MYCORRHIZAL ASSOCIATIONS IN ROCK CREVICES

Vesicular-Arbuscular Mycorrhizal Infections in decaying Aerial Portions of *Adiantum capillus-veneris* L. Induced by VA Mycorrhizal Bryophytes in Rock Crevices at Khanspur

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Abstract

The bryophytes in rock crevices at Khanspur were observed to be heavily VA mycorrhizal. Extramatrical vesicular infections were common comprising of simple and aggregated granulated vesicles surrounding the rhizoids and senescing leaves of mosses (*Funaria hygrometrica* and *Polytrichum commune*). Compartmented double-walled vesicles and simple vesicles were common in the thallus and rhizoids of liverworts (*Marchantia palmata*) while many types of vesicles occurred in the rhizoids, stem and leaves of mosses.

At the approach of winter, the aerial fronds of ferns and other plants in the rock crevices start senescing. The fine rhizoids of mosses and liverworts were observed penetrating the decaying aerial portions of *Adiantum capillus-veneris* L., making them heavily VA mycorrhizal. Vesicular and arbuscular infections were observed in the stem and fronds of *Adiantum*.

Introduction

VA mycorrhizal infections have been observed in mosses by Rabatin (1980) and in senescent leaves of *Funaria hygrometrica* (Park & Linderman, 1980). although it must be a symbiotic relationship by which liverworts and mosses absorb water and nutrients, their function in the naturally existing forest ecosystem has not yet been investigated.

Earlier, it has been observed that the strongly mycorrhizal roots of a host plant can make a non-host mycorrhizal (Hirrel et al., 1978). Strongly mycorrhizal substrate roots can even make non-root or dead plant portions mycorrhizal (Firdaus & Iqbal. 1988a,b). *Coprosoma* seedlings became infected from mycorrhizal bryophytes in a New Zealand Forest (Johnson, 1977). The present report provides evidence that strongly *mycorrhizal rhizoids* of mosses and liverworts can induce *mycorrhizal* infections in dead and decaying non-root plant portions like fronds of *Adiantum* by penetration into such plant material.

Materials and Methods

Bryophytes and senescing ferns were sampled from rock crevices in rocky walls at Khanspur during October, 1987. The decaying plants of *Adiantum capillus-veneris* which showed penetration by rhizoids of bryophytes were carefully separated out.

The bryophytes were separated out from the fronds of *Adiantum* and both were processed by the modified procedure of Phillips and Hayman (1970). Since the leaves of *Adiantum* were fragile, only 2% KOH was used for clearing and mild H_2O_2 solution was used for bleaching before staining them in 0.05% Trypan Blue prepared in lactophenol.

Results

The liverworts and mosses in the rock crevices were highly infected with VA mycorrhizal fungi. The thallus of liverworts was totally infected with multiple vesicular infections consisting of aggregated granular vesicles (Plate 1A, B) simple vesicles (Plate 1C) and double-walled compartemented vesicles (Plate 1C, D). The rhizoids also contained elongated vesicles (Plate 2A). The mosses were also infected by vesicles which showed penetration in stem and leaf cells and also appresoria and peg-like thickenings of mycelium (Plate 2B). Extramatrical web of hyphae bearing extramatrical vesicles (Plate 2C) and endogonaceous spores (Plate 2D) was very common around the thalli of mosses.

At the same place in the rock crevices an unidentified mass of organic matter consisting of decaying plants and roots was observed. In the decaying matter the decaying leaves and stems of *Adiantum* could be easily identified. The peculiar thing was the penetration of rhizoids and thalli of liverworts and mosses. In addition to the VA mycorrhizal infection in associated liverworts and mosses, infections were observed in decaying stem

