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EFFECT OF ARBUSCULAR MYCORRHIZA ON OIL PALM SEEDLING GROWTH AND DEVELOPMENT OF BASAL STEM ROT DISEASE CAUSED BY GANODERMA BONINENSE

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Chairman : Professor Azizah Hashim, Ph.D.

Faculty : Agriculture

Basal stem rot (BSR) caused by *Ganoderma* species is the most serious disease of oil palm. Infection by the fungi causes significant loss in yield, often resulting in the palm's death as the disease progressed.

Oil palm is a mycotrophic plant. Under natural conditions, the plant is often colonized by arbuscular mycorrhizal (AM) fungi. The current study carried out aimed to evaluate the role of AM in enhancing growth and development of oil palm seedlings and to examine the possibility of using this fungi as a biocontrol agent against basal stem rot (BSR) disease caused by *G. boninense.*

A greenhouse trial was carried out to determine the optimum AM inoculum density for maximum plant growth and AM root colonization. The palms were inoculated with 6 levels of AM inoculum (mixed species of AM spores, extramatrical hyphae and infected root segments of *Setaria ancep*) viz. 0, 20, 40, 60, 80 and 100 g inoculum/plant. Results obtained showed that 40 g inoculum/plant gave maximum growth and percent AM root colonization at 3 months after inoculation. This inoculum level was subsequently used in further experiments. A study was conducted to evaluate the effect of AM on plant growth and development. AM association significantly enhanced palm growth in terms of plant height, total leaf area and dry matter production. Physiological processes such as relative water content, photosynthetic rate and total root phenolic contents were also significantly improved through AM symbiosis. In contrast, stomatal resistance was significantly decreased. AM formation also alters root morphological characteristics. The effect was more profound in the tertiary roots. Number and length of tertiary roots were respectively 63-105% and 26-113% higher in mycorrhizal than in control palms.

The potential of using AM as a biocontrol agent against *G. boninense* was studied by inoculating 5 month old mycorrhizal and nonmycorrhizal seedlings with rubber wood blocks measuring 6x6x12 cm previously colonized by *G. boninense* mycelium. Presence of AM successfully delays the time required by the pathogen to infect and to kill the palms. All nonmycorrhizal seedlings were infected and killed by the

pathogen as early as 6 months after *Ganoderma* inoculation. However, only 75% of the mycorrhizal seedlings showed symptom of BSR infection while 25% of the palms were killed by the pathogen 9 months after *Ganoderma* inoculation. Various sizes of *G. boninense* inoculum block was used in another study: 3x3x6 cm, 3x6x6 cm, 6x6x6 cm and 6x6x12 cm. These respective blocks were used to inoculate 5 month old mycorrhizal and nonmycorrhizal oil palm seedlings. Results obtained confirmed earlier results obtained from the previous study. Mycorrhizal seedlings were more resistant to *G. boninese* infection. Resistance was expressed by a reduction in leaf necrosis, number of rotten primary roots, area of the basal stem tissues that decayed and growth inhibition. However, the potential of AM induced resistance was reduced with increase in size of the pathogen blocks. Spread of *Ganoderma* infection within the primary roots of palms was also significantly affected through AM symbiosis. Results from single root inoculation clearly showed that AM formation significantly decreased the length of primary root that rot as a result of *G. boninense* infection. Length of infected primary root was 7.4 cm and 11.1 cm in mycorrhizal and nonmycorrhizal seedlings respectively.

Abstrak disertasi yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN MIKORIZA ARBUSKUL KE ATAS TUMBESARAN ANAK BENIH KELAPA SAWIT DAN PERKEMBANGAN PENYAKIT REPUT PANGKAL BATANG OLEH *GANODERMA BONINENSE*

Oleh

MARIA VIVA RINI

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Reput pangkal batang (RPB) yang disebabkan oleh spesies *Ganoderma* merupakan penyakit yang amat serius pada kelapa sawit. Jangkitan oleh kulat ini mengakibatkan menurunnya produksi dan kematian tanaman di peringkat lanjut jangkitan.

