

Figure 5. A spore of *Glomus constrictum* from rhizosphere soil of safflower ($\times 100$).

followed by the formation of VA mycorrhizas in oil-seed crops grown under semi-arid tropical alfisol soil conditions.

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VESICULAR-ARBUSCULAR MYCORRHIZAL ASSOCIATION IN MULBERRY

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It is well known that mycorrhizal association in plant roots can lead to increased efficiency of nutrient uptake leading to the enhancement of plant growth^{1,2}. Successful yield trials with various economic crops after inoculation with vesicular-arbuscular-mycorrhiza (VAM) have been reported²⁻⁴. However, little or no information is available on VA mycorrhizal association and its role in nutrient uptake and growth of important economic crop plant like mulberry (*Morus* spp) under natural conditions. Kandasamy *et al*⁵ reported the response of four mulberry cultivars to VAM inoculation in pot culture.

The aim of this study was to survey the rhizosphere soil and roots of different mulberry cultivars for natural mycorrhizal association before selecting any VA mycorrhiza for field trials to increase the leaf yield. The present paper thus highlights the natural VAM association in various mulberry cultivars.

The fine roots of six mulberry varieties, viz. Kanva-2, Mysore Local, S₃₀, S₃₆, S₄₁ and S₅₄ grown at this institute were used in the present study. The roots of each mulberry variety in five replicates along with 0.5 kg rhizosphere soil collected in polythene bags were brought to the laboratory. The fine roots were washed in tap-water and cut into segments of approximately 1 cm in length (100 segments from each replicate plant). Root segments were processed and stained for detecting VAM association⁶. The percentage of root colonization by mycorrhizal fungi was calculated by

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the presence of vesicles, arbuscules and both in the colonized segments under microscope. VAM fungal spores 50 ml rhizosphere soil of each mulberry variety were also estimated⁷ and identified up to the genus level. The pH and the moisture content of rhizosphere soil were also determined. The results were statistically analysed (table 1).

From the stained and processed root segments it was observed that the entry of the mycorrhizal fungi into the mulberry roots takes place by appressorium (swollen structure) formation on the root surface (figure 1). Hyphal coiling occurs after penetrating the outer cortex of root which is followed by rapid formation of arbuscules and vesicles (figures 2-4). Subsequently hyphae of mycorrhizal fungi emerge out or remain within the roots, connected to the external mycelium in the rhizosphere and develop fruiting bodies (figures 5 and 7). Occasionally the mycorrhizal spores are developed even in dead roots (figure 6).

Statistically no significant variations were observed in the total percentage of mycorrhizal colonization among the roots of different mulberry varieties (table 1). However, significantly better percentage of root colonization by arbuscules was observed in Mysore Local variety followed by S₃₆, Kanva-2, S₅₄, S₃₀ and S₄₁. The percentage of root colonization with vesicles and vesicles + arbuscules were almost the same among the studied varieties. The maximum moisture and pH were observed in the rhizosphere soil of S₃₀ and S₃₆ respectively. The highest population of VAM spores was observed in the rhizosphere soil of Kanva-2 which was significantly higher over all other varieties studied. Most of the VA mycorrhizal fungi encountered in the present study belonged to the genus *Glomus* besides other generic forms like *Gigaspora*, *Acaulospora* and *Sclerocystis*. The genus *Glomus* appeared to be a

dominant VA mycorrhiza in the rhizosphere soil irrespective of different mulberry varieties.

The mycorrhizal hyphae which form appressoria have more cytoplasmic materials at their apical end and exert mechanical or biochemical pressure on the root cell wall of host, to facilitate the process of penetration. After penetrating the cell wall, the hyphae form coils which is followed by rapid formation of arbuscules and vesicles^{8,9}. Some hyphae when coming out of the root or maintaining any connection with the mycelia in the soil or on the root surface can also be developed as fruiting bodies like sporocarps, azygospores or chlamydospores. These may act as further sources of mycorrhizal association¹⁰.