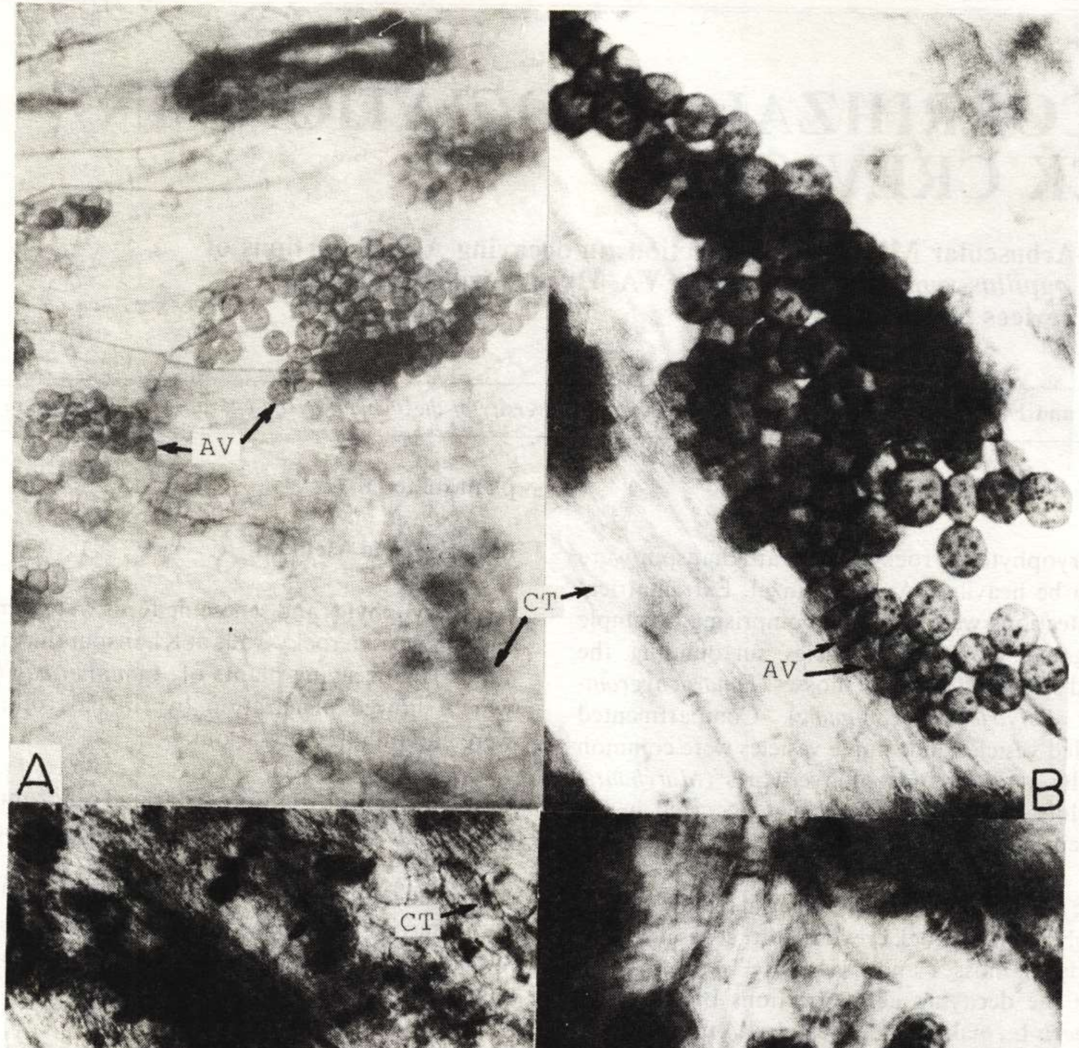

Plate 1A: Aggregated vesicles of *Glomus clarum* in thallus of *Marchantia sp.*
1B: Vesicles enlarged to show darkly stained granular structures.
1C: Part of the thallus of *Marchantia sp.* showing multiple vesicular infections (simple and compartmented doublewalled vesicles).
1D: Compartmented double-walled vesicles enlarged.

