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MYCORRHIZA IN TEA

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What is Mycorrhiza?

The word **MYCORRHIZA** (plural **MYCORRHIZAE**) is derived from two greek words for fungus and root. Therefore mycorrhiza by definition, literally means "**a fungus root**". This involves a group of fungi, capable of inhabiting root systems of higher plants, without necessarily causing a **disease** or a **diseased condition.** Conversely these associations are maintained for the mutual benefit of the host and the fungus concerned. Therefore it is necessarily a mutualistic, symbiotic association.

All the known mycorrhizal fungi are basically classified into two groups, based on their characteristic mode of association with the roots of higher plants:

i) **Ecto-Mycorrhiza** - the fungus grows on the surface of the root as a closely woven sheath and penetrates the cortex, only intercellularly to form a continuous network called, **Hartig Net**.

ii) **Endo-Mycorrhiza** - predominantly found within root cortex without inducing any alterations to the root morphology. These mycelia may occasionally, put out extensions to the root surface.

Fungi which are now known to cause **ectomycorrhizae**, with higher plants are in three classes within Eumycota (true fungi). These are the Basidiomycetes, Ascomycetes and Zygomycetes, the largest number of which are found in Basidiomycetes.

The group of fungi that are involved in **endomycorrhizae**, which is our immediate interest, are among the more common and widely distributed, of the soil borne fungi. Without exception all of them belong to a single family ***Endogonaceae***, in the order ***Endogonales*** (Zygomycotina).

This second group is popularly known by its synonym **'Vesicular Arbuscular Mycorrhiza'**, **VAM** for short, a name they have secured by their indispensable association with such structures known as **'vesicles'** and **'arbuscules'** within the cells of the inner cortex. In all successful associations of these fungi with root systems of higher plants, to which the tea crop is no exception, these structures are encountered inside feeder roots. The degree of abundance of one or more of these structures (as has been observed) may be the result of the interaction between the species of the fungus and the particular clone of tea. This is a point to ponder in directing this natural phenomenon to the benefit of the tea crop.

Where are they present?

They are essentially soil borne. Fungi forming mycorrhizal associations with roots of higher plants are so widespread in nature, that no perennial plants are free from this interaction. It can be said that mycorrhizal colonization is more common than its absence in higher green plants. Their survival and the spread is basically through spores which are of two kinds: **azygospores** (*Acaulospora* and *Gigaspora* spp.) and **chlamydospores** (*Glomus* and *Sclerocystis* spp.)(Carling and Brown, 1982). These spores are invariably found in the rhizosphere of the feeder roots, of successful mycorrhizal associations. The abundance of spores (sporocarps) in soil is a reflection of its immediate environment, i.e. soil moisture, soil organic matter, soil pH, usage of chemicals, etc. These could provide fresh inoculum for infection along with mycelial strands and vesicles in root debris. Except for a few extramatrical mycelial strands that may penetrate the root cortex to grow out to the surface, the majority of the fungal mycelia and the associated structures, e.g. vesicles, arbuscules and sometimes spores, are found within the absorptive zone of individual roots. They are very often concentrated in the inner cortex of feeder roots (Butler, 1938).

Importance of VAM to crop plants

Most of the annuals as well as perennials are associated with VAM. The net returns of these symbiotic associations are being progressively proved to be in favour of the host. These net gains are believed to accrue through one or more of the following ways:

i) Increased absorptive surface area for the efficient uptake of minerals such as P, Cu, Zn, at low availability levels (Tinker, 1975; Kothari, Marschner and Romheld, 1990). This has been abundantly proved with regard to P nutrition (Cress, Thornberry and Lindsey, 1979).

ii) Competition between mycorrhizal fungi and other soil borne micro-organisms, particularly with the pathogenic fungi, could bring down potential colonizations of the root systems of higher plants by the pathogenic soil fungi/micro-organisms (Dehne, 1982).

iii) Mycorrhizal roots have been found to be more lignified, a case in favour of plant resistance to pathogenic infections (Dehne, 1982).

iv) There is evidence to suggest that the mycorrhizal associations (VAM) are capable of keeping under control, some root infecting nematode populations (*Meloidogyne incognita*) by checking the development of larvae into egg producing females (Kellam and Schenck, 1980).

v) Mycorrhizal associations are always confined to the absorptive zones of root systems. Therefore they explicitly maintain a **balance** between the mycorrhizal infections and the total root volume. This has been evidently observed with VAM, where older structures (arbuscules, in particular) keep on disintegrating within the root as growth continues. Therefore there is no threat from the mycorrhizal fungi (VAM) of exhausting the host root system (Carling and Brown, 1982).

vi) As reported by Schenk in 1984, mycorrhizal plants could have some advantages over their counterparts which do not have such associations. They have greater tolerance to toxic heavy metals like Mn, Ni, Cr and Cd; tolerance to drought and high soil temperatures; tolerance to adverse soil pH and greater ability to withstand transplanting shock.

