Fall Lifting: Its Effects on Dormancy Intensity of Ponderosa Pine Seedlings - A Preliminary Investigation[1]

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Abstract.--Initial assessment of the feasibility of fall lifting ponderosa pine seedlings at Bend Pine Nursery, Oregon, involved calculating fall chilling hours and monitoring release of seedlings from dormancy. Seedlings lifted earliest failed to break bud, whereas budbreak was accelerated for trees lifted later in the fall. Results suggest that chilling was required to release seedlings from dormancy.

INTRODUCTION

Three basic lifting practices are available for use in high elevation or latitude nurseries: (Option 1) fall lift and plant, (Option 2) late winter or spring lift and plant, and (Option 3) fall lift, overwinter storage, and plant. Disadvantages of Option 1 include risks that early fall snows or drought will terminate the planting operation (Tung et al. 1986) and that stock will be lifted before it is physiologically ready (Ritchie et al. 1985). Fall lifting date is critical because of the potential to upset natural phases of dormancy and release of seedlings from dormancy.

A disadvantage of option 2, the most common practice in the Northwest, is that nursery soils may remain frozen in the spring when sites are ready for planting. In addition, seedlings left in the ground during winter months may be exposed to desiccating conditions and may be sensitive to physiological stress at the end of the safe lifting window (Ritchie and Dunlap 1980, Ritchie et al. 1985).

Disadvantages of option 3 include that of Option 1 regarding fall lifting date. Furthermore, storage can be unsuccessful if seedlings are lifted prior to the period of deep dormancy, when buds are not responsive to chilling (Stone and Schubert 1959, Ritchie and Dunlap 1980). Seedlings which are not at their fully dormant stage have higher respiration rates (Hocking and Ward 1972, Navratil 1973) and may deplete their reserves faster during storage than do fully dormant seedlings. Use of Option 3 has been discouraged in the past (Hocking and Nyland 1971, Hermann et al. 1972, Navratil 1973), based on data primarily derived from research on mid- or low-elevation conifer species (Tung et al. 1986). Recent studies, however, indicate that fall lifting and long-term cold storage of high elevation or latitude stock are feasible (Ritchie et al. 1985, Tung et al. 1986).

Fall lifting and overwinter storage ensure that stock is available when sites are ready for planting. This practice alleviates winter losses due to rodents, desiccating winds, or extreme temperatures (Hocking and Nyland 1971). In addition, it allows greater flexibility in the workload and makes nursery areas available for early cultivation (Hocking and Ward 1972, Mullin and Bunting 1972, Hinesley 1982). Low temperature storage of seedlings also can play a role in satisfying chilling requirements (van den Driessche 1977, Ritchie et al. 1985). The relationship among lifting date, chilling hours, and dormancy intensity for ponderosa pine is not well known.

Bend Pine Nursery (Bend, Oreg.) is located at an elevation of 3700 ft (1100 m), where soils can remain frozen in spring when lower elevation forest sites are ready to plant. Fall lifting has not been attempted recently at this nursery; however, the practice of fall lifting and overwinter storage is used for a variety of conifer species at three USDA Forest Service nurseries in the Northwest/Intermountain

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region--Wind River Nursery (Carson, Wash.), Lucky Peak Nursery (Boise, Idaho), and Couer d'Alene Nursery (Idaho). These nurseries are similar to Bend Pine Nursery in that their operations are subject to winter snows and frozen soils.

A preliminary trial was initiated in fall 1986 to assess the feasibility of fall lifting at Bend Pine Nursery. The objectives of the investigation were to determine (1) the dormancy status of fall-lifted trees and the preferred chilling range for release of seedlings from dormancy, and (2) the relationship between cumulative chilling hours and budbreak.

METHODS

Two-year old seedlings from three seed sources (courtesy of Warm Springs Indian Reservation in central Oregon--seedlots 38-85112 [3000 ft], 38-85110 [3500 ft], and 38-85105 [4000 ft]) were selected for study. These seed sources were chosen because seedlings could be destined for sites which are plantable prior to the average spring thaw in the nursery--a situation in which fall lifting and overwinter storage could be advantageous. Seedlings were shovel-lifted on three dates (October 22, November 5, and November 13, 1986) from four replications of each seed source. An additional lift of seedlings from seed source 3500 ft was made on February 19 , 1987. Immediately after lifting, seedlings were packed in ice, transported to Corvallis, Oreg., and placed in cold dark storage (2°C) for approximately 12 h. Seedlings from each replication then were potted (10 seedlings per pot, 4 pots per seed source) in a 1:1:1:2 soil:sand:peat:pumice mixture and placed in a glasshouse with a 13-h extended photoperiod supplemented with lighting from 300-watt incandescent bulbs. Daily maximum and minimum temperatures were approximately 24°C and 12°C, respectively. Soil moisture was maintained near saturation.