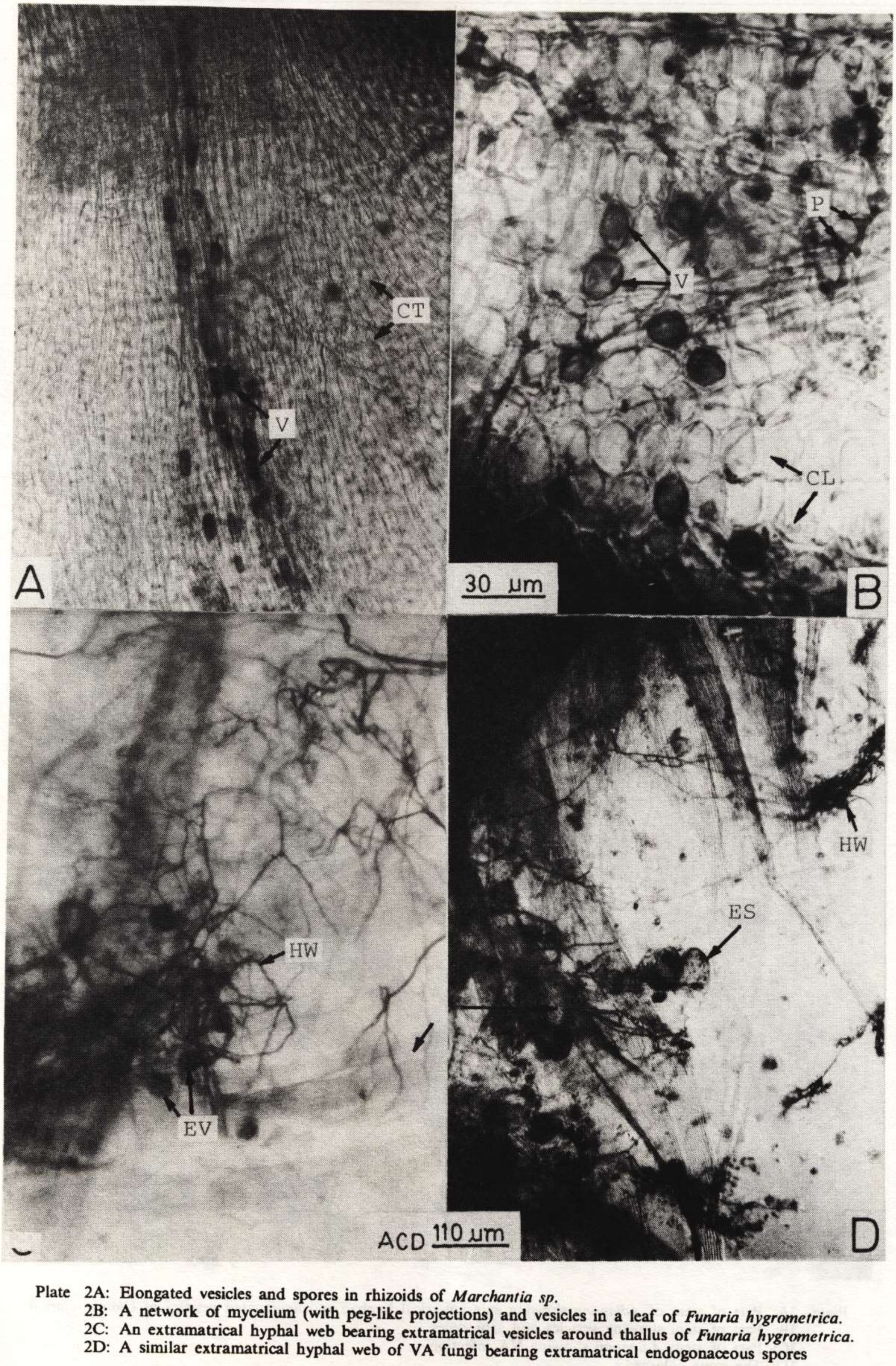

Plate 2A: Elongated vesicles and spores in rhizoids of *Marchantia sp.*
2B: A network of mycelium (with peg-like projections) and vesicles in a leaf of *Funaria hygrometrica.*
2C: An extramatrical hyphal web bearing extramatrical vesicles around thallus of *Funaria hygrometrica.*
2D: A similar extramatrical hyphal web of VA fungi bearing extramatrical endogonaceous spores