Kelapa sawit adalah tanaman 'mikotropik'. Dalam keadaan semula jadi, pokok sering dijangkiti kulat mikoriza arbuskul (MA). Oleh itu, kajian dijalankan untuk menilai peranan MA dalam meningkatkan pertumbuhan anak benih kelapa sawit dan mengkaji potensi kulat MA sebagai ejen kawalan biologi terhadap penyakit reput pangkal batang yang disebabkan oleh kulat *G. boninense*.

Satu kajian rumah kaca telah dijalankan untuk menentukan paras optima inokulum MA untuk tumbesaran pokok yang maksimum. Anak benih sawit telah diinokulasi dengan 6 paras inokulum MA (terdiri dari spora, hifa dan akar *Setaria ancep* yang dijangkiti campuran spsies MA) yaitu 0, 20, 40, 60, 80 dan 100 g inokulum/pokok. Hasil kajian menunjukkan paras inokulum 40 g/pokok memberikan pertumbuhan dan jangkitan akar MA yang maksimum, 3 bulan selepas inokulasi. Paras inokulum ini digunakan untuk kajian selanjutnya. Satu kajian telah dijalankan untuk mengkaji kesan MA ke atas pertumbuhan dan perkembangan pokok. Tinggi pokok, total luas daun dan produksi bahan kering secara bererti ditingkatkan oleh kulat MA. Proses fisiologi seperti kandungan air relatif, kadar fotosintesis dan total sebatian fenol pada akar secara bererti meningkat dengan adanya kulat MA. Sebaliknya, rintangan stomata menurun secara bererti. Kehadiaran kulat MA juga telah merobah ciri-ciri morfologi akar. Kesan MA adalah lebih ketara pada akar tertier. Jumlah dan panjang akar tertier masing-masing 63-105 % dan 26-113 % lebih tinggi pada pokok bermikoriza berbanding pokok kawalan.

Kajian menilai potensi penggunaan MA sebagai ejen kawalan biologi keatas kulat *G. boninense* telah dijalankan dengan menginokulasi anak benih bermikoriza atau tanpanya berumur 5 bulan dengan blok kayu getah berukuran 6x6x12 cm yang terlebih dahulu telah dijangkiti oleh miselium *G. bonienense*. Kehadiran kulat MA berjaya melambatkan

masa yang diperlukan oleh patogen untuk mengjangkiti dan membunuh pokok. Semua pokok tanpa mikoriza telah dijangkiti dan seterusnya mati 6 bulan setelah diinokulasi *Ganoderma.* Walau bagaimanapun, hanya 75% dari pokok bermikoriza menunjukkan gejala penyakit RPB dan hanya 25% pokok yang mati selepas 9 bulan diinokulasi *Ganoderma.* Saiz blok inokulum *G. boninense* yang berbeza telah digunakan pada kajian berikutnya : 3x3x6 cm, 3x6x6 cm, 6x6x6 cm dan 6x6x12 cm. Blok-blok ini telah digunakan untuk menginokulasi anak benih bermikoriza dan tanpa mikoriza berumur 5 bulan. Hasil kajian mengukuhkan lagi hasil kajian sebelumnya iaitu pokok bermikoriza didapati lebih resistan terhadap jangkitan *G. boninense.* Resistansi di tunjukan dengan kurangnya nekrosis pada daun, jumlah akar primer yang reput, area/kawasan pangkal batang yang busuk dan sekatan tumbesaran. Walau bagaimanapun, keberkesanan kulat MA dalam meningkatkan resistansi pokok menurun dengan meningkatnya saiz inokulum patogen. Penyebaran jangkitan *Ganoderma* dalam akar primer secara bererti juga dipengaruhi oleh simbiosis MA. Hasil kajian inokulasi akar tunggal jelas menunjukkan kehadiran MA secara bererti menurunkan panjang akar primer yang reput akibat jangkitan *Ganoderma.* Panjang akar primer yang dijangkiti adalah 7.4 cm dan 11.1 cm masing-masing pada pokok bermikoriza dan tanpa mikoriza.