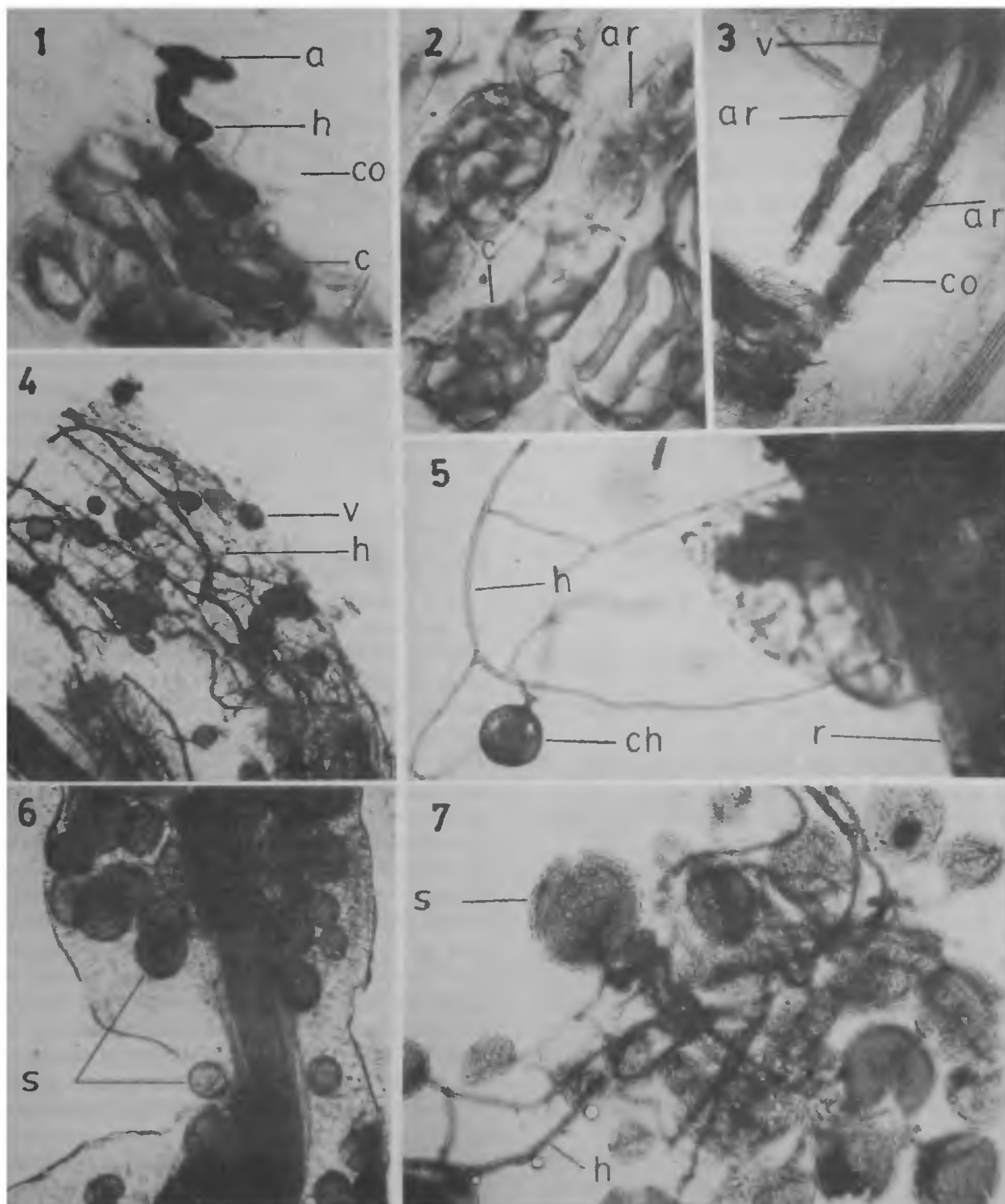
In the present study the different degrees of colonization and variation in the endomycorrhizal spore population among different mulberry varieties may be attributed primarily to the rhizosphere effect of the host plants. Further, the maximum number of endomycorrhizal spores in the rhizosphere of Kanva-2 is an indication of better symbiotic relationship of VAM fungi with this variety due to some ecological factors conducive for the growth of these organisms in the rhizosphere. Besides these, the available phosphorous and carbohydrate contents in the rhizosphere soil and roots of different mulberry varieties are also important factors for the variation in mycorrhizal population. However, the influence of pH and moisture content of the rhizosphere soil of different host plants on the prevalence of mycorrhizal fungi may not also be overlooked¹¹.