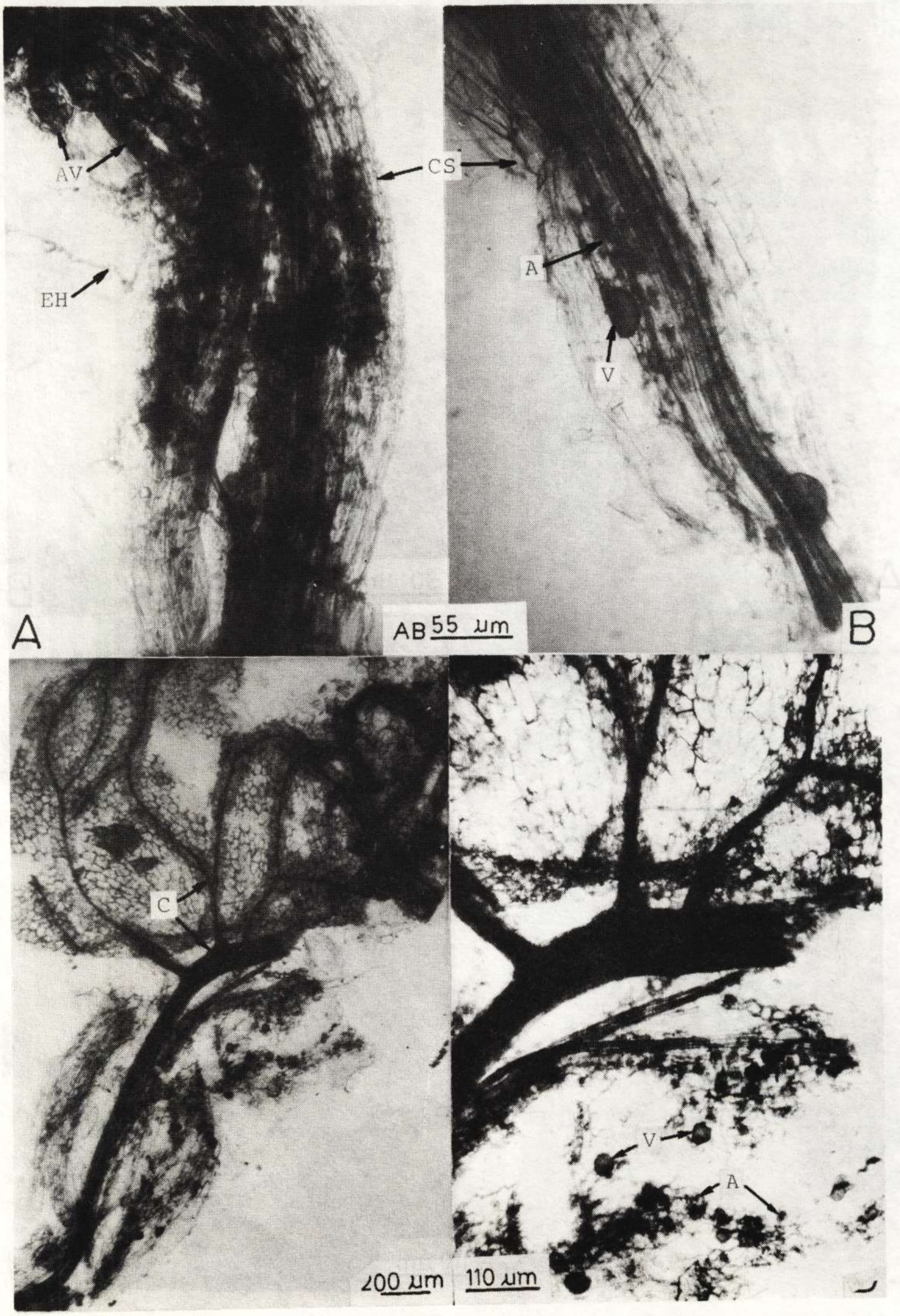

Plate 3A: Part of stem of *Adiantum* showing exteramatrical hyphae and aggregated vesicles of *Glomus clarum*.
3B: Part of stem showing vesicles and arbuscules
3C: Part of stem *Adiantum* showing VA infection.
3D: The same enlarged.

