Coating Materials Protect Douglas-Fir and Noble Fir Seedlings Against Drying Conditions

Not Recommended for Extended Storage-More Tests Needed

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Three coating materials tested in Oregon for protection effectiveness on seedlings subjected to desiccating conditions or cold storage show promise for dry weather plantings but are not recommended for seedlings destined for storage.

Coating roots with water-holding materials has shown promise for preventing desiccation of conifer nursery stock. A coating might provide more protection from moisture loss than sphagnum moss or other packing now used to cover roots of lifted Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) and noble fir *(Abies procera* Rehd.) seedlings. Three materials -clay slurry; sodium alginate, a seaweed product; and xanthan gum, a hydrophilic colloid of a polysaccharide-were tested in an Oregon study for protection effectiveness on seedlings subjected to cold storage or imposed drying conditions.

Exposure Experiment

Procedures

In November 1969, 2-0 Douglasfir and noble fir seedlings, each species representing a single seed source, were lifted from the Forest Service's Wind River Nursery near Carson, Wash. After transport to Corvallis, Oreg., storage overnight, and rinsing in tapwater, seedlings of each species were divided into 16 groups of six. Each group was randomly assigned a root treatment and length of exposure to drying conditions. Roots of seedlings were then dipped into one of four test materials: (1) A slurry made by mixing 1 pound of kaolin clay per quart of water, (2) a 1.5-percent solution of sodium alginate, (3) a 1-percent colloidal suspension of xanthan gum, or (4) distilled water (control). The concentration of the three preparations used produced treatments liquid enough to permit easy dipping, but viscous enough to leave dipped roots fully covered after they had drained for 1 minute. Groups of drained seedlings were fully exposed in a growth chamber to 850-900F. temperatures, 20- to 25-percent relative humidities, and approximately 1,500 foot-candles of light for 0, 10, 20, or 40 minutes.

Following exposure, seedlings were potted individually in sandy loam, placed on a greenhouse bench in a random arrangement, and grown under well-watered conditions. After 4 weeks, their internal moisture stress was measured using a pressure chamber (Scholander *et al.* 1965). This technique indicates greater moisture stress within the seedling as atmospheres of pressure increase.

Results

After 4 weeks for recovery, water uptake was still moderately impaired in seedlings whose roots had been dipped in distilled water and then exposed to desiccating conditions in a growth chamber for 40 minutes. Those exposed for a shorter length of time and all those with coated roots showed little, if any, impairment. Douglasfir seedlings exposed 40 minutes after roots were dipped in water averaged 20 atmospheres moisture

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stress; coated seedlings averaged 10.3 atmospheres (table 1). Waterdipped noble fir seedlings exposed 40 minutes averaged 13 atmospheres; coated seedlings 9.0 atmospheres. These differences, tested by covariance analysis using top/root weight ratio as a covariate, proved statistically significant at the 99percent level of probability.

Moisture stresses in Douglas-fir and noble fir seedlings exposed 40 minutes to desiccating conditions

TABLE 1.—*Average moisture stress in seedlings after treatment, exposure to drying conditions, and 4 weeks' growth in pots*

Exposure in growth chamber (minutes)	Protective treatment			
	Distilled water	Clay slurry	Sodium alginate	Xanthan gum
	—Moisture stress, atmospheres—			
Douglas-fir				
0	8	11	10	8
10	8	11	9	9
20	9	11	11	8
40	20	10	12	9
Noble fir				
0	6	7	9	8
10	9	7	7	8
20	10	9	7	8
40	13	8	11	8

averaged 250 and 217 percent greater than the base levels of 8 and 6 atmospheres, respectively, for seedlings whose roots were dipped in water and not desiccated. Maximum difference between unstressed and stressed seedlings with coated roots was only 29 percent. Thus, all coatings provided substantial protection against exposure to drying conditions. How ever, coatings raised the average base level up to 3 atmospheres above non-desiccated, water-dipped controls, which may indicate that the coatings per se have a slight depressing effect on water uptake. If ranked by degree of this effect, xanthan gum was the best coating on Douglas-fir and clay slurry the best on noble fir.

Moisture stresses tended to be lower in noble fir than in Douglasfir, but the general trend was not without exceptions. Moisture stress in Douglas-fir for all treatments combined averaged 10.2 atmospheres; for noble fir, 8.4 atmospheres. The difference is significant at the 99-percent probability level.

