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Comparison of Survival Enhancement Techniques for Outplanting on a Harsh Site in the Western Oregon Cascades[1]

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Bareroot seedlings of Douglas-fir (Pseudotsuga menziesii *(Mirb.) Franco) survived and grew better than container-grown stock planted on a droughty site in the western Cascade Mountains. Shading improved survival and growth, but field application of a solution of* Pisolithus tinctorius *basidiospores to the roots did not.* Tree Planters' Notes 37(4) :24-28; 1986.

Droughty sites on the west slope of the Oregon Cascade Range can be difficult to reforest after clearcutting, and intensified reforestation efforts are often needed. The use of container-grown seedlings, shading, or mycorrhizal inoculations may help regenerate these sites.

The performance of container-grown and bareroot seedling stock of Douglas-fir *Pseudotsuga menziesii* (Mirb.) Franco has been compared in field tests in Oregon (5,6,9,21). These studies suggest that container-grown stock survives better than bareroot stock on south-facing slopes or sites with rocky or shallow soil. Bareroot stock, which is generally larger, competes better than container stock with brush on wet sites or slopes with northern aspects.

Other studies have shown that shade can increase survival on droughty sites with southern exposures by reducing water stress and surface soil temperatures that may damage the seedling's cambium near the root collar (1,7,8,11,17,22).

The ectomycorrhizal fungus *Pisolithus tinctorius* (Pers.) Coker & Couch has demonstrated a tolerance to xeric, high-temperature sites with low fertility (12,13,16,23). Research to date has primarily involved inoculation of nursery seedlings (3,10,14,15,25). Applying basidiospores of mycorrhizal fungi to seedling roots in the field immediately before outplanting has logistic advantages, including ease of application and low costs.

The purpose of this experiment was to examine reforestation improvement methods for harsh sites by comparing survival and height growth of Douglas-fir seedlings after the first and third growing seasons. The following methods were compared: bareroot versus container-grown stock; shaded versus nonshaded seedlings; application of *Pisolithus tinctorius* basidiospores to seedling roots versus no application.

Methods and Materials

The experiment was installed in a clearcut on the west slope of the Cascade Mountains, 50 kilometers east of Sweet Home, Oregon. The site has a south-southwest aspect and an elevation of 1000 meters. It was logged in 1974 and broadcast-burned in 1976. Existing brush consisted of scattered, short (1.5-meter) clumps of rhododendron, salal, and vine maple. Adjacent forest communities are characterized by the *Tsuga heterophylla / Castanopsis chrysophylla* association (4). An intense broadcast burn; deer browsing; south-southwest exposure; and the shallow, skeletal soils had contributed to past reforestation failures.

We used a split block experimental design with six blocks. Each block of 400 seedlings had 100 trees in each of four treatments: (1) control, (2) shade, (3) spore application, and (4) shade and spore application. Within each treatment, 50 bareroot and 50 container-grown seedlings were installed in randomly arranged rows of 10 seedlings each. The data were analyzed

[1] This study was conducted in cooperation with the U.S. Department of Agriculture, Forest Service, Willamette National Forest, Sweet Home Ranger District, and the Pacific Northwest Forest and Range Experiment Station, Forest Sciences Laboratory, Corvallis, OR.

using multivariate analysis of variance (18, 20). Tukey's honestly significant difference test for multiple comparisons (19, 24) was used to compare treatment means.

Seed used for both the bareroot and container-grown seedlings was collected from the appropriate seed zone. Container trees were 1-0 stock grown in Ray Leach pine cells (65 cubic centimeters) at Beaver Creek Nursery near Philomath, Oregon, and were mostly nonmycorrhizal when spores were applied. The bareroot seedlings were 2-0 stock grown at Wind River Nursery near Carson, Washington, and had some mycorrhizae.

The basidiospores were provided by Dr. James Trappe of the Forestry Sciences Laboratory in Corvallis, Oregon. Sporocarps had been collected the previous fall, then dried and refrigerated. Spores were extracted March 1980 and stratified by soaking in cold water for a week. Bareroot seedlings were dipped in a spore solution slurry at the planting site and container seedlings were watered with the spore solution the day before. Spore concentration and water usage were such that the roots of each seedling, of both stock types, received about 1 milligram of spores.

Seedlings were hand planted in early May 1980 at a 3-foot spacing. Shading was provided with slitted, waxed cardboard rectangles (25 by 50 centimeters) slipped on and stapled to wooden lath that was staked on the southwest side of appropriate trees. Existing brush was cut by hand to eliminate natural shade. Deer browse was reduced with big-game repellent. Survival and leader growth were measured in October of 1980 and 1982.

Results and Discussion

There were no significant interactions between treatments and stock types in either the first or third year survival or leader growth analyses, so interpretation of the results was straightforward.

Bareroot stock survived and grew in height significantly (P = 0.01) better than container-grown stock the first year. After 3 years, survival still differed significantly (P = 0.05), but height growth did not (fig. 1).

