Evaluating the Role of the Arbuscular *Mycorrhiza* (AM) Fungi in: I. Alleviating the Accumulation of Heavy Metal Residues in Cocoa Tissue and II: Rehabilitation of Unproductive Cocoa Farms with High Yielding Clones*

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Introduction

Fertilizers form one of the major components in increasing cocoa productivity. This however, should be closely associated to proper fertilizer management strategies based on the diagnosis of the soil characteristics and its crop production potential. Excessive use of the conventional fertilizers has detrimental effects on the environment, one of which is the accumulation of heavy metals in the soil. Cocoa is one crop that needs high nutrient input. The importance of the AM fungi in enhancing plant growth and hence yield has been well documented. In fact, an earlier study has even reported the ability of AM fungi in alleviating Al toxicity in Durian seedlings grown in Acid Sulphate soils (Azizah et. al, 1986). Vegetatively propagated cocoa plants responded positively to AM symbiosis in the glasshouse. These plants were observed to produce twice the yield of uninoculated plants when transferred to the field in Sungai Mai Plantation (Azizah, unpub. data, 1988). The subsequent project was carried with the aim of evaluating presence of heavy metal residues in both soils and cocoa tissues (leaves and cocoa beans) from a selected cocoa plantation in Gadung Jaya, Negeri Sembilan. The other trial aims to evaluate accumulation of heavy metal residues under glasshouse condition as a result of fertilization. This was subsequently followed by a rehabilitation trial in the same field at Gadung Jaya.

Material and Methods

Representative cocoa plants were selected and sub-divided into plots with or without *mycorrhiza* using a Randomised Complete Block Design. The soils from each plot were sampled, once every three months. These plots were subsequently used for the rehabilitation study. Uniform sized cocoa seedlings were planted into polybags each measuring 15 cm x 30 cm, containing 5.0 kg soil per bag, with or without the *mycorrhizal* treatments. The seedlings were fertilized monthly with NPK green 15:15:15 for six months.

Results and Discussion

Analysis done on soils sampled from this cocoa plantation failed to detect heavy metal residues in these soils, probably due to the fact that this plantation was not fertilized on schedule (because of the drop in cocoa price). The situation is further aggravated when this and the other surrounding farms were abandoned or chopped to make way for oil palm planting. Results of analysis on cocoa beans salvaged from the farm indicated presence of: Fe, Mn, Zn and Cu at the respective level of 223, 21,66 and 13 ug/g dry cocoa beans. In the glasshouse fertilization experiment, very low levels of As and Pb were detected in the soil. Other heavy metals such as Cd, Ni, Cu and Zn could not be detected. According to Fauziah et al (1998), the maximum permitted concentrations of Cu, Cd and Zn are 70, 10 and 40 mg/kg soil respectively. Hence from the results obtained it can be concluded that there is low possibility of heavy metal residues in cocoa beans especially from the smallholder farm or from a short-term fertilizer experiment. In another inoculation trial, preliminary results from this glasshouse trial showed significant increase in vegetative growth of the cocoa seedlings treated with mixed AM species. Maximum plant height of 43.7 cm and total leaf area of 1819.2 cm2 were recorded from AM inoculated seedlings compared to only 28.5 cm height and leaf area of 736.7 cm2 as recorded from the uninoculated controls. Subsequently a field trial was set up at the Gadung Jaya farm in July 1997. AM inoculated clones (using mixed AM species) had better and more significant plant growth with longer scion lengths and larger leaf area index compared to uninoculated scions. The fast growing clones means a saving of 4 months for the grafted plants to become productive. AM scions were also observed to be less susceptible to destruction by leaf insects. The control plants were very susceptible to insect pests and 60% of their young leaves were eaten by insect pest. The most interesting observation made during the experimental period was, AM inoculated PBC 137 clones started to flower 8.5 months after grafting compared to control plants which sent out flowers only at 12 months after grafting. However, it was most unfortunate that we could not do further analyses for heavy metal residues or the nutrient contents of the cocoa beans produced because the beans were either harvested by the farmers (despite the remaindance not to do so) or eaten by animal pests (*musang*) since the beans were produced very low on the main branch of the grafted trees.

Conclusions

Very low and insignificant heavy metal residues were detected in soils and cocoa tissues from the glasshouse trial, probably need to give much higher fertilizer doses and for a longer period of experimentation. Soils and cocoa beans analysed did not give significant levels of heavy metals (Zn, Pb, Cd, Mn, Cu). *Mycorrhizal* symbiosis significantly enhanced growth and yield of rehabilitated cocoa plants in the field. Yields were obtained much ear-

lier than the stipulated time as reported by earlier scientists, but in the absence of the *mycorrhizal* fungi.

Benefits from the study

One plant growth enhancer was formulated and eventually commercialised under the trade name of DRAZ-M. Two companies are currently producing and marketing this product. Malaysian Agri Hi-Tech Co. Ltd. and Malaysian Agri Hi-Tech Co. Ltd. (Sarawak).

Literature cited in the text

Azizah, H and Ragu, P. 1986. Growth response of *Theobroma* cacao L. seedlings to vesicular-arbuscular *mycorrhizal* inoculation. Plant and Soil. 96:279-285.

Azizah, H., Pauziah, S. and Chan Y.K. 1987. Utilization of the VA endophyte on fruit trees grown on Acid Sulphate Soils. In: *Mycorrhizae* in the Next Decade, Practical Applications and Research Priorities (Sylvia DM, Hung L and Graham JH, eds.) pp. 46.

Azizah, H. 1999. The endomycorrhizal fungi for soil management of year 2020. In "Modern Approaches and Innovations in Soil Management " eds. Bagyaraj, DJ, Verma, A, Khanna KK, Kheri HK, Rastogi Publications, Meerut – India. Pp 59-68.

Rini, M.V. Azizah, H., Idris, Z.A. 1996. The effectiveness of two arbuscular *mycorrhiza* species on growth of cocoa (*Theobroma* cacao L.) seedlings. Pertanika J. Trop. Agric. Sci. 19(3): 197-204.

Project Publications in Refereed Journals

Rini, M.V., Azizah, H., Idris, Z.A. and Jamal, T. 1996. The effectiveness of two AM species on the growth of cocoa seedlings. Pertanika Journal of Tropical Agriculture Science. 19: 197 – 204.

Project Publications in Conference Proceedings

Rini, M.V., Azizah, H., Idris, Z.A. and Jamal, T. 1998. The arbuscular *Mycorrhiza* Fungi for rehabilitation of matured cocoa trees: Growth and Physiological responses. In: Proceedings Soil Conference of Malaysia. (Eds : J. Shamshuddin and I. Fauziah). Pp: 299 – 311.

Graduate Research

Maria Viva Rini. 1996. Soil Microbiology [M.Sc. (Agric)]. Universiti Putra Malaysia.

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