FROST HARDINESS TESTING

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Frost damage has long been a problem for the conifer nurseryman. Spring can bring red needles, buds that fail to flush, and often 20 percent or more of the crop is lost. What is needed is a method to assess frost hardiness so that crops judged not sufficiently hardy to withstand expected low temperatures can be protected. If frost protection is not possible, then losses can be calculated immediately rather than waiting for spring which may be months away.

There are a number of methods being used by the research community to test for frost hardiness. A good review of these methods has been provided by Timmis (6) and by Ritchey (5). Few of these methods, however, are being used on an operational basis. There are only two methods being used operationally by the forest nursery industry.

The first method is the electrolytic conductivity of water surrounding a tissue sample that has been frozen. This method is being used by the Ontario Ministry of Forests in Ontario, Canada (2). This technique is based upon the principle that freeze injured cells will allow cell fluid to escape through damaged membranes. This cell fluid has a higher electrical conductivity than water and therefore a large increase in the electrical conductivity of the water indicates severe freezing damage. The second method for determining frost hardiness is one being used extensively in the Western United States and British Columbia, Canada. This method is based on the discoloration of various plant tissues after freeze damage, and is referred to as the whole seedling browning test.

The following steps are common to both operational frost hardiness testing methods mentioned:

1. Randomly select a sample of seedlings from the population of interest (15 to 40 seedlings) (5).
2. Place the seedlings in a programmable freezer.
3. Lower the temperature at a set rate [5°C/hr. recommended (7)].
4. Hold the test temperature for a set time period [2 hours recommended (7)].
5. Return to the starting temperature at a given rate [not to exceed 20°C/hr. (7)].

The rate at which seedlings are frozen and thawed is critical; increased rates of freezing and thawing beyond those recommended may compound the damage. Increasing the duration of the low temperature may also cause more damage. Whatever rates or durations of freezing are chosen, all tests should be carried out in precisely the same manner for results to be comparable (4). Repeated freezing also tend to increase damage levels (3).

The electrolytic method of assessing frost hardiness is described in Colombo, Webb and Glerum (2). This method has limited use when determining the extent of damage to the various seedling tissues such as needles, buds, and stems. It is, therefore, not as useful in determining the economic viability of stock. Since economics is very important to the commercial grower, no further description of this method will be given here.

The whole seedling browning method of assessing frost hardiness involves visually assessing needles, buds, and stem tissue of whole seedlings after the seedlings have been frozen and then placed in a warm greenhouse for 7 days. The percentage of dead needles is recorded, the buds are sliced longitudinally and the percentage with brown meristimatic tissues are noted, and then the stem is scraped the entire length and the location of dead tissue is evaluated. The various tissues each have their own importance in the ultimate fate of the seedling. The buds determine growth potential for the following year and for nurserymen counting on growth in the second season, this is critical. Girdling of the stem by frost near the root collar is common (1) as this area is more sensitive to frost damage and ultimately means loss of that seedling. Losing the top 50 percent of the stem can also make an economically dead seedling for the nurseryman.

The whole seedling browning test is being used to determine the economic viability of seedlings by the Industrial Forestry Association which has four conifer nurseries in Washington and Oregon. It is using this information to determine the need for frost protection in their three bareroot nurseries. Seedling Quality Services is using this test for other private and some government nurseries in determining frost protection needs. Seedling Quality Services is also using this test, along with the British Columbia Ministry of Forests, to determine frost hardiness levels which correlate with stress resistance. Stress resistance levels are needed to judge when seedlings can withstand the stresses involved in lifting, packing, and possibly storing seedlings prior to planting in the field sites.

Frost protection of any crop can prove expensive. Use of frost hardiness data to limit the use of that protection can prove to provide a large savings for the nurseryman. The browning technique for determining frost hardiness is very simple and straightforward and should be readily adapted to most woody plants.

LITERATURE CITED

1. Alden, J. and R. K. Hermann. 1971. Aspects of the cold hardiness mechanism in plants. Bot. Rev. 37:37-142.
2. Colombo, S. J., D. P. Webb and C. Glerum. 1984. Operational monitoring of frost hardiness for guiding the extended greenhouse culture method of hardening spruce container stock. Ontario Ministry of Natural Resources. For. Res. Rep. No. 10.
3. Green, L. M. and I. J. Warrington. 1978. Assessment of frost damage in Radiata pine seedlings using the diffusate conductivity technique. *New Zeal. Jour. For. Sci.* 8:344-350.
4. Levitt, J. 1980. Responses of plants to environmental stresses. Vol. I. Chilling, freezing, and high temperature stresses. Academic Press. New York. 497 pp.
5. Ritchey, G. A. 1984. Assessing Seedling Quality. In Duryea, M. L. and T. D. Landis (Eds.) 1984. Forest Nursery Manual: Production of bare root seedlings. Martinus Nijhoff/Dr W. Junk. The Hague. 386 pp.
6. Timis, R. 1976. Methods of screening tree seedlings for frost hardiness. In Tree Physiology and Yield Improvement, M. G. R. Cannell and F. T. Last (Eds.) Academic Press. New York pp 421-435.
7. Timmis, R. 1980. Unpublished data, Weyerhaeuser Technology Center, Tacoma, Washington.

FOAMS FOR FREEZE DAMAGE CONTROL IN CONTAINER NURSERIES

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Nurserymen across the Southeastern United States have suffered extensive losses from cold temperatures during the past two winters. The minimum temperatures have been considerably below what is expected for the climatic zones. The worst events were associated with fast moving fronts. The fronts brought high winds as the temperature dropped, then clear cold weather for several days.

Killing weather fronts reach our nurseries only a few times each winter even though they are predicted five to ten times. Much more frequent are freezes associated with clear, cold nights. These events have minimums in the mid-twenties