Shaded seedlings survived significantly better after both the first (P = 0.01) and third (P = 0.05) growing seasons than did unshaded seedlings, regardless of spore application. Spore application did not significantly affect survival. Shaded-only seedlings had grown significantly (P = 0.05) more than spore-application-only seedlings after the first year. After 3 years no significant growth differences remained among the treatments (fig. 2).

Stereo-microscope (3 to 5 times magnification) examination of first- and third-year roots of selected seedlings showed no development of *Pisolithus tinctorius* mycorrhizae.

The poor performance of container-grown stock in our study conflicts with recent reports of better survival of container-grown seedlings on south-facing, droughty sites (6,9). Our container stock may have sustained root damage during a hard freeze the previous winter, as suggested by some early summer mortality. The smaller stems of the container-grown seedlings may also have been more easily damaged by rough handling during planting.

In spite of their small size, surviving container seedlings had as much leader growth as bareroot seedlings by the third year. Also, survival of bareroot stock declined by 26 percent between the first and third year, whereas container-grown seedling survival declined only 4 percent during the same period. Clearly, many factors influence the relative long-term benefits of using these stock types.

Our shading results concur with the literature, but survival differences were small (less than 20 percent). The first growing season was moist and cool, which possibly reduced the benefits of shade during a more typical growing season. As of 1980, the cost for materials and installation of artificial shade approached $180.00 per acre. Closer initial seedling spacing would have been more cost-effective on this site, given the first growing season's weather. Shade is justified when other treatments cannot reasonably ensure acceptable stocking levels.

Although planting nursery inoculated mycorrhizal seedlings may enhance survival, the application of *Pisolithus tinctorius* spores to a seedling's roots immediately preceding outplanting appears to be ineffective. Alvarez and Trappe (2) hypothesized that dusting roots with spores before outplanting was ineffective or harmful because a dense coating of hydrophobic spores would inhibit water uptake by the seedlings. This was not the case in our study, because spores were applied in a liquid suspension; however, the lack of *Pisolithus tinctorius* mycorrhizae formation argues against the effectiveness of this technique.