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CHAPTER I

INTRODUCTION

The oil palm industry is one of the most important agricultural sector in Malaysia. In year 2000, 3.44 million hectares was under oil palm, with a production of about 11.13 million tonnes of crude oil. The export value of oil palm products in 1999 was RM 19.21 billion (MPOB, 2001). However, the oil palm industry is being threatened by a serious fungal disease, known as the basal stem rot (BSR) caused by *Ganoderma* sp.

The BSR affects the root and basal stem portion of the palm. Infection by this fungus begins in the roots and move into the stem causing a dry rot, which eventually lead to death of the palm. Infection of living palms occurs through contact of healthy palm root with the infected root mass or bole tissues, which serve as the inoculum source (Turner, 1981).

An incubation period of several years is believed necessary before the infected palm shows any symptoms of infection. However, Ho and Khairuddin (1995) in their study found that the external symptoms on the three leaf stage oil palm seedlings developed about three months after artificial inoculation with *Ganoderma.*

Earlier, this disease was confined only to the coastal areas and areas having the history of coconut planting. Currently, the incidence of the disease has increased with the fast expanding oil palm cultivation. Palms grown on inland as well as on peat soils have also been reported to be under *Ganoderma* attack (Gurmit, 1995).

Although the BSR disease has long been known, it was earlier thought to be economically unimportant, as infections were recorded on very old palms. At present, the disease is a limitation to production and in certain areas can become catastrophic at a time when the palms are reaching their most productive life (Turner and Bull, 1967; Turner and Gillbanks, 1974; Turner, 1981; Gurmit, 1995). The BSR disease can kill more than 80% of the stand by the time palms are 25 years old. This is especially rampant in areas where oil palms were replanted from coconut or old oil palms. Losses amounting to 50% are common in palms of 15 years, hence reflecting the economic importance of the disease (Gurmit, 1991; Khairudin, 1993). In Sumatra, where a replanting has been carried out simply by pushing over the old stand, with no attempt to remove the BSR affected tissue, palms in the replanted area succumbed to the disease from the second year onwards after planting (Hasan and Turner, 1998). Economic losses usually begin to occur within 10 years with severe losses after 15 years of the normal life span of a planting of about 25 years. Losses in yield as a result of BSR disease arise from negative yield from dead or fallen palms and a reduction in bunch number and

bunch weight of infected palms (Turner, 1981; Khairudin, 1993; Gurmit, 1995). Diseased palms produced 24% to 31% fewer number of bunches and 16% - 27% lighter bunches than those of healthy palms (Khairudin, 1993).

Clean clearing of the former oil palm or coconut stand during replanting is the main method of control currently practised. This is followed by removal of the infected palm to reduce secondary spread (Gurmit, 1991). However, the incidence of this basal stem rot disease is still sufficiently high to warrant concern in the subsequent planting. Biological control using *Trichoderma, Aspergilus* and *Penicillium* as well as chemical control using fungicide such as triazole, dazomet have also being evaluated in the field (Ariffin and Idris, 1991a; Gurmit, 1991; Khairuddin, 1993; Sariah *et al*., 1996 and 1998). However to date neither the biological control nor treatment with fungicides have given satisfactory results.

Mycorrhizal fungi are ubiquitous soil inhabitants and form symbiotic relationship with the roots of majority terrestrial plants. The mutual symbiosis benefits both the host and the fungus (Harley and Smith, 1983). The largest group, which is predominantly associated with agricultural crops, is the arbuscular mycorrhiza (AM) fungi. These fungi penetrate root cortical cells and form special haustoria like structures (arbuscules) that interface with host cytoplasm (Jackson and Mason, 1984). The fungal