Hence it was observed that mycorrhizal fungi do form natural symbiotic association with perennial crop plant like mulberry too. Similar finding on mulberry was also reported by others¹². All the cultivars used in this study were mycorrhizal. The

Table 1 Occurrence of VA mycorrhiza and their spores in the mulberry cultivars

Mulberry cultivars	Total per cent of root segments colonization	Per cent of colonized root segments containing			Endomycorrhizal spores/50 ml soil	Soil pH	Soil moisture
		Arbuscules	Vesicles	Arbuscules + vesicles			
Kanva-2	79.08	13.70	15.12	50.26	398	8.204	14.0
Mysore Local	79.44	15.94	17.28	46.22	197	7.90	15.9
S ₃₀	75.06	10.36	14.84	49.86	184	8.20	18.6
S ₃₆	79.12	14.64	12.20	52.28	182	8.31	13.4
S ₄₁	78.92	8.36	13.66	56.90	89	8.16	15.3
S ₅₄	75.82	13.64	11.74	50.44	191	8.15	15.4
C.D. at 5% level	NS	4.988	NS	NS	148	0.1465	2.277

NS, Non-significant.



Figures 1-7. Mycorrhizal association in mulberry roots. **1.** Development of appressorium on the root ($\times 160$); **2.** Typical hyphal coiling and developing arbuscules in the cortical cells ($\times 160$); **3.** Vesicles and arbuscules in the root ($\times 25.6$); **4.** Non-septate hyphae with vesicles running through a root ($\times 40$); **5.** Root showing development of a chlamyospore of a *Glomus* species on external hyphae in the rhizosphere ($\times 83.2$); **6.** Mycorrhizal spores developed in the dead root ($\times 25.6$), and **7.** Clusture of mycorrhizal spores of a *Glomus* species ($\times 22.4$). [a, Appressorium; ar, Arbuscule; co, Cortex; c, Coil; ch, Chlamyospores; h, Hypha; r, Root epidermis; s, Spore; v, Vesicle.]

importance of these observations lies in the fact that it is possible to use this beneficial effect of symbiotic association existing under natural condition to reduce the application of phosphatic fertilizers to a great extent in mulberry cultivation specially under tropical condition without any reduction in the leaf yield. It is also possible to reduce the phosphatic fertilization to a great extent in mulberry cultivation by introducing an efficient strain of VA mycorrhiza in the rhizosphere of mulberry plants where the efficient strain of local endophytes is not available in the soil to increase the leaf yield. Besides these it may also be possible to use this beneficial effect of symbiosis to combat soil-borne root infecting pathogens and root nematodes.

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AN INDUCED LEAF DIFFERENTIATION MUTANT IN *SESAMUM INDICUM* L.

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DEVELOPMENTAL mutants affecting laminar growth are of interest as they influence the plant form and growth rate^{1,2} and may involve only a small number of genetic substitutions³. In addition to their use in the genetic manipulation of plant architecture amenable for combine harvest and improved yield at higher densities reported in various crop plants, the modified leaf types are valuable for basic studies on source-sink relationships, relative distribution of assimilates between vegetative and reproductive parts² and the evolution of leaf form in relation to distinct adaptive differences as in some geographical forms of *Sesamum*⁴.

In a mutation breeding programme on *Sesamum* for resistance to charcoal rot using locally adapted cultivars in Venezuela, a narrow lamina mutation with only vestiges of lamina around the veins was detected in 1985 in a progeny in the M 4 generation of a variety Ven-52. The material was derived from an initial seed treatment of a dose of 60 kr of γ -radiation from a ⁶⁰Co source. The secondary and tertiary veins of the lamina were disorganized in growth similar to the leaf mutants in cotton reported by Dilday *et al*⁵. The number and the size of capsules and seed size in the mutant were comparable to its normal counterpart. However, seed set in crosses with the mutant as female was low. This mutant is of practical interest as chemical defoliant and dessicants are sprayed on the crop before harvest for easy mechanical harvest to get seeds free from tiny leaf bits. This mutant can reduce the cost of such a treatment. The genetics of this character was analysed in the subsequent generations and reported in this paper.

The selfed progeny Ven 52-4-N₄-H₃₂ in the M 4 generation segregated with 236 plants with normal lamina and 22 with narrow lamina, χ^2 (1df) for 15:1 being 2.8539 (*P* 0.05-0.10) indicating that the mutant genotype is duplicate-recessive. To confirm the segregation pattern, the next generation was examined with the selfed progenies of 44 randomly selected normals and 33 narrow lamina segregants (table 1) and six crosses, including reciprocals between