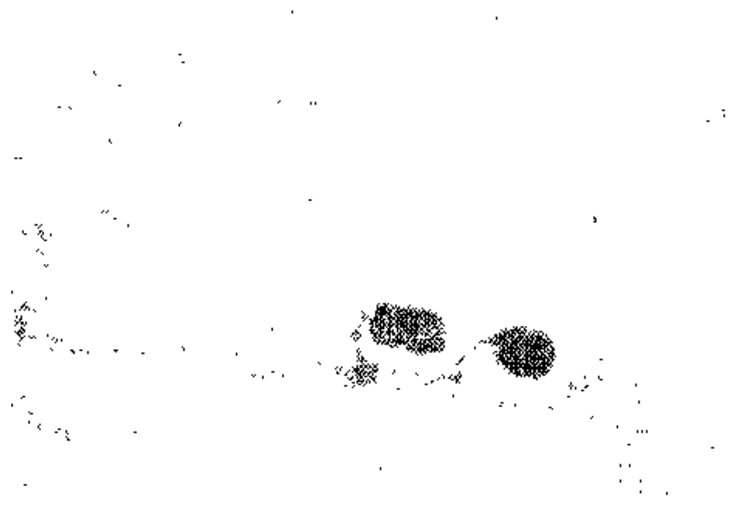

Figures 1 and 2. 1, Vesicles with VAM mycelia in the roots of *Cymbopogon citratus* (×70). 2, Vesicles in the roots of *C. winterianus* (×70).

On the other hand the functional units, the arbuscules, were also present in most of the tested *Cymbopogons* except in three cases (Table 1).

Interestingly all the *Cymbopogon* species that showed high per cent of VAM colonization are very common in the acidic soil which may be one of the reasons in obtaining higher herb yield with increased percentage of essential oil contents.

Further studies on relative merits of VAM association on these species in relation to different doses of phosphorus and plant growth, oil yield and quality

Table 1. Per cent colonization of VAM fungi in roots of different *Cymbopogon* species

Species	VAM colonization in roots (%)	Vesicles	Arbuscules
Cymbopogon winterianus	75.5	+++	++
C. martini var *motia*	40.2	Nil	+
C. flexuosus	75.5	+	+
C. citratus	80.2	++	++
C. flexuosus var *sikimensis*	72.0	++	Nil
C. khasianus	75.7	Nil	Nil
C. jwarancusa	50.4	Nil	Nil

+ Scanty, ++ Moderate, +++ High.

are in progress.

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Phenols and lipids in mycorrhizal and non-mycorrhizal roots of *Sesamum indicum*