Dormancy intensity was determined by scoring each seedling for terminal budbreak (separation of bud scales to reveal emerging needles) and tallying percent budbreak for each pot of 10 seedlings. Seedlings were monitored for 20 wk after each 1986 lift date; the 1987 lift was assessed for 7 wk.

Sensors at the nursery weather station took a temperature reading every 5 min and recorded hourly averages. Cumulative chilling hours were determined by summing the number of hours that the average hourly temperature was within a given range. Temperature ranges were defined as: (1) less than or equal to 5°C (41°F), (2) 0-5°C, (3) less than or equal to 10°C (50°F), and (4) 0-10°C. The starting date for accumulation of chilling hours was set arbitrarily as September 10. Chilling hours were calculated for three sensor locations from September 10, 1986 to February 19, 1987.

To quantify the relationship between chilling hours and budbreak, percent budbreak for each seed source after 20 wk was plotted against cumulative chilling hours. Examination of residual plots after fitting linear relationships, lack of fit tests, and tests for nonconstant error variance (Weisberg 1985) suggested that linear models were not appropriate for the untransformed data. An arcsine square root transformation of the budbreak proportions was found to linearize the relationship and stabilize the variance for seed sources 3000 and 4000 ft; a quadratic term was required for fitting the regression equation for seed source 3500 ft.

RESULTS

Chilling hours generally started to accumulate during September, and increased later in the fall, regardless of chilling temperature range (fig. 1). However, as indicated in

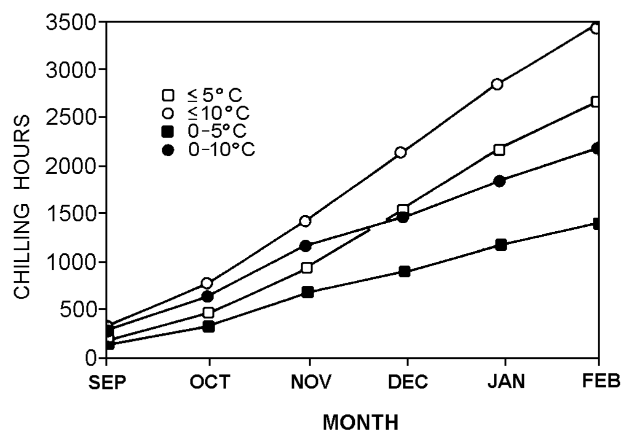

Figure 1.--Cumulative chilling hours from September 10, 1986 to February 19, 1987 at 20 cm above the surface for four temperature ranges.

figure 1, cumulative chilling hours differed, depending on the temperature range defined. For example, cumulative chilling hours in February differed nearly threefold between the temperature range less than or equal to 10°C and that from 0 to 5°C.

As expected, the later the lift date, the more chilling hours the seedlings received (table 1). Chilling hour data (temperature range less than or equal to 5°C) for the sensor 20 cm above ground surface indicated that the first three lift dates differed by over 100 h each (table 1). More than 2400 chilling hours were received by seedlings lifted February 19.

Percent budbreak was similar for all three seed sources (fig. 2). Budbreak in the glasshouse environment was virtually nonexistent for trees lifted October 22; no budbreak occurred in seedlings from seed sources 3000 and 4000 ft. Slightly more activity (8-13 percent budbreak after 5 mo) occurred in seedlings lifted November 5, and the percentage of seedlings which flushed after 12, 16, and 20 wk increased consistently for all seed sources lifted November 13. Budbreak was especially accelerated for seedlings (seed source 3500 ft) lifted February 19 (fig. 3). These trees achieved the same amount of budbreak after 6-7 wk as the trees lifted on November 13 did after 20 wk.

In an attempt to determine a preferred chilling range for releasing ponderosa pine seedlings from dormancy, percent budbreak after 20 wk was plotted against cumulative chilling hours for the four temperature ranges studied. Similar to findings of Ritchie et al. (1985), all chilling ranges exhibited similar patterns and none was clearly advantageous. Therefore, the range less than or equal to 5°C was utilized for remaining analyses because of its practical use in tallying chilling hours in some Northwest nurseries (Ritchie et al. 1985).

The relationship between budbreak proportion after 20 wk (transformed) and cumulative chilling hours was linear for the 3000 and 4000 ft seed sources. Regression equations derived from data on these seed sources did not differ statistically ($p > .05$); therefore, data were combined to produce a single linear regression model (fig. 4, budbreak = -1.074 + .003 [chilling hours]). Differences in chilling hours accounted for 74 percent of the variation in budbreak for

Table 1. Chilling hours accumulated from September 10, 1986 to four 1986-1987 lifting dates at three sensor locations for four temperature ranges.

