The Practical Application of Specific Ectomycorrhizae in Forest Tree Nurseries

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Abstract.--Artificial inoculations of nursery seedbeds and container mixes with the ectomycorrhizal fungus Pisolithus tinctorius (Pt) have significantly increased growth and quality of nursery seedlings on a variety of conifer and some hardwood species in the United States and Canada. In related field outplantings, significant increases in tree survival and growth also have been observed on a wide variety of conifer species and planting sites when seedlings had abundant Pt ectomycorrhizae at planting. Machine application technique and several other methods for applying inoculum are practical for bare-root nurseries.

Additional keywords: Pisolithus tinctorius, commercial inoculum, conifer species, seedling quality, field survival and growth, inoculum applicator-nursery seeder, seedbed inoculation techniques.

For several years, researchers at the Institute for Mycorrhizal Research and Development (IMRD) in Athens, GA, and pest management specialists, in Asheville, NC, both with the USDA, Forest Service, have been conducting extensive mycorrhizal research and field application studies with a number of cooperating forestry agencies and companies. The practical application of one ectomycorrhizal fungus, Pisolithus tinctorius (Pt), in forest tree nurseries and field forestation has been the major emphasis of this work.

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The efficacies of different formulations of Pt vegetative inoculum produced by Abbott Laboratories, North Chicago, IL, and the IMRD have been evaluated on a variety of conifer and some hardwood seedling species in containers and bare-root nurseries. The results of the container studies have been published (Marx and others 1982), and those of the bare-root studies will be published as a FOREST SCIENCE Monograph in September 1984. Over 80 bare-root nursery tests were conducted in 38 states.

In the Northeast, nursery studies were done at Union State, IL (loblolly pine), Vallonia, IN (Virginia pine), Parson, WV (2-0, white pine), Marietta, OH (2-0, white pine), Potlatch, MN (2-0, red pine), NEPCO, WI (2-0, red pine), USDA-SCS, MI (2-0, red pine), and Tourney, MI (3-0, red pine). Results indicated that the commercial (Abbott) or the research (IMRD) vegetative inocula were only effective in producing Pt indices >50 in two of these eight nurseries (Vallonia and USDA-SCS). We have found in the South that pine seedlings must have a Pt index >50 before they can respond significantly to Pt ectomycorrhizae on routine reforestation sites. Cultural practices (i.e., high soil fertility) or winters in the Northeast may have been responsible for the low incidence of Pt ectomycorrhizae formed by our southern isolate of Pt in these other nurseries.

These northern nurseries had an average of 1094 ppm of total nitrogen in the soil at inoculation and sowing time. This level is nearly twice that encountered in more southern nurseries in which inoculations were routinely more effective. Our worst combination of soil fertility was encountered in 1983. Negative results were obtained in a northern nursery soil containing 2050 ppm of total N, 335 ppm of available P, and a pH of 7.2. This nursery section was

heavily limed and fertilized the previous two growing seasons for cover crops. Unfortunately these practices were unfavorable for pine seedling growth and ectomycorrhizal development. Anyone of these soil conditions can depress ectomycorrhizal development. In the container program, good results were obtained in Ontario, Canada, with jack pine both in the container phase and in the field. Seedlings grown at moderate container mix fertility developed abundant Pt ectomycorrhizae (Pt index >50) survived and grew faster after outplanting than larger seedlings from a higher fertility regime but which developed less (Pt index <50) Pt ectomycorrhizae in the nursery (Navratil and others 1981).

We are now testing various formulations of vegetative inoculum of Pt produced by Sylvan Spawn Laboratories, Worthington, PA. The 1984 tests are at the IMRD (bare-root and container, loblolly pine), Buckeye Cellulose Corp. Nursery, Perry, FL (slash pine), Taylor Nursery, Trenton, SC (loblolly pine), and Vallonia Nursery, IN. The last is a large-scale test of inoculation by machine on various tree species. Initial results look very promising.

The machine applicator of vegetative inoculum has performed well in various nurseries since the prototype model was designed in 1979 (Cordell and others 1981). This unique machine has produced practical, operational, bare-root seedbed inoculations using various commercial Pt vegetative inocula. To meet the needs of the wet Pt vegetative inoculum produced by Sylvan Spawn Laboratories, the inoculum applicator has been modified. A commercial applicator is available from R. A. Whitfield Forestry Manufacturing Company, Mableton, GA. This applicator is designed for either separate or simultaneous use with conventional nursery seeders.

An alternative Pt nursery inoculation technique is the spore-encapsulated seed treatment available on a custom order basis from International Tree Seed Company, Odenville, AL. Results obtained from several nursery tests on spore-encapsulated pine seeds during the past 4 years show considerable promise for the use of this technique in certain bare-root nurseries. International Tree Seed Company also produces Pt spore pellets that are currently being tested as yet another inoculation technique.

Forest tree nursery and field planting results continue to be encouraging for the effective, practical use of Pt ectomycorrhizae for custom seedling production. Overall, the best field results are obtained on adverse sites (i.e., coal spoils and poor reforestation sites) and with seedlings having Pt indices >50 at planting. Marginal or insignificant results are usually obtained on high quality reforestation sites or with seedlings with Pt indices <50. Nursery seedbed and container inoculations with Pt have repeatedly provided significant increases in seedling quality (nursery cull reduction), along with increased tree survival and growth in field plantings. The need for quality, tailored nursery seedlings for successful field forestation and disturbed site reclamation by Federal, State, industry, and private forest land managers is becoming increasingly apparent. Although seedling costs represent a minor portion of forestation expense (8 to 10%), seedling quality is the most significant factor in successful forestation. Consequently, the benefits of producing Pt ectomycorrhizal seedlings for selected forestation and reclamation sites should far exceed the costs when the total forestation and reclamation site expenses and potential tree survival and growth benefits considered.

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