Study of Mycorrhiza in tea roots

No work has been carried out on the mycorrhiza of tea in Sri Lanka, since Webster in 1953 demonstrated briefly, the presence of endomycorrhiza in tea roots of clone TRI 2024. In the present studies, two methods were employed to assess successful mycorrhizal associations in tea, they are:

i) Study of VAM spores in the root zone soil;

ii) Study of percentage infection of absorptive roots by VAM.

Study of VAM spores

In the first method mycorrhizal spores were separated from soil, using `wet sieving' and `sucrose centrifugation' methods (Daniels and Skipper, 1984). However sucrose centrifugation method is preferred as it mostly, gives the viable spore count. Spores were separated onto a grid (made of filter paper) for counting under a dissecting microscope.

Spore counts

Spore counts were obtained from a known weight (100 g) of soil from a depth of 5 -10 cm in the root zone as this gives a good indication of VAM populations associated with them (Daniels and Skipper, 1984). The soil samples tested at St.Coombs proved to carry a fair number of VAM spores of different kinds (Fig. 1). They belong to at least three genera of VAM, namely, ***Acaulospora***, ***Glomus*** and ***Gigaspora***. (Figs. 2-4). Table 1 gives the results of a preliminary assessment carried out on soil samples obtained from different associations at St.Coombs Estate.

TABLE 1. - *Spore counts of soil samples obtained from different root zone associations at St.Coombs Estate*

Source	No.of spores/100g of soil*
Jungle soil (*Eucalyptus* sp.)	400
Guatemala soil (1st year)	389
Root zone soil TRI 2023	489
Root zone soil TRI 2025	400
Root zone soil TRI 2043	573

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* Means of two readings

Study of root infections by VAM

In the second method, roots were cleared and bleached using KOH and freshly prepared alkaline H_2O_2, respectively. The roots were then stained using acid fuchsin-lactic- acid stain (Kormanik and McGrow, 1984). Successful VAM infections were observed under x100 and x400 magnifications of a dissecting microscope (Fig. 5). We were able to identify the three major components of VAM associations.

i) **Vesicles** - storage organs

ii) **Arbuscules** - exchange organs

iii) **Intercellular hyphae** - means of spreading infections

Variations were observed with respect to the appearance, clarity, and abundance of these components among the clones that were studied.

Clone TRI 2043 had the highest per cent of colonization of the feeder roots. The roots of TRI 2023 (Fig. 6) and of seedling (Fig. 7) were found to possess a very clearly defined vesicular system. Both TRI 2025 and TRI 3055 had similar forms of arbuscules which were abundant and dark brown in colour (Fig. 8).

Per cent root infections

The quantification of VAM infections was based on the percentage length of roots infected, as measured on a grid of 1x1 cm^2 (Kormanik and McGrow, 1984), under the dissecting microscope (Infected intercepts/ Total intercepts x 100). This method though laborious, gives a more realistic picture, since we are counting the actual infections of roots. Tea feeder root infections of some of the clones that were studied are given in Table 2.

TABLE 2. - *Per cent VAM infections of some of the popular tea clones.*

Clone	% infection of roots*
TRI 2043	44.0
TRI 2023	14.8
TRI 2025	6.6

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* Means of two readings.

How could the tea industry benefit from VAM?

We have enough evidence of successful mycorrhizal colonizations of tea roots by VAM (Figs. 5-8). Some of the tea soils tested (at St.Coombs) proved to carry in nature, a fair number of spores (Table 1) of at least three different genera of VAM (Figs. 1-4). Data in Tables 1 and 2 are suggestive of a variability in the interactions of VAM and the tea crop, having different affinities towards some clones in preference to others. For example the observations made on clone TRI 2043, on its drought endurance may be due, at least partly to these enhanced associations with the mycorrhiza (Table 2), (Schenk, 1984). This could be further proved only through detailed investigations. If proved positive, mycorrhizal associations of the tea crop would undoubtedly be a useful tool in our quest for improved crop.

The tea crop being a perennial, the cumulative gains over the years may be substantial, if we could help establish a sound, 'Root-VAM' association at the time of planting in the field. Once established, if we take care to moderate the immediate environment of these associations, viz. the rhizosphere soil (5-10 cm of surface soil), so that optimum populations are maintained at all times, the potential returns should invariably be higher.

Mycorrhizal associations of tree crops are a marvellous gift of nature. When we pay attention to mycorrhiza we are invariably paying attention to nature. Therefore what we have to do is to pay a little more attention and derive benefits through mycorrhizal associations.

