# The Endomycorrhizas of Rubber Growing Soils of Sri Lanka

and

# Their Effect on Plant Growth

By

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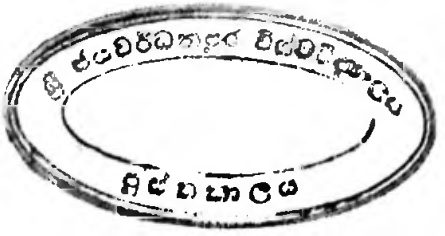

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# A C K N O W L E D G E M E N T S

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# The endomycorrhizas of rubber growing soils of Sri Lanka and their effect on plant growth

by

A.H.R. Jayaratna.

## A B S T R A C T

Vesicular-arbuscular mycorrhizas occur in a large number of agricultural, orchard and plantation crops such as corn, forage legumes, soyabean, cotton, tobacco, potato, sugar-cane, tomato, peas, apples, strawberry, avocado, citrus, coffee, tea, coconut and in many other plants. Most of these associations show an increased growth responses due to inoculation with VA endophytes. Current evidence suggests that these growth responses are mainly associated with phosphate nutrition. Though the VA mycorrhizal association in Hevea roots have been reported from Sri Lankan soil, the exact mycorrhizal status is not clear. Therefore a detailed endomycorrhizal survey was carried out in rubber growing soils of Sri Lanka. Spore types and numbers present were determined.

Among the spore types observed, Glomus monosporus, Acaulospora elegans, Acaulospora scrobiculata, Gigaspora nigra, Gigaspora gigantea, Gigaspora gilmorei and Sclerocystis coremioides from local soils and Glomus multiculis, Glomus macrocarpus, Sclerocystis sinosa and Sclerocystis clavispora from our rubber growing soils were reported for the first time.

The number of endomycorrhizal spores and the amount of available phosphate in soil was negatively correlated.

Soil moisture content was positively correlated to the VA mycorrhizal spore numbers.

Soil pH and root percentage infection did not show direct correlation to spore numbers.

Four types of VA mycorrhizas were compared for their growth responses on Hevea and Pueraria plants. These were Glomus fasciculatus, Glomus mosseae, $E_3$ type (Glomus sp.) and Gigaspora margarita. There were no significant differences in the rate of infection development in Hevea roots by the four mycorrhizal types compared. But the initial level of infection differed significantly.

No significant growth responses were observed with Hevea plants due to inoculation with these VA mycorrhizas, except in the case of mycorrhizal plants inoculated with Gigaspora margarita in sterilized soil.

The percentage phosphorus content of leaves of Hevea plants, grown in sterilized soil, was always significantly lower than plants grown in unsterilized soil.

Similarly the N and K content of the plants grown in unsterile soil were significantly higher than in sterile soil.

Mycorrhizal plants inoculated with Glomus fasciculatus showed significant differences in leaf $\frac{Ca}{P}$ percentages when compared with the non-mycorrhizal plants.

The total dry matter content of mycorrhizal plants inoculated with Glomus faciculatus were significantly higher than non-mycorrhizal plants, watered to 50% field capacity.

The dry weights of mycorrhizal plants, watered every 10th day were significantly greater than non-mycorrhizal plants watered in the same manner.

Leaf xylem pressure potentials of the mycorrhizal plants watered every 10th day were also significantly lower than in non-mycorrhizal plants.

Pueraria plants always grew better when they were mycorrhizal.

All mycorrhizal Pueraria plants in sterilized soil, with added rock phosphate grew much better than mycorrhizal plants in unsterilized soil with added P.

The growth differences between added P and without P differs significantly in both soils (sterilized and unsterilized).

Root nodule formation was favoured by the addition of rock phosphate in both soils. In sterilized soil the mycorrhizal plants had a significantly greater nodular dry weight than non-mycorrhizal plants.

In sterilized soil, all mycorrhizal plants except Glomus mosseae inoculated plants, contained a higher percentage of leaf phosphorus than non-mycorrhizal plants.

There was a correlation between the leaf percentage K content and the added rock phosphate. The mycorrhizal plants with added rock phosphate had a higher percentage of leaf N than non-mycorrhizal plants.

# ABBREVIATIONS

| | |
|---|---|
| Ca | Calcium |
| cm | Centimeter |
| F/A | Flotation-Adhesion |
| F.C. | Field Capacity |
| G.F. | *Glomus fasciculatus* |
| G.M. | *Glomus mosseae* |
| Gi. mar | *Gigaspora margarita* |
| K | Potassium |
| Kg | Kilogram |
| lbs/sq/in | Pounds per square inch |
| Mg | Magnesium |
| N | Nitrogen |
| nm | Nanometers |
| P | Phosphorous |
| VA | Vesicular-Arbuscular |
| W/D | Wet-sieving decanting |
| $\mu$ m | Micron |

# 1. INTRODUCTION

The rubber tree (Hevea brasiliensis) was first introduced into Sri Lanka in the year 1876. Rubber plays an important role in the day to day life of human beings as it is used in the manufacture of shoes, hose pipes, motor car parts mattresses and other household goods. The consumption of rubber increases with the improvement of living standards of a country.

