MYCORRHIZAE AND CONTAINER SEEDLINGS[1]

by B. Zak

Mycorrhizae do indeed benefit the tree. They increase availability and absorption of nutrients, especially phosphorus. Recent studies have shown that ectomycorrhizae also protect fine absorbing roots from pathogen attack. There is also some evidence that mycorrhizae may resist attack by root aphids and nematodes and even protect the plant from phytotoxins produced by soil microorganisms. Under natural conditions, the tree would not be able to survive without mycorrhizae.

Seedlings can, however, be grown quite satisfactorily without mycorrhizae provided that adequate nutrients are supplied and that pathogens are controlled. Thus, nonmycorrhizal seedlings are successfully raised today both in fumigated and fertilized beds and with intensive culture in containers.

However, if we find the right fungi and develop successful and economical inoculation techniques, it may be desirable and advantageous to use mycorrhizae from the beginning to benefit the container-growing stage. We might thus achieve biological control of root pathogens, and we might save enough in fertilizer costs to offset the expense of inoculation.

Actually, the greatest need for mycorrhizae is when the seedling is outplanted, not during the container-growing phase. The nonmycorrhizal seedling planted in a forest area will normally develop mycorrhizae as new roots emerge; but depending on soil moisture and temperature, this may require several months. In the meantime, intake of water and nutrients may be deficient and nonmycorrhizal roots may be invaded by damaging fungi.

The nonmycorrhizal seedling planted on a site devoid of mycorrizal fungi, such as a mining spoil or an area long treeless or never forested, will fare even worse. It will be without mycorrhizae for a longer period until infection occurs from airborne spores. If it survives, it will remain severely stunted until an adequate mycorrhizal root system is developed.

On the other hand, the mycorrhizal seedling, especially a container seedling with an intact, undamaged root system, will be able to function soon after planting. Its mycorrhizal roots will be better able to absorb water and nutrients from the soil, they will be more drought resistant, and they will resist attack by pathogens. The result should be quicker establishment and enhanced survival, especially on more difficult sites.

The fungi which form mycorrhizae with conifers are many and varied. For example, it is estimated that at least 200 different species form ectomycorrhizae with Douglas fir in the Pacific Northwest. Some fungi may benefit the tree more than others. Some may aid absorption of nutrients better, and some may protect roots from pathogens more effectively than others. Certain fungi may stimulate formation of a larger and more fibrous root system which should aid establishment and survival of the seedling after outplanting. Some mycorrhizal fungi may also help containerized seedlings in another way. Those which form abundant mycelium and rhizomorphs bind together potting material and roots into a firm mass making the root plug easier to handle after removal from the container. It is likely that some may even be "super" mycorrhizal fungi, capable of significantly

1-3 months in a vermiculite-peatmoss medium wetted with nutrient solution. When ready, it is thoroughly leached with cold tap water to remove

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stimulating the growth of both nursery and container seedlings.

Inoculation of the container seedling with a selected specific fungus should not be regarded as providing a permanent infection, or one that will endure long after outplanting. Rather, the condition should be viewed as a temporary one intended primarily to aid establishment and survival of the seedling. On the typical cutover site as new roots grow out into the surrounding soil, they will also be infected by indigenous mycorrhizal fungi which may gradually dominate the root system as the tree becomes older. Exceptions may be sites which are completely devoid of mycorrhizal fungi; but even on these, as the trees develop and modify their soil environment, various mycorrhizal fungi may become established by airborne infections.

A major obstacle to practical inoculation of nursery and container stock, however, is the lack of easy and reliable inoculation methods. Although it is fairly simple to introduce nondescript mycorrhizal fungi into nursery soil or container mix by incorporating soil and humus from the forest, it is not easy to establish pure cultures of specific fungi.

If we wish to develop mycorrhizae to benefit the seedling growing stage as well as outplanting survival, inoculation can best be done when medium is prepared and containers are filled and seeded. Or, we may find it more advantageous to simply grow the seedlings as they are now, under intensive culture with heavy fertilization, and inoculate when they are possibly two-thirds grown to produce mycorrhizae solely for outplanting.

The most feasible method at present is to inoculate the growing medium, such as a 1:1 mixture of vermiculite and peatmoss, with vegetative mycelium just before filling and seeding containers. The potting mixture must first be treated to suppress existing microorganisms which otherwise would hinder or prevent establishment of the mycorrhizal fungus. Fumigation with methyl bromide and low temperature aerated steaming are two possible ways; autoclaving and high temperature steaming should be avoided because of the likelihood of toxin formation.

Inoculum is prepared by growing the fungus for unused nutrients, and then mixed with the potting material. A ratio of 1 part inoculum to 9 parts container mix, by volume, has been satisfactory for some fungi tested. After filling containers and sowing seed, normal container-growing procedure is followed, except that fertilization must be reduced or mycorrhizae will not develop. The optimum nutrient level for best inoculation and best growth of seedlings is not known but can be expected to vary with both fungus and tree species. And, application of fungicides, such as benomyl to control *Botrytis,* may have to be curtailed.

Actually, spores would be the ideal inoculum if only we knew how to use them. We could apply them directly to the seeded containers in a water suspension, possibly by the overhead irrigation system, and thus inoculate seedlings at any stage of development. Or, we might coat seeds with spores just before sowing — limited success has been reported with this method in nurseries. However, besides methods of inoculation, several important problems prevent the use of spores. Unlike vegetative mycelium, which can be grown at any time, spores are available only at certain times during the year — usually in the fall when sporophores are produced. And the occurrence and abundance of sporophores is erratic from year to year. Collection itself would be a major problem. A method of storing spores is needed to assure a ready supply of inoculum. Possibly freeze-drying may be the answer. And, too, we need to solve the problem of germinating spores of mycorrhizal fungi in the laboratory to check viability.

The all important question yet to be answered, however, is whether providing container seedlings with mycorrhizae will actually prove worthwhile — will it aid in the production of seedling stock, and will it significantly improve outplanting success? I think it will, and several container inoculation studies now underway may give us the answer to this question within the next 2 or 3 years.

Plant Pathologist
Forestry Sciences Laboratory
USDA Forest Service
Corvallis, Oregon