Diversity of AM Fungi and Their Exploitation for Disease Management in Horticultural Crops in NW Himalayan Region

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Abstract

Mycorrhiza, symbiotic association between fungi and roots of plants, supplies its plant partner with mineral nutrients and protects against soil-borne pathogens, whereas plant feeds fungus partner with photosynthates. Amongst mycorrhizae, arbuscular-mycorrhizae (AM) are common form occurring in association with most of plant species of different ecological regions. These fungi have been reported in thousand genera of plants including crops, shrubs and trees. 80 to 90 % of plants ranging from bryophytes to flowering plants have dynamic association of AM fungi. Apple, most important horticultural crop of north-western Himalayan region, is mycorrhizal dependent. In the region, AM fungi related to four genera viz., *Glomus, Acaulospora, Gigaspora* and *Scutellospora* were isolated. Frequency of occurrence was maximum (80%) in *Glomus* spp. followed by *Acaulorpora* spp. and *Gigarpora* spp. i.e. 10 and 9 % while minimum frequency of occurrence was in case of *Scutellospora* sp (1%). In *Glomus*, different species observed were identified to be *G. fasciculatum, G. mosseae, G. macrocarpum, G. heterosporum, G. epigaeum* and *G. clarum* amongst these maximum frequency of occurance was that of *G. fasciculatum* followed by *G. mosseae* and *G. macrocarpum*. Apple is affected by various soil borne diseases like root rot and replant disease. Recent reports have indicated that host plant inoculated with indigenous AM fungi increased tolerance to a wide range of root diseases in apple. Infection with mycorrhizal fungi elicited a resistance mechanism in inoculated plant which suppressed subsequent infection by fungal pathogens. Inoculation of apple root stock with a potent AM fungal isolate increased growth in apple replant disease (ARD) soil. Growth of apple root stock in ARD soil was more when AM fungi were inoculated along with antagonists like, *Trichoderma* spp. These indigenous AM fungi have potential of improving plant growth and suppressing soil borne pathogens in most of horticultural crops particularly apple.

Keywords: AM fungi, apple, disease, diversity, Himalayan region, horticultural crops

1. Introduction

The term mycorrhiza is derived from Greek words 'mycus' means fungus and 'rhizus' means root which refers to the symbiotic association between fungi and roots of many plant species. Mycorrhizae are described as the ultimate in reciprocal parasitism (symbiosis). The fungus supplies the higher plant partner with mineral nutrients like phosphorus (P) and protects the root against different soil-borne pathogens causing wilts and root rots whereas the plant feeds the fungus partner with the photosynthates.

Mycorrhizae are found to be associated with approximately 92 % of plant families. It means that almost all the higher plants have mycorrhizal association. Initially, mycorrhizae were distinguished into two main types of viz., Ectomycorrhiza and Endomycorrhiza. Presently seven different types of mycorrhizae are known:

i) Ectomycorrhiza,
ii) Endomycorrhiza,
iii) Arbutoid mycorrhiza,
iv) Monotropoid mycorrhiza,
v) Orchidaceous mycorrhiza,
vi) Ericoid mycorrhiza, and
vii) Ectendomycorrhiza.

Endomycorrhizae also known as arbuscular-mycorrhizae (AM) are the most common form of mycorrhiza occurring in association of most of the plant species growing in different ecological regions. AM are the type of endomycorrhiza in which the fungus penetrates cortical cell wall of the host. The hypha grows both inter as well intracellularly into the cortical cell by penetrating the wall and causing invagination of the plasma membrane. These produce coil, highly branched haustorium like structure called arbuscule, which swells at the end producing roundish bodies called sporangioles. Arbuscules are known to be the site for nutrient exchange. In some cases vesicles which are globose sac like structures are formed as a result of intercalary or terminal swellings of the fungal hyphae. Vesicles contain high concentration of triglycerides at maturity and are thought to be storage and survival organs (Bharat and Mehta, 2013).

There is no specificity between plants and fungus in AM fungi. However, it is important to distinguish between specificity ability to colonize effectiveness (plant response to colonization) and infectiveness (ability to colonize) because AM are widely different in these abilities depending on the environment. They do have wide host range, and are capable of long term relationship with many different plants. It is well known that AM fungi are not host specific. However, the degree of AM colonization and its effect can differ with different host-endophytic combinations for example plants like maize and soybean appear to be more mycorrhizal than crops like potato and bean. However, AM fungi do not normally exhibit any species or strain specificity to the particular host plant except perhaps some host preference. The same plant may be infected by more than two species at a time. Extent to which a species or variety of mycorrhizal fungi colonize is determined by background of the host plant or kind of root exudates of host plant or other barriers to AM infection in tree crops.

