedlings.

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INOKULASI MIKORIZA UNTUK MEMPERCEPATKAN PERTUMBUHAN DAN MENINGKATKAN HUBUNGAN AIR ANAKBENIH MANGGIS (*GARCINIA MANGOSTANA* L.)

Oleh

MASRI BIN MUHAMAD

April 1997

Pengerusi: Profesor Madya Dr. Azizah Hashim

Fakulti: Pertanian

Manggis (*Garcinia mangostana* L.) ialah sejenis buah-buahan Malaysia yang eksotik, berperisa dan mempunyai potensi tinggi untuk dikembangkan secara komersial. Walau bagaimanapun, tempoh kematangan yang panjang akibat dari pertumbuhan anakbenih yang perlahan telah membantutkan penanaman manggis secara meluas. Pertumbuhan anakbenih yang cepat menjadi prasyarat penting untuk perkembangan komersial tanaman ini. Kadar pertumbuhan yang perlahan ini berkait rapat dengan pembentukan dan pertumbuhan akar yang perlahan. Sistem perakaran manggis adalah kasar, kurang berakar sisi dan tidak banyak bercabang. Sifat perakaran begini sangat mudah dijangkiti mikoriza arbuskul (MA). Oleh itu, objektif utama kajian ini ialah untuk menilai prestasi pertumbuhan anakbenih manggis yang disuntik dengan MA.

Hasil kajian inokulasi menunjukkan lebih 60% akar manggis telah dijangkiti kulat MA. Kulat MA telah mempercepatkan kadar pertumbuhan anakbenih manggis. Jumlah bahan kering didapati meningkat 40%-64% dan kadar asimilasi net sebanyak 30%-40% lebih tinggi berbanding anakbenih kawalan. Anakbenih bermikoriza mempunyai 20%-40% lebih helaian daun yang mana telah menambahkan luas permukaan daun sebanyak 35%-65%. Rintangan stomata, kadar transpirasi dan kandungan klorofil juga didapati tinggi bagi pokok yang disuntik dengan mikoriza.

Kecepatan kadar pertumbuhan anakbenih MA berkait rapat dengan keupayaan penyerapan zat nutrien yang tinggi terutamanya fosforus (P), zingkam (Zn) dan kuprum (Cu). Kadar penyerapan P , Zn dan Cu adalah masing-masing 67%-88%, 50%-93% dan 53%-59% lebih tinggi berbanding dengan pokok kawalan. Jangkitan kulat MA juga telah merobah ketumpatan panjang akar (RLD), ketumpatan percabangan akar (RBD) dan bilangan hujung akar. RLD, RBD dan bilangan hujung akar anakbenih MA masing-masing 58%-87%, 18%-20% dan 22%-25% lebih tinggi berbanding anakbenih kawalan. Anakbenih MA juga berupaya mengekalkan konduksi stomata dan fotosintesis yang tinggi pada tahap kandungan air yang rendah. Keputusan ini menunjukkan penutupan stomata anakbenih MA berlaku pada potensi air daun yang rendah menyebabkan mereka lebih tahan kepada tegasan air melalui kawalan stomata yang berkesan.

Anakbenih bermikoriza didapati mampu pulih daripada tegasan air sepenuhnya dengan cepat . Keupayaan untuk pulih dengan cepat ini disebabkan kadar penyerapan air yang tinggi. Anakbenih suntikan MA memperlihatkan penyesuaian yang cepat dan mampu tumbuh dengan pantas apabila ditanam ke ladang. Pertumbuhan yang pantas ini disebabkan oleh kadar regenerasi akar yang cepat.

Keputusan semua ujikaji menunjukkan dengan jelas faedah inokulasi kulat MA terhadap tanaman manggis. Kulat MA bukan sahaja mampu mempercepatkan pertumbuhan pokok tetapi secara keseluruhannya telah berjaya meningkatkan kualiti bahan tanaman. Ingin disyorkan agar inokulasi MA dijadikan komponen utama dalam proses pengeluaran bahan tanaman manggis.

CHAPTER I

INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is undoubtedly the most delicious tropical fruits of Malaysia. The government has identified mangosteen as one of the fruits with a potential for future commercial development. The export potential of good quality mangosteen is vast, especially in developed countries like Japan and Europe. The demand for this mild and pleasant flavoured fruit is growing at the rate of 18% per year. In 1992 Malaysia has 2,895 ha planted with mangosteen and exported 1,814 ton worth RM2.98 million. In 1994, the acreage increased to 7,717 ha (Department of Agriculture Malaysia) with export earnings of 3,168 ton valued at RM 3.16 million (Department of Statistics Malaysia). Current production depends mainly on the traditional mixed orchard holdings and as such the yield and quality of the fruits are low.

Despite its vast potential, some problems need to be overcome before embarking on a large scale commercial production of mangosteen. The most serious problem is the very long juvenile period resulting from the slow growing habit of the plant. Plants raised from seeds usually do not assume first fruiting until 7-12 years after field establishment (Almeyda and

Martin, 1976; Cox, 1976; Rukayah and Zabedah, 1992). This long pre-bearing time will subsequently result in high capital input and extended payback period.

Another common problem is the high seedling mortality rate after field transplanting. Sharif et al. (1983) considered mangosteen as a difficult plant to establish. The low establishment success has been related to poor root production and therefore poor ability of the seedlings to withstand adverse environmental conditions during transplanting and establishment. The problem is aggravated under dry conditions. In Malaysia, areas with a distinct and prolonged dry spell supported very poor growth of mangosteen seedlings (Sharif et al., 1983). This is in agreement with report by Hume and Cobin (1946) that mangosteen required a well distributed annual rainfall exceeding 1270 mm.

The slow-growth of mangosteen seedlings may be related to several factors. Downton et al. (1990) found that the slow growth is due to low photosynthetic efficiency and delayed budbreak. The gas exchange capacity of mangosteen leaves is extremely low, ranging from 2-5 $\mu mol/m^2/sec$ (Wieble et al., 1992a). The stomatal frequency of about 77 per mm^2 may be partly responsible for the low rates of gas exchange (Downton et al., 1990). Mangosteen leaves exhibit low stomatal conductance even under optimum growing conditions (Downton et al., 1990; Masri, 1992).