Natural rubber is one of the most important commodities exported by our country, earning about 17% of its foreign exchange income. The prospects of the natural rubber industry will improve in future with the constantly increasing petroleum prices. Therefore, it is important to increase our production of natural rubber. This could be achieved in two ways:

1. By increasing the area under rubber plantation. This is not practicable; as Sri Lanka is a small Island, the cultivable land is limited and, at present, almost all of it is used for agricultural crop production.

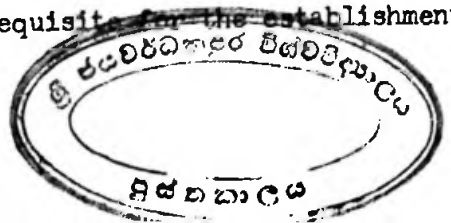
2. By increasing the yields obtained from the existing plantations. This could be achieved by increasing tree yields and improving techniques of tapping. Increased yields could be obtained by breeding methods and supplying the resulting trees with essential nutrients by the application of appropriate fertilizers to soil. An alternative is to use a biological process such as mycorrhiza, which is a symbiotic association between the roots of higher plants and certain groups of fungi, which enables plants to absorb nutrients from insoluble soil minerals via these fungi.

Of the two main types of mycorrhizas, the endotrophic mycorrhizas, the Vesicular-Arbuscular (VA) types are more common in nature. The occurrence of the ectomycorrhizas is restricted to a few plant families, whereas endomycorrhizas exist in almost all the other plant families (Mosse, 1973; Baylis, 1962; Gerdemann, 1968) including Hevea brasiliensis and legumes such as Pueraria phaseoloides, Centrocema pubescens, Calapogonium mucunoides, Desmodium ovalifolium and Stylosanthes guinensis, all grown as ground covers under rubber. Wastie (1965) studied the mycorrhizal association of Hevea and showed that the endophyte is an Endogone type similar to that described previously in other plants (Butler, 1939; Mosse, 1956; Gerdemann, 1961). It is now evident that this endophyte belongs to the family Endogonaceae which comes under the order Mucorales. Many plants have shown improved growth and uptake of nutrients in association with VA mycorrhizal fungi (Mosse, 1973; Baylis, 1967; Gerdemann, 1964). But Wastie (1965) has reported that VA mycorrhizal infection in rubber roots has no effect, beneficial or harmful, on the growth of the rubber plant. Therefore, studies were carried out to find out whether VA mycorrhizas in Hevea have any effect on growth of the host plant under our environmental conditions. Studies were also carried out to determine whether there is any growth effect on Hevea due to inoculation with four types of VA mycorrhizas, at two levels of available phosphorus, in sterilized and non-sterilized soil.

The nutrients required by the Hevea plant, under local soil conditions, have been recognised as N, P, K and Mg. Since substantial quantities of N and P are essential for plant growth, the supply of these two elements to the soil as fertilizer is very important. As the cost of production and application of soluble phosphatic fertilizers

is increasing, it is important to investigate all alternative means of increasing phosphate availability in P deficient soils. The current evidence suggests that growth responses due to VA mycorrhizas are **mainly** associated with phosphate nutrition, suggesting that the VA mycorrhizal plants are able to extract soil phosphate better than non-mycorrhizal plants. Therefore, it is important to find out whether Hevea too, in association with VA mycorrhizas, can exploit the soil phosphate more efficiently than non-mycorrhizal plants. If we can find plants with highly effective endophytes which can absorb nutrients more efficiently from the soil, specially slowly mobile ions such as phosphorus, we will be able to reduce the expenditure on phosphate fertilizers. Further, these endophytes may be able to utilize cheaper forms of phosphorus fertilizers such as rock phosphates efficiently as a P source. Therefore it is important to isolate more effective varieties of these fungi either from our indigenous population or from exotic varieties. Plants can be inoculated with these varieties in sterile sand beds and later transferred to the field. Studies were carried out to determine whether there is any increased uptake of nutrients by VA mycorrhizal Hevea plants at two levels of available P in sterilized and non-sterilized soil. Studies were also carried out to determine the rate of infectivity of Hevea by different species of VA mycorrhizas and to compare the rate with natural populations of endophytes.

Usually a leguminous cover crop is grown in the inter-row spaces of immature rubber plantations as a soil conservation measure. These help to increase the fertility of the soil, mainly by the fixation of atmospheric nitrogen. Therefore, it is important to have a good ground cover in young rubber plantations. It has also been found that the mycorrhizal condition is an obligatory prerequisite for the establishment



of Pueraria in sterilized soil with low levels of available phosphorus (Waidyanatha et al, 1969). Hence the establishment of a good ground cover will depend on the size and the effectiveness of the native VA mycorrhizal population. The endomycorrhizal survey carried out in these studies will give details of the VA mycorrhizal status in rubber growing soils of Sri Lanka, and the species present. Experiments were carried out to determine whether same species that infect Hevea will also infect the cover legumes and to determine the growth effects due to the presence of these mycorrhizas.

VA mycorrhizas can also have other secondary effects such as resistance to drought and transplanting shock, which have great agronomic importance under Sri Lanka conditions. As the effects of VA mycorrhizas on water relations of the host plants were virtually unexplored, studies were carried out to observe the growth responses to VA mycorrhizas in Hevea plants under water stress conditions.