2. Diversity of AM Fungi

AM Fungi are placed in four orders, i.e., Archaeosporales, Diversisporales, Glomerales, and Paraglomerales, comprising of 10 families and 13 genera, belonging to the class Glomeromycetes of the phylum Glomeromycota These fungi have been reported in thousand genera of plants covering 200 families including agricultural and horticultural crops, shrubs and trees. 80 to 90 per cent of plants ranging from bryophytes to flowering plants have dynamic association of AM fungi. There are 120 species of AM fungi on 300 thousand receptive host plants.

The soil collected from various locations from apple growing regions yielded different type of spores after wet sieving and decanting. The spores thus isolated were characterized on the basis of their shape, size, wall structure etc. In all AM fungi related to four genera viz., *Glomus, Acaulospora, Gigaspora* and *Scutellospora* were isolated. The frequency of occurrence was maximum (80%) in *Glomus* spp. followed by *Acaulorpora* spp. and *Gigarpora* spp. i.e. 10 and 9 per cent while the minimum frequency of occurrence was in case of *Scutellospora* sp (1%). In *Glomus*, different species observed were identified to be *G. fasciculatum, G. mosseae, G. macrocarpum, G. heterosporum, G. epigaeum* and *G. clarum* amongst these the maximum frequency of occurance was that of *G. fasciculatum* followed by *G. mosseae* and *G. macrocarpum* (Bharat and Bhardwaj, 2002; Mehta and Bharat, 2011; Mehta and Bharat, 2013).

In the rhizosphere of cherry the population of *Glomus* spp. *viz., G. macrocarpum, G. mosseae, G. constrictum*, *G. fasciculatum* and *G. clarum* was more as compared to other genera. The frequency of occurrence of spores followed the trend as *Glomus* (75%), *Acaulospora* (10%) and *Scutellospora* (10%) and *Gigaspora* (5%) (Kirti et al, 2016).

3. Disease Management in Horticultural Crops

In north-western Himalayan region apple is the most important fruit crop grown commercially especially in Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Apple crop is affected by various soil borne diseases like root rot and replant disease. A wide variety of reports in recent years with experimental evidences have indicated that a host plant previously inoculated with a AM fungal symbiont increased tolerance to a wide range of root diseases in apple plants.

Inoculation of host plants with indigenous AM fungi has been shown to exert probiotic influence on the management of these diseases. It is speculated that infection with mycorrhizal fungi elicits a resistance mechanism by the host which may suppress the subsequent infection by fungal pathogens. Disease caused by soil borne fungi can be influenced by the formation of AM fungi in the root system. In general, mycorrhizal plants suffer less damage by the pathogens, incidence of diseases is decreased and pathogen development is inhibited (Bharat and Mehta, 2013). Bharat and Bhardwaj (2001) while studying the interactions between AM fungi and root rot pathogen *Dematophora necatrix* on apple seedlings found that the apple seedlings previously inoculated with local isolate of AM fungi (*Glomus* spp.) suffered less root rot as compared to the seedlings which were not inoculated with AM fungi. The mycorrhiza inoculated seedlings also exhibited increased growth as compared to un-inoculated ones. Mehta and Bharat (2013) have observed that inoculation of apple seedling root stock with a potent AM fungal isolate resulted in increased growth of the seedlings viz., plant height, stem diameter, internodal length, leaf area, shoot/ root fresh and dry weight of inoculated seedlings as compared to un-inoculated seedlings when grown in apple replant disease (ARD) soil. Amongst various AMF isolates, inoculation of seedlings with AMF isolate AMFG-1showed highest growth followed by that inoculated with other isolates like AMFN-1 and AMFS-1. The height and stem girth of apple seedlings inoculated with AMF isolate AMFG-1 was statistically better than other isolates and un-inoculated ones (Bharat, 2017).

These AM fungi have potential to improve growth and suppress soil borne pathogens in most of crops particularly grown in nutrient deficient soils under organic agriculture. It is important to coordinate comprehensive research on disease control mechanisms with AM fungi. Studies are needed to identify the compatibility of AM with others management practices.

