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164. © Cold-hardiness of containerized loblolly pine seedlings. Mexal, J. G., Timmis, R., and Morris, W. G. Southern Journal of Applied Forestry 3(1):15-19. 1979.

Cold-Hardiness of Containerized Loblolly Pine Seedlings

Its Effect on Field Survival and Growth

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ABSTRACT. Loblolly pine seedlings grown in the greenhouse for 92 days in 64 ml Leach cells were hardened outdoors for 0, 14, 28, or 42 days. Those seedlings outplanted in November after cold-hardening for 14 days did not survive temperatures below −4°C (25°F). Seedlings cold-hardened for 42 days were hardier and their survival and height growth better the following season than trees hardened for 14 days or less. Seedlings kept in the greenhouse under an 8-hour photoperiod survived as well as seedlings hardened outdoors during a 42-days period. But seedlings held in the greenhouse under the natural photoperiod (=11.5 hours) were unable to survive temperatures below −6°C (21°F). Results suggest that a short photoperiod may be substituted for cold temperatures to induce hardiness. For a successful fall planting of containerized seedlings, seedlings must be cold-hardened for at least 42 days, either outdoors or under shortened photoperiod.

Containerized seedlings are grown in the South as a means of extending the planting season. Containerized loblolly stock can be more successfully planted during the summer, early fall, and late spring than can bareroot stock. A common problem of late fall planting is that trees are not sufficiently hardened against low temperatures to be transferred directly from the greenhouse to the field.

Poor fall and winter survival of outplanted containerized seedlings has been attributed to high nutrient concentrations in the growing media which prolong growth and prevent the onset of dormancy (Levitt 1956). Conversely, Christersson (1975) reported that nutrient regimes, while markedly affecting the growth of *Picea abies* (L.) Karst, did not influence the ability of these seedlings to become dormant. Yet Timmis (1974) found that a rather extreme nitrogen-potassium imbalance strongly reduced the ability of containerized Douglas-fir seedlings to achieve cold hardiness. He found that the K/N ratio must be less than 1.0 to permit maxium cold-hardening after an 11.5-week hardening regime.

Temperature and photoperiod induce dormancy of Douglas-fir. A 6- to 8-week period of warm short-days, while itself conferring a small but important degree of hardiness (Tanaka 1974; Tanaka *et al* 1975, Van den Driessche 1969, 1970), is necessary for the subsequent induction of deeper hardening by low temperature (Timmis & Worrall 1975).

Goodwin (1975a, 1975b) reported that survival and growth of late fall, outplanted, containerized southern pines were inferior to that of spring or summer outplantings. Hardening regimes of 28 to 35 days prior to late fall outplanting may have resulted in incomplete hardening and contributed to the unsatisfactory performance of the containerized stock. However, site-specific factors such as frost heaving and drowning also contributed to the poor performance of the fall and winter outplantings.

The objective of this study was to determine the effects of hardening regimes on freezing damage, field survival, and subsequent growth of outplanted loblolly pine seedlings.

EXPERIMENT 1

Stratified seed from a piedmont source grown in a North Carolina orchard was sown on August 7, 1974, in 64 ml cylindrical plastic cells (Leach tubes) containing a commercial mixture of peat moss and vermiculite. Seedling emergence began about August 12, 1974. When emergence was complete, the seedlings were fertilized each week with Hoagland's nutrient solution (Hoagland and Arnon 1950). Ninety-two days after sowing (13 weeks) the seedlings were placed outdoors and allowed to cold-harden or condition under natural day length (Figure 1). Unconditioned (control) seedlings were kept in the greenhouse under natural day length and average daily temperatures of 20 C (68 F). Dry weight after 92 days averaged 270 mg, and seedling height was 130 mm (5.1 inches).

Cold hardiness was determined 14 (November 21), 28 (December 7), and 42 (December 21) days after placing the seedlings outdoors. Seedlings were packed in vermiculite and shipped by air freight to Centralia, Washington, for these determinations. All shipments arrived 24 hours later. Cold hardiness was determined by lowering shoot temperature of 20 seedlings at a rate of 5 C (9 F) per hour to one of three selected temperatures. The minimum temperature was maintained for two hours. Root systems were insulated to prevent freezing. The temperature required to kill 50 percent of the seedlings (LT_{50}) was interpolated from the injury-temperature curve obtained from the three selected temperatures (Figure 2).