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Predicting Cold Hardiness of Douglas-Fir Nursery Stock With an Oscilloscope/Square-Wave Apparatus

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The oscilloscope/square-wave apparatus was not useful in predicting the cold hardiness of Douglas-fir nursery stock. No correlations were observed between square-wave trace form and damage or kill in seedlings subjected to freezing tests.

Efforts to evaluate the quality of forest nursery stock have included investigations of dormancy and cold hardiness. Dormancy and cold hardiness often occur in parallel (5). As conifer tree seedlings are exposed to lower temperatures, hardiness increases, a progression that often coincides with the development of the dormant state as reviewed by Cleary and others (2). If dormancy and cold hardiness are correlated, a method that measures the dormant state might also be used to estimate cold hardiness.

Ferguson and others (3) developed an oscilloscope/square-wave apparatus to evaluate dormancy in nursery stock. This article reports the final results of a further study using the same procedures to predict cold hardiness of Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) seedlings. Preliminary results of the current study were reported earlier (4).

Materials and Methods

The Douglas-fir seedlings used were from the Humboldt Nursery at McKinleyville, Calif., and the D. L. Phipps State Forest Nursery at Elkton, Oreg. Seedlings were from two seed sources at the 1,500-foot (457 m) elevation in the Umpqua River drainage of southwest Oregon. Samples were lifted in mid-September, mid-October, and mid-November of 1978.

Seedlings were classified as very active, slightly active, dormant, or dead, according to their response to an electric current delivered through an electrode inserted in the tissue just below terminal bud (fig. 1). Responses were classified

Figure 1—*Douglas-fir seedling with electrode from oscilloscope/square wave apparatus attached.*

visually according to trace patterns observed on an oscilloscope screen (fig. 2). The equipment used for this procedure was a portable oscilloscope (Tektronix Model 212) connected to a portable square-wave generator (Wavetek Model 30) (fig. 3). Attached to this

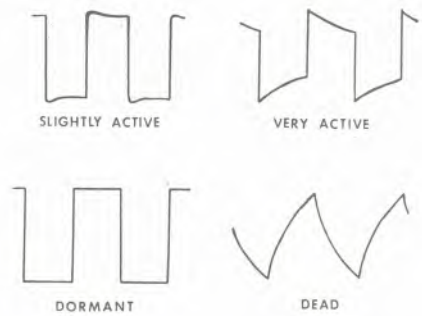

Figure 2—*Growth conditions indicated by square-wave trace forms (3).*

instrument was an electrode consisting of four surgical stainless steel needles in clear plastic.

Trace patterns were observed on 18 groups of 10 seedlings immediately after each lifting at the two nurseries (hereafter called nursery observations). These seedlings were then discarded. Another 18 groups of 10 seedlings were potted after lifting. These were used for laboratory freezing tests and were not subjected to oscilloscope readings. A third set of five seedlings per group was potted and subjected to both freezing and square-wave analysis in the laboratory.

The freeze test was made at —4° C for 3 hours, 2 to 3 weeks after potting. After 6 weeks in a greenhouse under growing conditions, seedlings were classified as survivors if they had not been killed or as severely damaged if more than half the foliage was brown and the terminal bud injured.

Figure 3—*Portable oscilloscope/square-wave apparatus used for square-wave observations.*

Results and Discussion

Test results (table 1) show no similarities between the percentages of seedlings classified as dormant by square-wave trace form and the percentages surviving freezing tests. For example, the highest percentage of seedlings classified dormant and the lowest percentage of seedlings surviving the freezing tests were from laboratory observations made in November on stock from both nurseries. Also, the lowest percentage of dormant seedlings and the highest percentage of survivors were from October observations of Phipps stock. Similarly, there were no correlations between percentage of seedlings dormant as determined by square-wave form and percentage undamaged by freezing tests in the 1977 tests (4).

Table 1—*Comparison of dormant seedlings, as determined by square-wave form, and seedling survivors following freezing tests of Douglas-fir seedlings from the Humboldt and D. L. Phipps nurseries in 1978 tests of cold hardiness*

Nursery	September		October		November	
	Dormant	Survivors	Dormant	Survivors	Dormant	Survivors
			%			
Humbold						
Nursery observations	7	99	0	96	0	92
Laboratory observations	1	95	5	97	36	87
D. L. Phipps						
Nursery observations	3	87	1	96	3	82
Laboratory observations	4	85	0	94	32	79

We would expect that as dormancy and cold hardiness increase from September through November, wave-form indications of dormancy would also increase. A slight increase in the percentage of dormant seedlings from September to November occurred only in laboratory observations of Humboldt stock.

We would also expect that as cold hardiness of seedlings increases from September through November, severe damage or mortality following freeze tests would decrease. This did not occur. In all cases, there were fewer survivors in November than in September. Careful review of handling and testing procedures did not reveal any explanation for this result. Whatever the reason, square-wave readings did not give a good prediction of response to freezing.

The percentage of seedlings severely damaged or dead was greater in those subjected to freezing tests than in unfrozen seedlings placed under similar growing conditions. Higher mortality in frozen seedlings than in unfrozen seedlings indicates that mortality in the frozen seedlings was related to the treatment and thus to lack of cold hardiness.

The two sets of oscilloscope trace observations, one immediately following lifting at the nursery and one shortly before freezing tests, were carefully made to minimize factors that might influence test results, such as the time between lifting and freezing tests and the use of two separate samples or the same sample for observations of both square-wave trace and freeze damage. Using two separate samples for dormancy readings and freeze tests did not give results different from those made on the same seedlings.

Askren and Hermann (1) used ratios of voltage measurements on the oscilloscope/square-wave apparatus as a more quantitative way to detect dormancy and survival potential of Douglas-fir seedlings. Although their observations demonstrated a seasonal trend in square-wave trace form, they concluded that the technique offered little promise in predicting survival potential. In studies of the relation of electrical impedance to vegetative maturity and dormancy in red-osier dogwood, Parmelee (6) ruled out use of the oscilloscope/square-wave technique because of difficulties she encountered with interpretation and reliability of the square-wave trace.

Conclusion

Because of the lack of similarities between the percentages of dormant seedlings (as determined by the oscilloscope/square-wave apparatus) and survivors of freezing in this study, it appears that the oscilloscope/square-wave technique (3) is not useful in measuring cold hardiness of Douglas-fir nursery stock.

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