The AM fungi have also shown compatibility with fungal biological control agents and antagonists like *Trichoderma* spp. Artificial inoculation of newly planted apple rootstock with consortia of indigenous AM fungi (*Glomus* spp., *Acaulospora* spp., *Gigaspora* spp. and *Scutellospora* spp.)

and soil application of formulation of biological control agent (*Trichoderma viride*) during transplanting in replant diseased soil proved to be a good management practice for apple replant problem (Bharat, 2013). The growth of apple root stock in replant disease soil was more when AM fungi were inoculated along with antagonists.

Commonly used fungicides like carbendazim have comparatively less effect on the association of AM fungi with apple plants (Bharat, 2011). Such fungicides can therefore be used in integrated manner with these symbionts in the areas where the use of such fungicides is unavoidable due to high disease pressure.

Efforts to mass multiply AM fungi in large quantity using lighter carrier material should be intensified. Molecular techniques like polymerase chain reaction (PCR) should be standardized to identify mycorrhizal colonization within the plant root using different species specific primers. Efforts to make AM fungi as a potent biological control agent for plant diseases caused by fungi, bacteria and nematodes should be done in fields. Possible role of AM fungi in biological control must be considered and exploited in plant breeding programmes aimed at selecting resistant cultivars. Efforts to use AM fungi in tissue culture so that tissue culture plants inoculated with AM fungi with more resistance to soil borne pathogens, temperature and any others stress factor can be produced.

4. Conclusion

Arbuscular-mycorrhizae are naturally occurring fungal symbionts in apple rhizosphere. Their association with roots increased tolerance to a wide range of root diseases in apple plants. The infection with mycorrhizal fungi elicits a resistance mechanism by the host which suppresses the subsequent infection by fungal pathogens. Plant inoculation with indigenous AM fungi exert a probiotic influence on the management of these diseases.

5. Further research

It is pertinent to coordinate comprehensive research on mass multiplication and disease control mechanisms of AM fungi. Field studies are needed to work out the compatibility of AM with others management practices so as to make AM fungi as a potent biological control agent for horticultural crop diseases caused by fungi, bacteria and nematodes.

6. References

Bharat N.K., 2017. Evaluation of components for integrated management of apple replant disease in Himachal Pradesh. Plant Disease Research 32(1), 15–21.

Bharat, N.K., 2011. Effect of commonly used fungicides on arbuscular-mycorrhizal association with apple roots. World Journal of Science and Technology 1(6), 61-64.

Bharat, N.K ., Bhardwaj, L.N., 2002. Association of arbuscular-mycorrhizal fungi with apple in Himachal Pradesh. Plant Disease Research 17, 326–328.

Bharat, N.K., 2013. Effect of indigenous AM fungi and BCAs on health of apple seedlings grown in replant disease soil. Indian Phytopathology 66(4), 381–386.

Bharat, N.K., Bhardwaj, L.N., 2001. Interaction between VA-mycorrhizal fungi and *Dematophora necatrix* and their effect on health of apple seedlings. Indian Journal of Plant Pathology 19, 47–51.

Bharat, N.K., Mehta, P., 2013. AM fungi and their role in plant disease management. Pp. 141–157. *In*: Approaches and Trends in Plant Disease Management (eds. Gupta SK and Sharma M). Scientific Publishers (India), 429.

Kirti, S., Sharma, R., Dipta, B., Pawar, R., Kaushal, R., Bharat, N.K., 2016. Status of arbuscular mycorrhizae associated with rhizosphere of sweet cherry (*Prunus avium*) in high hills temperate zone of Himachal Pradesh. Indian Phytopathology 69(3), 286–289.

Mehta, P., Bharat, N.K., 2011. Population dynamics and characterization of arbuscular-mycorrhizal fungi associated with apple plantations. Journal of Mycology and Plant Pathology 41(2), 255–258.

Mehta, P., Bharat, N.K., 2013. Arbuscular-mycorrhizal associations with apple plantations of different age groups in Himachal Pradesh. Indian Phytopathology 66(1), 88–92.

Mehta, P., Bharat, N.K., 2013. Effect of indigenous arbuscular-mycorrhiza (*Glomus* spp.) on apple (*Malus domestica*) seedlings grown in replant disease soil. Indian Journal of Agricultural Sciences 83, 61–66.