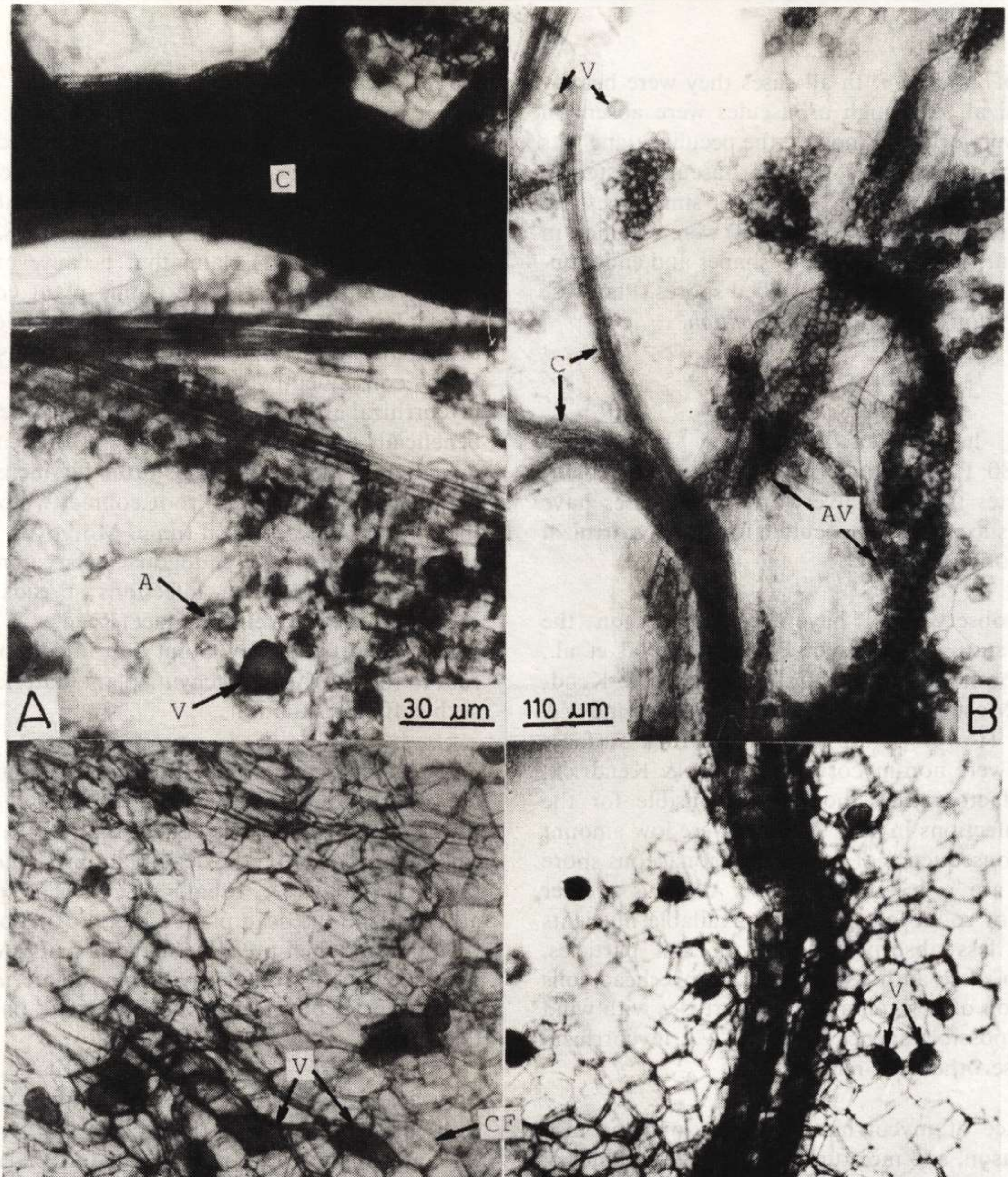

Plate 4A: The same enlarged to show vesicles and arbuscules.
4B: Multiple vesicular infections in a decaying frond of *Adiantum*.
4C: Vesicles of various shapes and sizes in a frond of *Adiantum*.
4D: Vesicles and spores in frond.

