MYCORRHIZAE OF FOREST TREES IN NORTHEASTERN NURSERIES

Robert L. Anderson 1/

Mycorrhizal fungi are found in association with nearly all forest tree species. These specialized fungi are beneficial because they invade the root tissue and form a structure called "mycorrhizae." Mycorrhizae are very beneficial to tree growth and with certain species, such as pine, are indispensable for their growth.

Mycorrhizae benefit trees by increasing (a) the absorbing surface area of the feeder roots, (b) the availability of nutrients to the trees, (c) the resistance to certain diseases, and (d) the tolerance of the tree to stress. Trees lacking good mycorrhizal development normally have reduced vigor and may be highly susceptible to diseases.

Mycorrhizae can be classified into three types: ectomycorrhizae, endomycorrhizae and ectendomycorrhizae. Ectomycorrhizae are normally found on the roots of pine, spruce, fir, beech, eucalyptus, alder, oaks and hickories. Ectomycorrhizal feeder roots develop a swollen appearance and normally a forking habit in pine. The fungi are found growing in-between the root cells (Hartig Net) and around the outside of the feeder root (mantle). Endomycorrhizae are found in association with maple, sycamore, ash, sweetgum, walnut, cypress, and cedar. In this case, the fungus grows into the root cells and a mantle is lacking. Some species such as poplars may have ecto and endomycorrhizae. Ectendomycorrhizal fungi penetrate the root cells, grow between the cells and may or may not form a mantle. Very little is known about the host species except for conifer seedlings in northern nurseries.

Poor mycorrhizal development is normally not a problem under natural conditions. Mycorrhizal fungi are usually present in forest soils and the new seedling is invaded soon after establishment. However, nurseries, strip mines, prairie soils and other areas that may be abnormal for the tree species may pose problems. The solution to the problem ultimately lies in proper selection of the tree species and mycorrhizal fungus and possible alteration of controllable factors such as soil fertility.

In 1974, Northeastern Area, State and Private Forestry surveyed several forest tree nurseries in the Lake States to determine the amount of ectomycorrhizae on pine species, In most cases, the number of ectomycorrhizae was well below the desired level. All 2-0 and 3-0 pine seedlings had some ectomycorrhizae, but in several cases the average amount per seedling was only 10-15 percent. Because of these low levels, an extensive evaluation of two nurseries was started. The amount of ectomycorrhizae was determined on 1-0, 2-0, and 3-0 red pine at monthly intervals. Cultural practices such as fertilizer, pesticides, etc., were recorded for each sample area; and soils were analyzed for all major elements and many minor elements. Multiple regression analysis was run on all variables with the only apparent controlling soil factor being the cation exchange capacity. In other words, as the ability of the soil to hold nutrients decreased, the amount of ectomycorrhizae decreased. Root pruning also reduced the amount of ectomycorrhizae by about 10 percent per seedling since smaller roots were removed, but recovery was rapid. There was no difference in the amount of ectomycorrhizae present between transplants and seedlings except in one area where the transplants were placed in nonnursery soil. A 30 percent increase in ectomycorrhizae. occurred on those trees compared to transplants grown in nursery soil.

1/ Supervisory Pathologist, USDA Forest Service, Southeastern Area State and Private Forestry, FI&DM

In an attempt to increase the amount of ectomycorrhizae in nursery soils we inoculated red pine beds with Pisolithus tinctorius and Thelephora terrestria in 1976. It was about this time that Don Marx published a paper showing a relationship between available P_2O5 and ectomycorrhizae. Since the levels of available P_2O_5 in the soils at both nurseries exceeded 200 lbs/ac, cooperative experimental plots were established with North Central Forest Experiment Station to try to tie up the available P_2O_5. Inoculation with readily available ectomycorrhizal fungi (P. tinctorius, T. terrestris) reduction of $P2O_5$, with soil additives duff and soil exchange methods all failed to significantly increase the amount of ectomycorrhizae. However, in all cases (even with the P_2O_5 reduction) the amount of available P205 remained above 200 lbs/ac. It was about this time that we found some red pine beds at the nurseries containing high levels of ectomycorrhizae. A check of the soil fertility in those beds showed 110 lbs/ac available P_2O_5 as compared to over 200 lbs/ac in the low ectomycorrhizae areas. This provided evidence for the importance of P_2O_5 in the development or lack of development of ectomycorrhizae.