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Fig. 1 – A collection of VAM spores from the tea soils at St. Coombs. Note the range of shapes available. x 30

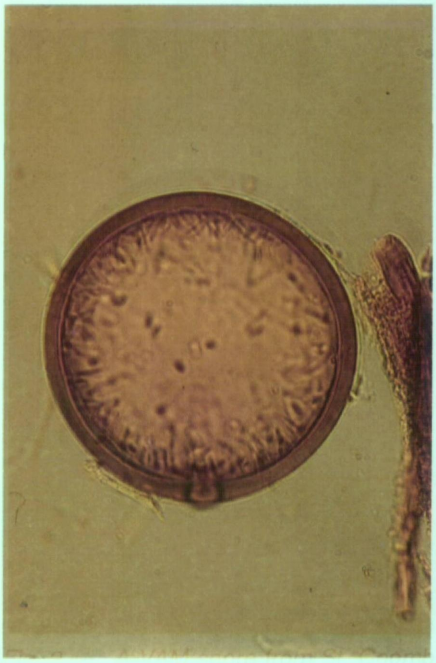

Fig. 2 – A VAM spore from St. Coombs tea soils. Acaulospora sp.? x 200

Fig. 3 – A VAM spore from St. Coombs tea soils. Glomus sp.? x 200

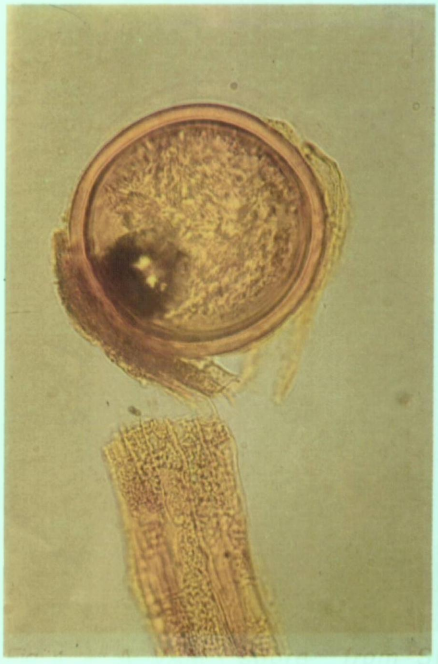

Fig. 4 – A VAM spore from St. Coombs tea soils. Gigaspora sp.? x 120

Fig. 5 – VAM mycelium on TRI 2024 roots. Note the free vesicle attached to the hypha. x 50

Fig. 6 – A clearly developed VAM vesicle inside TRI 2023 roots. x 200

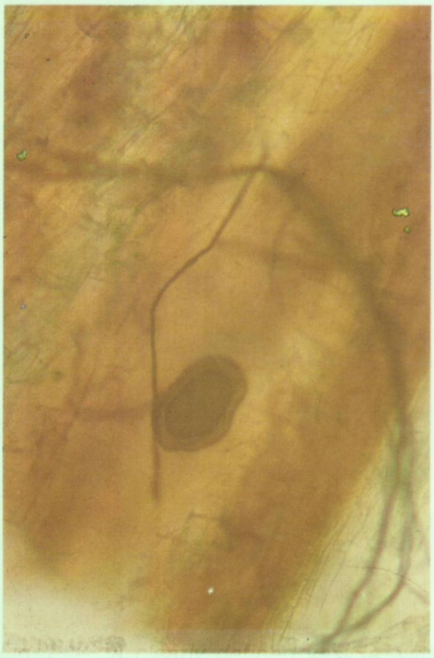

Fig. 7 – A clearly defined vesicle, with zonations inside a seedling tea root. x 50

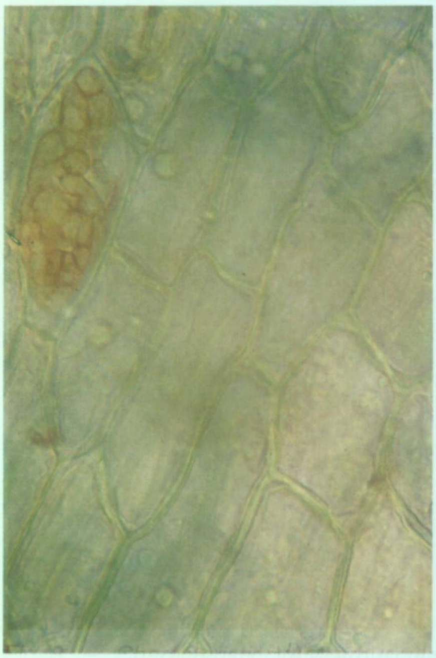

Fig. 8 – Characteristic VAM arbuscular forms as seen in TRI 2025 roots. x 200

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