Key AV = aggregated vesicles; CT = cells of thallus (*Marchantia* sp.); V = vesicles; CV = compartmented vesicles; P = peg-like projections of mycelium; HW = hyphal web of VAM fungi; EV = extramatrical vesicles; ES = endogonaceous spores; SF = sporangium of fern (*Adiantum* sp.); LM = leaves of moss (*Funaria* sp.); CS = conducting strand; CS = cortical cells of stem; CL = cells of leaf; A = arbuscules; DS = Double-walled spores.

and fronds of *Adiantum*. In all cases they were heavily VA mycorrhizal. Although arbuscules were absent in associated liverworts and mosses, the peculiar tying was the occurrence of vesicles as well as arbuscules in stem & fronds. Aggregated vesicles (Plate 3A) simple vesicles and arbuscules (Plate 3B, C, D; 4A, B) were common in decaying stem. Vesicles of various shapes and endogonaceous spores including double-walled spores (Plate 4C, D) were common in fronds of *Adiantum*.

Discussion

Mosses have been found VA mycorrhizal (Rabatin, 1980; Park & Linderman, 1980). VA mycorrhizal bryophytes including liverworts and mosses have proved to be successful as in oculum for VA mycorrhizal fungi (Johnson, 1977).

Some observations have been made on the mycorrhizal status of ferns in Pakistan (Iqbal et al., 1981) and Southern Ontario, Canada (Berch & Kendrick, 1982). Most species of *Adiantum* were found VA mycorrhizal. However, ferns from bare rock surfaces and crevices were non-mycorrhizal (Berch & Kendrick, 1982). The factors they thought responsible for the absence of infections in such habitats were low amount of soil as a consequence of which endogonaceous spore populations are reduced. Moreover, there is greater competition of roots for space and available nutrients which show less absorption onto the soil particles. According to these authors runoff from overhead soils and circulation of dry soil and root particles with wind are the only possible agencies to carry VA mycorrhizal fungi to these otherwise remote sites.

Incidence of mycorrhizal colonisation may also vary with season, soil moisture availability (Staffeldt & Vogt, 1975) habitat (Miler, 1979) and composition of a plant community (Hirrel et al.,) 1978; Read *et al.*, 1976). In the present study a mechanism for the retension of in oculum of VA mycorrhizl fungi was observed in the rock crevices. The bryophytes were taken from the crevices during the beginning of November when the winter season is at hand. The aerial parts of rhizomatous plants start decaying before they are embedded under the snow. After the snow melts in March and April the rhizomes sprout up again. The same type of yearly changes occur in plants in rock crevices. In the alpine plant communities, despite low soil temperature, extensive new root growth is occurring in a very short period during and after disappearance of snow cover (Read & Haselwandter, 1981). In this survey, the transference of VA infections from the bryophytes to decaying ferns was observed. Thus on renewal of growth activity, after the snow melts, the newly elongating roots get a ready made inoculum.

Most obviously, VA mycorrhizal infections in the newly formed rock crevices arise from the endogonaceous spores present in the soil or by the possible methods as described by Berch and Kendrick (1982). Read & Haselwandter (1981) claim that because of low mean annual temperatures in the alpine plant communities, rates of mineralisation of nutrients are slow and the availability of the important major nutrients like N and P is consequently restricted. In these situations, mycorrhizal associations if present would be most likely beneficial to plant communities. The intensity of infection in such situations is probably increased by the high incidence of root to root contact which facilitates the spread of mycorrhizal fungi. Moreover, the extremely low number of endogonaceous spores in soils supports the view that infections spreads largely by roots to root or mycelial contact (Read et al., 1976). Our study supports the view point that infection spreads by root to root or root to decaying plant material contact in such difficult situations.

An important observation in the present study was the occurrence of arbuscules in the decaying stems and fronds of *Adiantum*. The benefit that the VA mycorrhizal fungi derive from the dead plant material is yet to be known (Firdaus & Iqbal, 1987b). The presence of arbuscules in the dead plant material is reported for the first time and their presence suggests that VAM fungi do get some benefit from decaying plant material especially when transfer of infections to such plant parts starts to take place .

The presence of a large number of epiphytic liverworts and mosses in the rock crevices with multiple VA infections is very meaningful for VA mycorrhizal fungi. Their ability to induce AV mycorrhizal infections in non-root portions of plants at the end of growing season as evidenced by their penetration, enlightens their active role in rock crevices.

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