In 1977, a cooperative Southeastern and Northeastern Area ectomycorrhizae survey of the pine species at 30 eastern nurseries was started. The data analysis for the Northeastern nurseries is incomplete, but there are some tentative conclusions:

1. Some pine species tended to have more ectomycorrhizae

Highest	Virginia
	Shortleaf
	Loblolly
	Jack
	White
	Scotch
Lowest	Red

2. There seems to be a relationship between the amount of available P_2O_5 in the soil and the amount of ectomycorrhizae. The reduction in mycorrhizae seems to occur at 150 lbs/ac available P_2O_5 and above. (All soil analysis was done by the University of Minnesota.)

3. Species differ in their ectomycorrhizal development caused by high levels of P205,

Most Sensitive	Red
	Jack
	Pitch
	Austrian
	Scotch
	Shortleaf
	Virginia
	Loblolly
Least Sensitive	Eastern White

One question that kept coming up was "How many ectomycorrhizae are enough?" The answer seems to vary between 98 and 50 percent of the roots on each seedling. To gain additional information on this question, red, Virginia, shortleaf, and white pines were grouped at the Vallonia, Indiana Nursery by the percent of ectomycorrhizae (0-25, 26-50, 51-75 and 76-100) and then outplanted on a good site. The first year after outplanting, the outplanting index showed a 50 percent increase for the 76-100 percent category over the 0-25 percent with a linear relationship between. In one case

(shortleaf), survival alone was increased by 25 percent between the two categories. This outplanting project is being duplicated on severe low-quality sites in 1978. The data to date show that increased ectomycorrhizae mean increased growth and survival--the amount depending on the objective of the nursery or forest manager.

In conclusion, I would recommend the following approach to managing ectomycorrhizae on pine species in a forest tree nursery:

Survey the entire nursery (because of rotation this may take several years) and make a map showing percent ectomycorrhizae by area by tree species after the trees have gone dormant in the fall. Here is a suggested method:

1. Lift five seedlings every 30 feet down each pine bed. Attempt to get most of the roots but, do not be overconcerned if complete root systems are not obtained since the analysis is in percent. Wrap selected seedlings in a wet paper towel and place in labeled plastic bags.

2. Use a nursery bed map to identify each sampling point. Examine all feeder roots for the 5 seedlings when total time required will be less than 15 minutes. Classify each feeder root as ectomycorrhizal (as indicated by a swollen appearance of the feeder roots--normally black, white, or golden) or nonmycorrhizal. For trees requiring more than 15 minutes, use the following 10 percent sample method.

a. Cut all lateral roots from the main root; separate all lateral roots over 3" in length into individual sections.

b. Group the lateral roots into three categories by length.

c. Using strips of velcro (Material used to replace zippers or buttons) taped to a board stretch the lateral roots end to end on the bench starting with the longest and ending with the shortest.

d. Measure the total length of the roots. Divide into 100 equal units and cut each 10th unit from the root system.

e, Place the roots in water and count the number of ectomycorrhizal and nonmycorrhizal feeder-roots in each 10th unit sample,

f, Select one ectomycorrhizal and one nonectomycorrhizal feeder root from each sample and examine for Hartig Net through the microscope to insure that the mycorrhizae classification is accurate for the trees being examined.

3. Refrigerate tree roots (35°F) until examined or immediately ship by the fastest means to the place of analysis. The seedlings can be frozen (20°F) if analysis will be delayed more than 30 days after collecting.

4. Plot the percent ectomycorrhizae on the nursery map and identify problem areas.

5. Collect as many cultural data as possible on high and low areas to see if a common denominator such as soil fertility, fumigation or pesticide use or other cultural practices can be identified as a cause of low ectomycorrhizae,

6. If problem areas are identified - grow other species in those areas.

7. Attempt to eliminate the cause of the deficiencies and then repeat these procedures in the areas using the problem species whenever feasible.

8. Consider using commercially produced ectomycorrhizal fungi in fumigated non-problem areas when they become available.