USE OF VESICULAR - ARBUSCULAR MYCORRHIZA (VAM) AS BIOFERTILIZER FOR HORTICULTURAL PLANTS IN DEVELOPING COUNTRIES

S.B. SULLIA, DEPARTMENT OF BOTANY, BANGALORE UNIVERSITY, BANGALORE 560 056.

1. INTRODUCTION

Mycorrhiza is the product of an association between a fungus and plant root. Vesicular-arbuscular mycorrhiza (VAM) is formed by the symbiotic association between certain phycomycetous fungi and angiosperm roots. The fungus colonizes the root cortex forming a mycelial network and characteristic vesicles (bladder-like structures) and arbuscules (branched finger-like hyphae). The mycelia are aseptate or septate ramifying intercellularly thus causing little damage to tissues. The arbuscules are the most characteristic structures, formed intracellularly and probably having an absorptive function. The vesicles are terminal swellings of hyphae formed inter and intracellularly having a storage function. There are six genera of fungi belonging to Endogonaceae which have been shown to form mycorrhizal associations: Glomus, Gigaspora, Acaulospora, Entrophospora, Sclerocystis and Scutellospora. These are mainly identified by their characteristic spores and sporocarps which are formed mostly in the soil surrounding the roots and rarely inside the roots. The identification of VAM fungi directly from roots has been difficult. One of the striking features of VAM fungi is their very wide host range which includes angiosperm species belonging to almost all the families. Even the roots of some aquatic plants are colonized by VAM fungi.

2. WHAT IS SPECIAL ABOUT VAM?

Though the mycorrhizae have been known for a century now, mycorrhizal research gained impetus only recently with the demonstration that VA-mycorrhizal fungi increase the efficiency of plants in phosphate utilization (Baylis, 1967; Gray and Gerdemann, 1969; Mosse et al., 1973). Since the 1970s, agricultural scientists have been trying to use VAM fungi for better utilization of phosphorus by plants in poorly endowed soils. The VAM mycelia are capable of extending the region of absorption reaching away from the phosphorus depletion zone which forms around absorbing roots. These fungi also make available to plants insoluble phosphates such as rock phosphate.

It has been shown in recent years that the VAM fungi confer on host plants several other benefits in addition to enhancement of phosphate uptake. These benefits are biological control of root diseases (Shonbeck, 1979), nodulation and nitrogen fixation in legumes (Crush, 1974; Mosse et al., 1976) hormone production (Schultz et al.,

1979; Allen et al., 1980), drought resistance (Powell and Bagyaraj, 1984) and increased uptake of several elements such as N, K, Zn, Mg, Ca and S (Gray and Gerdemann, 1979; Hayman, 1982). VA mycorrhizae have, therefore, found use in agriculture, horticulture afforestation and reclamation of deserts.

3. SOIL MICROORGANISM AND VAM FUNGI

Interactions between the general soil microbiota and VAM fungi have been studied extensively (reviewed: Bagyaraj, 1984). More recent works have shown suppression of soil-borne plant pathogens due to prior inoculation of plants with VAM fungi especially with reference to wilt and root rot pathogens. Significant reduction of infection by Rhizoctonia solani due to mycorrhizal inoculations has been shown in several hosts. Seed pelleting with sporocarps of the VAM fungi gave maximum protective effect against Rhizoctonia solani. Control of Aphanomyces euteiches, the root rot pathogen of peas has been shown. However, most of the studies on biological control of root diseases have been conducted under controlled conditions in glasshouses and the results obtained may not be necessarily reproducible under field conditions.