Storage Experiment

Procedures

In another experiment, 2-0 Douglas-fir and noble fir seedlings lifted in November 1969 were treated and placed immediately in cold storage. Four groups of about 60 seedlings each were used for each species, one for each of the same four treatments used previously. Each group of treated seedlings was packed in an individual polyethylene bag. Moist sphagnum moss was packed only around roots of seedlings dipped in water. After 8 weeks' storage at 35°F., eight seedlings were randomly selected from each group, potted, grown for 4 weeks, and then measured for moisture stress.

Results

Moisture stress ranged from 2 to 7 atmospheres in sample trees of each group when removed from cold storage. But during 1 month in pots, larger average differences in moisture stress developed as shown in the following tabulation:

Protective treatment	*Douglas-fir*	*Noble fir*
	—Atmospheres—	
Water plus moist sphagnum moss	13	10
Clay slurry	36	13
Xanthan gum	42	19
Sodium alginate	53	22
Species average	36	16

Moisture stress averaged significantly lower (probability level, 99 percent) in seedlings whose roots had been dipped in water and covered with sphagnum moss than in those with coated roots. The difference in average moisture stress between slurry-coated and alginateor xanthan-coated seedlings was similarly significant. Again, moisture stress averaged significantly lower in noble fir seedlings than in Douglas-fir (probability level, 99 percent).

Discussion

Textbook information plus recent experimental evidence indicates that moisture stress should be minimized to increase survival and growth of outplanted seedlings to the maximum. Cleary (1971) found that photosynthesis in Douglas-fir seedlings under laboratory conditions was reduced to 88, 36, and 17 percent of maximum at moisture stresses of 10, 20, and 24 atmospheres, respectively. Permanent damage resulted when moisture stress exceeded about 35 atmospheres. Winjum noted that field performance of bare-root Douglasfir seedlings is adversely affected when their moisture stress before planting reaches 20 atmospheres. [2]

[2]Jack K Winjum. Personal communication May 21, 1971. Weyerhaeuser Company, Centralia, Wash.

Judged against the foregoing values, all three coating materials provided adequate protection to roots exposed to drying conditions for 40 minutes. Thus, they should prove useful when planting must be done during dry, sunny, or windy weather. Clay slurry, best for noble fir, has already been proven satisfactory for protecting roots of other species from exposure (Tabor and Davey 1966; Slocum and Maki 1956, 1959, 1960). Xanthan gum, the most effective coating for Douglas-fir, had not been tried before. Under our test conditions, sodium alginate did not afford as much root protection as the other two materials. But European trial results of another seaweed product named Agricol have been very promising (Dimpflmeier 1969). In fact, Agricol is used operationally in Bavaria. 3

The stress induced in unexposed seedlings by coating alone needs more attention. In Mississippi plantings, unexposed bare-root seedlings of loblolly pine (Pinus taeda L.) survived better than claydipped seedlings, whereas the latter survived better after 30- or 60minute exposure (Williston 1967). Slocum and Maki (1959) reported similar tendencies in one of their studies. Conversely, Tabor and Davey (1966) reported, as did Slocum and Maki (1956), that unexposed loblolly pines dipped in clay slurry survived better than bare-root seedlings. Perhaps concentration of the coating material and subsequent effects on water uptake or gas exchange affect the seedling's survival potential.

None of the coatings tested can be recommended for use on Douglas-fir or noble fir seedlings destined for extended storage. Hammer and Broerman (1967) also observed a storage effect; survival of clay-dipped slash pines (Pinus elliottii Engelm.) was somewhat lower than moss-packed seedlings after both groups had been stored for 8 weeks, though 4 weeks storage revealed no difference. On the other hand, Agricol has had no detrimental effects on seedlings stored as long as 2 months.' Perhaps results vary with coating, concentration, seedling condition, and dipping and packing techniques. Additional storage tests seem advisable. These should include different concentrations of Agricol and other coating materials, seedlings lifted on several dates, and field plantings.

Study results seem to indicate that fall-lifted noble fir is less susceptible to damage during storage or exposure than fall-lifted Douglas-fir. If this holds true for other seed sources and different lifting dates, separate guidelines for storing and handling should be developed for each species.

Conclusions

Clay slurry, xanthan gum, and sodium alginate protected roots of freshly lifted Douglas-fir and noble fir seedlings during 40 minutes' exposure to drying conditions. Xanthan gum was best for Douglas-fir, and clay slurry best for noble fir.

As used in this study, the materials are not recommended for coating roots of seedlings destined for extended storage.

8R. Dimpflmeier. Personal communication, September 7, 1971. Bayerische Landesanstalt fur forstliche Saat- and Planzensucht. Teisendorf, Germany.

*See footnote 3.

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