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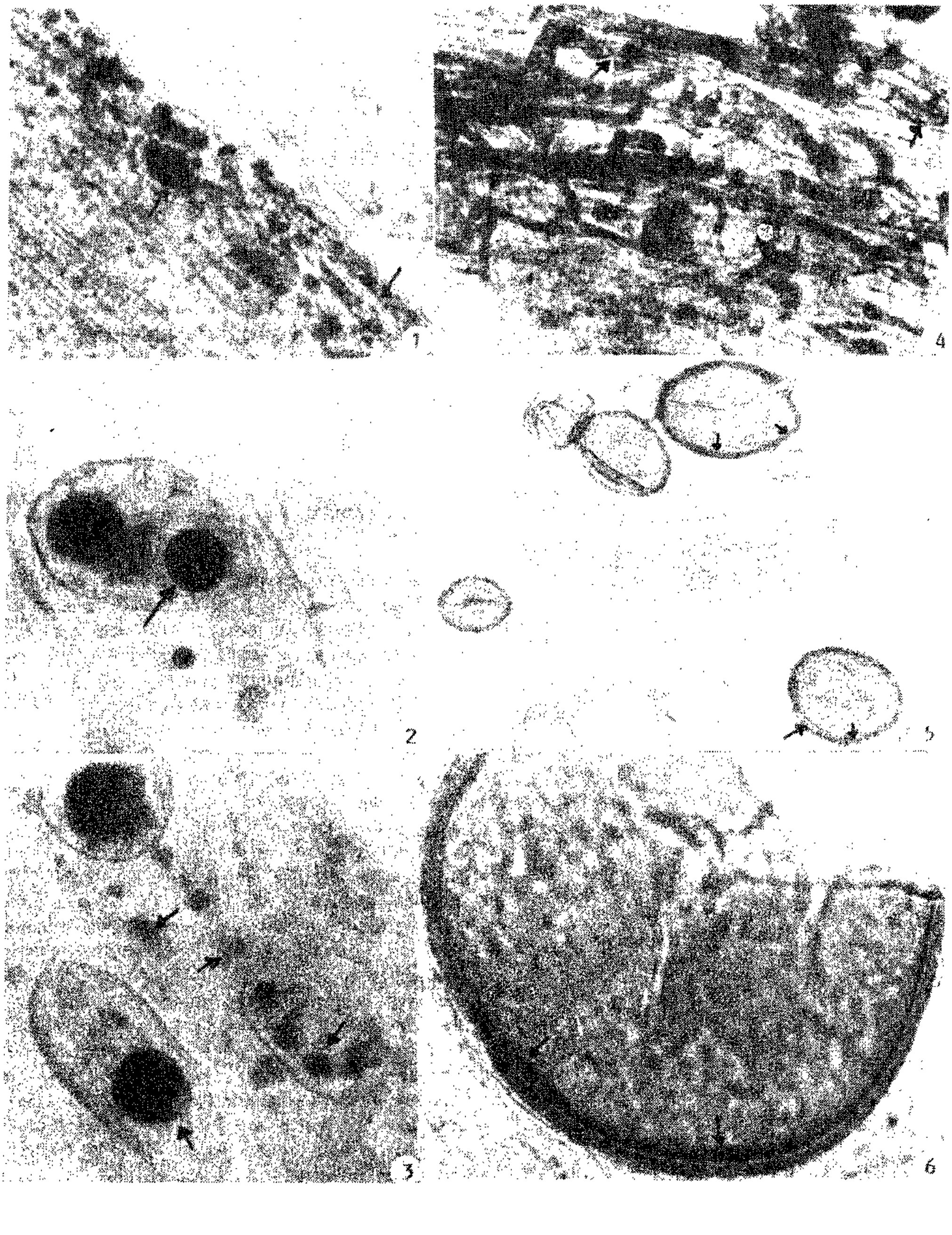
Mycorrhizal inoculation resulted in a significant enhancement of the percentage of infection, dry matter and phenolic content of plants in sterilized soils compared to others. Histochemical studies revealed an accumulation of different types of lipids and phenolic compounds in VAM structures; particularly neutral lipids and catechol tannins in vesicles. It is suggested that the reports on increased amounts of lipids and phenols in mycorrhizal plants could be the contribution of fungal structures.

Research in the last few decades has established that vesicular-arbuscular mycorrhiza (VAM) can improve plant growth through increased uptake of mineral nutrients. However, recent studies suggest that VAM infection may change the biochemical composition of the host plant. Information on the effects of VAM on histochemical and biochemical composition of the host plant is limited[1]. A few studies have shown that considerable differences exist between mycorrhizal and non-mycorrhizal plants with respect to total carbohydrates[2,3], amino acids[4], lipids[5–8] and phenols[9,10] The present work relates to the effect of *Glomus fasciculatum* infection on phenolics and lipids in the roots of *Sesamum indicum* L. var. Co-1 plants.

A pot culture experiment was conducted using phosphorus-deficient (5 mg of available P kg^{-1} of soil extracted with NH_4F and HCl), sandy loam soil with pH 7.2. Soil was sterilized in an autoclave for 3 h at 15 psi pressure for three consecutive days. Pots (15



Figures 1 – 6. Histochemical characteristics of VAM structures in sesame roots. **1**, Hyphae and arbuscules positive for neutral lipids (→) with Sudan dyes (× 340). **2**, Hyphae and young vesicle positive for neutral lipids (→)with oil red 'O' (× 240). **3**, Hyphae and young vesicles positive for phospholipids (→) with Nile blue (× 240). **4**, Hyphae and pelotons, positive for phenolics (→) (× 180). **5 & 6**, Vesicles and young spore strongly positive for phenolics (catechol tannins) with nitroso reaction (× 180), (× 340).