4. INOCULUM PRODUCTION

The mass production of VAM inoculum for commercial purpose is beset with practical problems that are yet to be fully overcome. One of the major problems is that of growing VAM fungi in axenic cultures. These fungi need host roots for growth and remain as dormant spores in the absence of the host. The axenic culture of Glomus aggregatum has been reported recently (Janardhanan et al., 1990) but the method is tedious and the growth and sporulation in the medium is poor. Initial growth of the fungus on the medium requires stimulation from the roots of axenically cultured plants of the host palmarosa (Cymbopogon martinii var. motia). With our present knowledge it may be safer to consider VAM fungi as obligate symbionts and this fact has restricted researches on the genetics and molecular biology of this group of fungi. The existing methods of raising bulk inoculum are based on (i) plants grown on solid substrates, (ii) plants grown in hydroponic cultures and (iii) root organ cultures in agar media.

4.1. Inoculum on plants grown on solid substrates

Solid substrates for raising plants used till recently include soil, sand, soil-sand mixture and synthetic inert materials such as vermiculite, perlite and soilrite. Vermiculite has been most useful because of its layered structure which favours sporulation of VAM fungi (Mosse, 1990). It is necessary to begin inoculum production

with a single species free from contaminants. Spores obtained from soil, identified and surface-sterilized with 2% chloramine T and 200 mg L streptomycin or 2% sodium hypochlorite have been used as initial inoculum. Sterilization of the solid substrate is done (i) by autoclaving at 15 psi for one hour, (ii) by steaming 2 to 3 times (iii) by fumigation with methyl bromide and (iv) by gamma irradiation. Nutrient media provided in the substrate should not contain large amounts of available phosphorus which may suppress colonization of the fungus. However, the medium should be fertile enough to allow the growth of the plant (Menge, 1984). A wide variety of host plants have been used for inoculum production, e.g., citrus, sorghum, coleus, onion, pepper, corn, clover, groundnut, cotton and guinea grass. Grasses have been most useful because of the plentiful adventitious roots produced at lesser depths in the substrate.

Several new substrates have been recently introduced for VAM inoculum production and it is claimed that these are superior to vermiculite or perlite. "Calcined montmorillonite clay" marketed under the trade name "Turface" proved to be a good substrate for plant growth and abundant mycorrhizal colonization. A more recent introduction is the "Light aggregated clay particles (LECA)", also called "Blanton". The advantage of these clay based substrates is that the physical structure of the porous material and the absorptive capacity of the clay function as a slow release mechanism for nutrients particularly phosphorus (Mosse, 1990).

4.2 Nutrient Flow cultures

Circulating hydroponic cultures have been used for inoculum production eliminating the necessity of soil or other solid substrates. Inoculum in this case becomes purely root based. In nutrient flow technique (NFT) plant roots grow between plastic sheets or capillary matting. A weak nutrient solution is pumped into the inclined plane where it flows down over the roots as a film and into a container from where it is recycled. Root mats several centimetres thick build up under such conditions. By this method, root mats of beans (Phaseolus vulgaris) containing up to 60% mycorrhizal roots with attached floating films of mycelium, spores and sporocarps have been obtained.

4.3 Root Organ Cultures

VAM colonization of root organ cultures of clover in modified White's medium was reported. However, the method did not hold promise for large scale inoculum production as the root growth remained relatively restricted. By using roots of Convolvulus sepium transformed with Ri-T-DNA (root inducing plasmid genes), carried by Agrobacterium rhizogenes, the growth potential of roots greatly increased (Mosse, 1990).

5. CONCLUSIONS

Introduction of new substrates such as expanded clay aggregates has made the inoculum packets less bulky and lighter reducing transport costs. If root organ culture method is further improved using genetic engineering techniques, there is hope for still better inoculum package that could also be trusted for its purity. Use of VAM inoculum may minimize fertilizer inputs. though VAM incolum is claimed to be a biofertilizer cum biopesticide, its potential as a biopesticide is limited to the containment of root pthogens, and not foliar pathogens. The protective effect of VAM against virus and bacterial diseases has not been proved. Exaggerated claims on the benefits of VAM, therefore, may be misleading and may divert the attention of the users from the real scope of VAM use.

6. REFERENCES

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