Project costs for field application of basidiospores to seedling

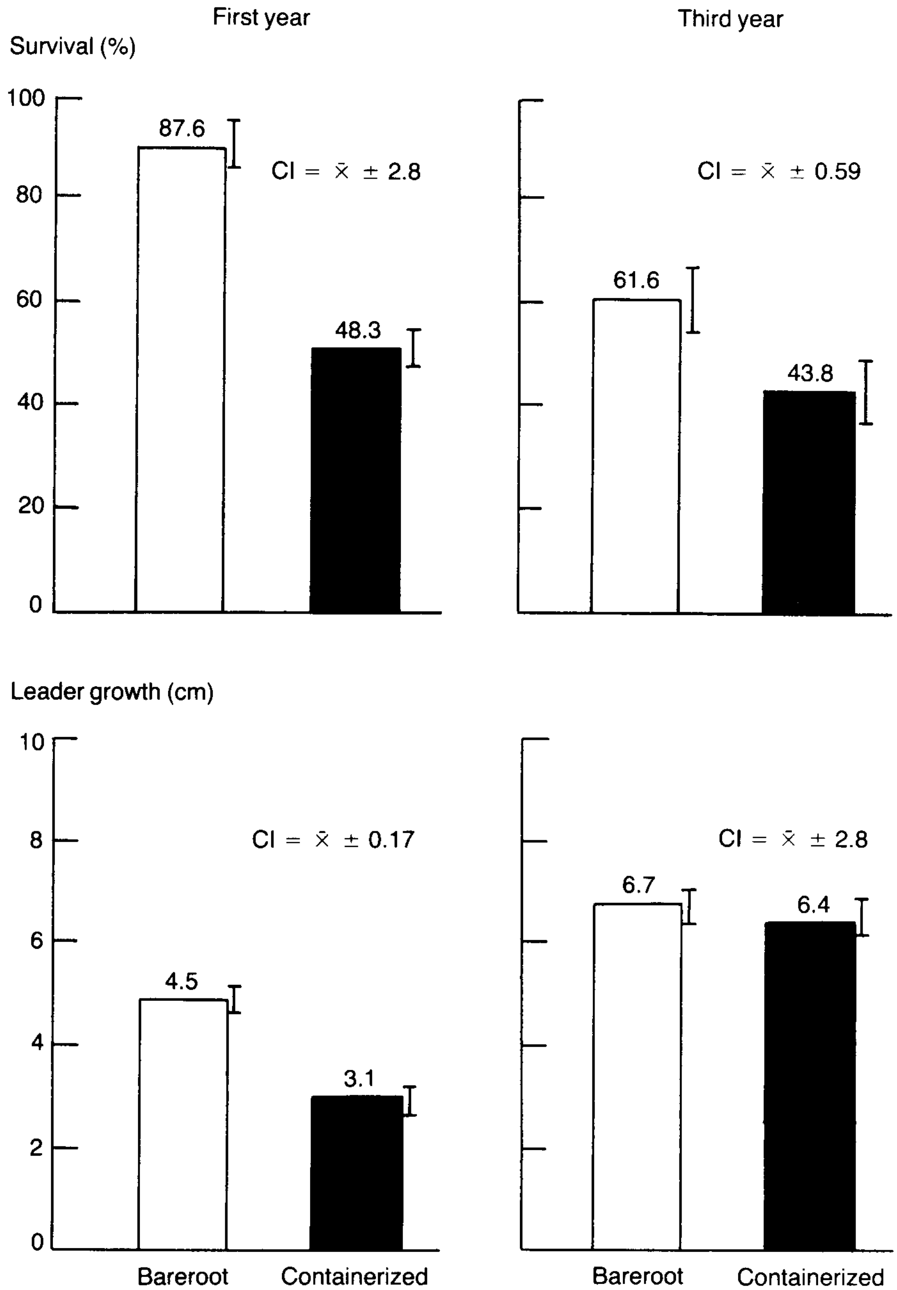

Figure 1—*Survival and growth of outplanted Douglas-fir seedlings by stock type.*

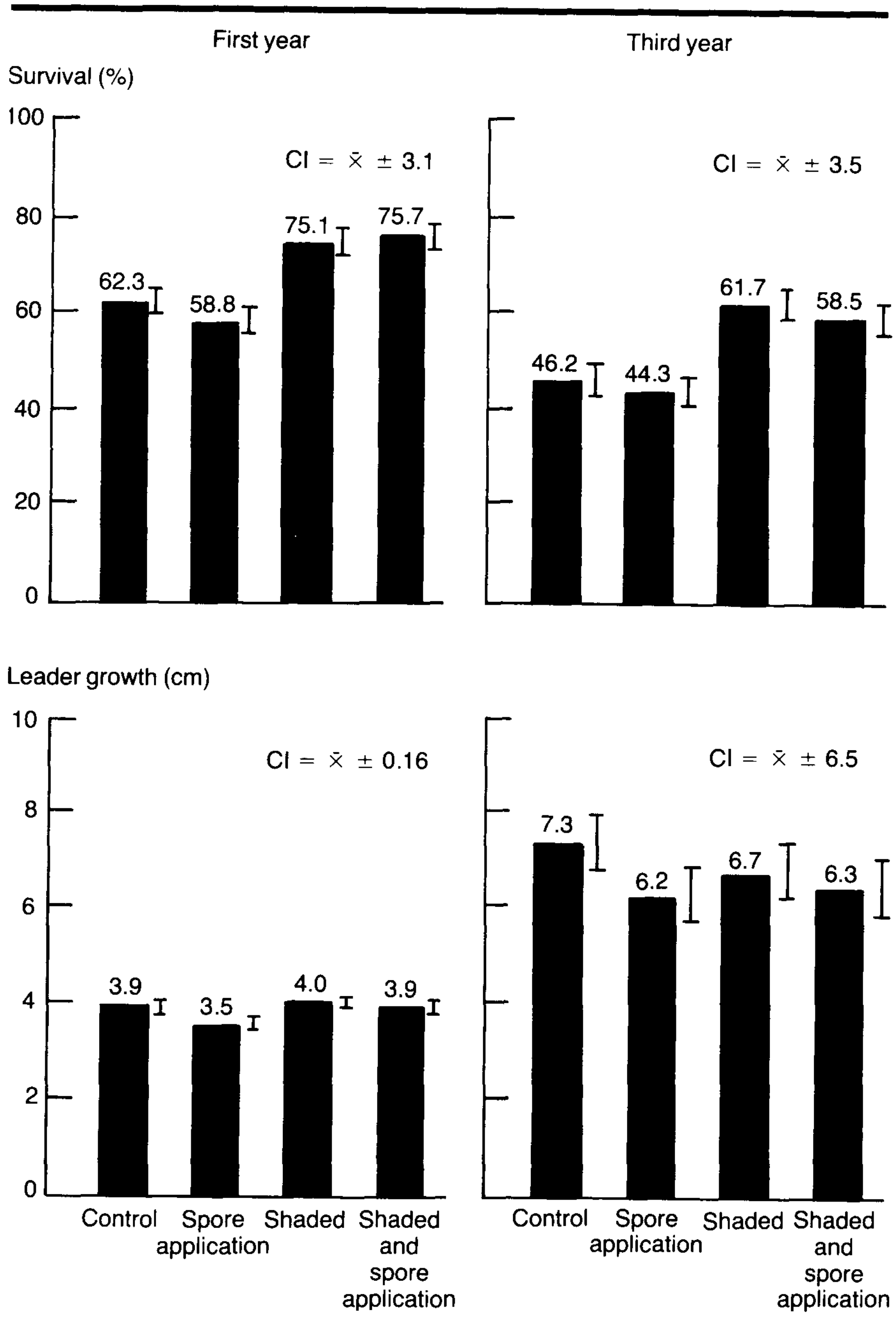

Figure 2—*Survival and growth of outplanted Douglas-fir seedlings by planting treatment.*

roots are negligible. If survival or growth could be enhanced by 1 or 2 percent, this technique could prove to be cost-effective. Further experimentation with different fungi, spore concentrations, or spore germination treatments would be worthwhile.

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