Table 1. Percentage of mycorrhizal infection, dry matter and phenol content of the mycorrhizal and non-mycorrhizal sesame roots (mean of 5 replicates).

Treatments	Mycorrhizal infection (%)	Plant dry matter g/plant Shoot	Root	Total phenol µg/g/fresh weight sample	O-D phenol µg/g fresh weight sample
Sterilized					
Uninoculated	0	2.05	0.224	277.0	73.8
Inoculated	94 + 1.0	3.82	0.288	388.0*	139.8*
Unsterilized					
Uninoculated	59 + 3.2	2.15	0.235	298.0	87.6
Inoculated	79 1.9	3.00	0.265	320.0	93.2
SEM +	ND	0.35		20.6	9.5
CD at 5%	ND	1.11		44.9	20.8

* Values statistically significant. ND, Not determined.

cm diameter) were filled with 3 kg soil each of either sterilized or unsterilized soil. Mycorrhizal inoculum contained extramatrical chlamydospores (350 spores per 50 ml) and root segments of *Cenchrus* sp. infected with *Glomus fasciculatum* (Thaxster) Gerde. and Trappe grown for 90 days. The inoculum was placed 2 cm below the soil surface before sowing the seeds to produce mycorrhizal plants. Two healthy seeds of sesame were sown in the centre of each pot. The plants were maintained in a cage house. Plants (5 replicates) were harvested after 60 days. Shoot and root dry weights were recorded. Mycorrhizal infection of the root[11] was assessed. Fresh root samples were ground well and extracted with ethanol[12]. From the extract thus obtained total[13] and *ortho*-dihydroxy (O-D)[14] phenols were estimated. Fresh roots were mounted on 1 cm diameter brass Cryostat specimen plates and quickly frozen with ice. Sections of roots about 15 µm thick were cut longitudinally in a Cryostat Microtome (Bright Instrument Company Ltd, England). Sections were stained with 0.05% toluidine blue 'O' in benzoate buffer at pH 4.4 for 5 min[15] and nitroso reaction test for phenols and oil red 'O'[16], Nile blue[17] and Sudan dyes[18] methods for lipids. Appropriate controls were run with duplicate tissue in both lipids[18] and phenols[19] test.

Mycorrhizal infection and dry matter, as a result of mycorrhizal inoculation showed very significant enhancement with sterilized soil (Table 1). Even in uninoculated, unsterilized soil, there was some increase in plant dry matter compared to the uninoculated sterilized soil. Total and O-D phenols were maximal in inoculated sterilized soil compared to uninoculated controls (Table 1). In unsterilized soil without inoculation, the increase in phenols compared to the uninoculated sterilized soil was only marginal. Although, the native VAM species in unsterilized soils brought about an increase in phenols, the inoculation of VAM resulted in very significant enhancement. In histochemical studies, lipids in vesicles and hyphae reacted positively to a variety of reagents that have an affinity for neutral lipids (Figure 1–3). The vesicles and arbuscules were distinctly rich in different types of lipids and phenolic compounds (Figures 4–6). Vesicles showed relatively higher amounts of neutral lipids (Figure 3) and catechol tannins (Figures 5 and 6). A similar abundance of phenols especially O-D phenols and neutral lipids in VAM structures was reported by Krishna and Bagyaraj[10] and Nemec[7].

The mycorrhizal inoculation has been reported to impart resistance to the host against disease[20]. Resistance to pathogens has been correlated with the phenol content of roots[21]. Histochemical study suggested that the higher amounts of phenols and lipids observed in mycorrhizal plants might be the contribution of the fungal structures. The lipids synthesized by the fungus appear to serve a dual role of a growth sink for the fungus and a storage sink of energy for the host[7].

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