Time period	Sensor location above ground	Chilling hours accumulated — Temperature ranges <5°C	0-5°C	<10°	0-10°C
Sept 10-Oct 22	1.5 m	322	278	666	622
	20 cm	396	290	644	538
	surface	205	195	533	523
Sept 10-Nov 5	1.5 m	443	382	884	823
	20 cm	533	391	856	714
	surface	337	327	737	727
Sept 10-Nov 13	1.5 m	599	477	1065	943
	20 cm	683	472	1029	818
	surface	474	441	908	875
Sept 10-Feb 19[1]	1.5 m	2459	1466	3336	2343
	20 cm	2478	1369	3238	2129
	surface	2551	1863	3210	2522

[1]Information from 4:00 p.m. December 8 to 11:00 a.m. December 9 not available.

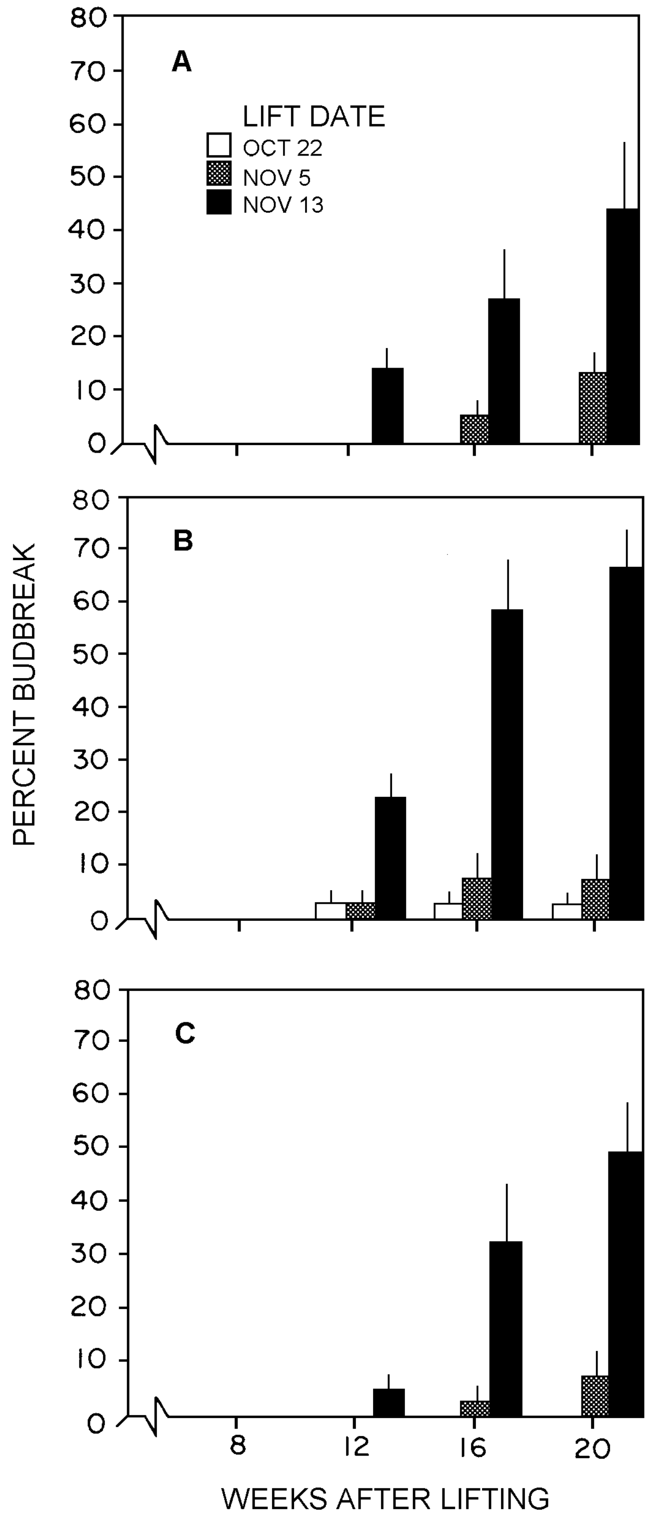

Figure 2.--Percent budbreak (± SE) for seedlings from seed sources (A) 3000 ft, (B) 3500 ft, and (C) 4000 ft assessed for 20 wk after three lifting dates.

these two seed sources (n = 24). A curvilinear relationship existed for seed source 3500 ft (n = 12), with a coefficient of determination equal to .85 (fig. 4, budbreak = 2.874 – .013 [chilling hours] + .00001 [chilling hours]^2).

DISCUSSION

The number of chilling hours required for growth to resume following dormancy has been estimated at 1200 h at 0-10°C or 1400 h below 5°C for Douglas-fir (Ritchie and Dunlap 1980). Such information for ponderosa pine is lacking. With the assumption that differences in budbreak between lifting dates were due to differences in cumulative chilling hours, the results of this trial suggest that seedlings from the tested seedlots had a chilling requirement. Seedlings in the greenhouse were never exposed to long photoperiods (e.g., 16 h), which can compensate partially for inadequate chilling (Campbell and Sugano 1975). Apparently, seedlings were in deep dormancy during the early fall lift, and may have been unable to resume growth because they needed chilling hours (Perry 1971). Thus, seedlings could have been released from dormancy with the accumulation of chilling hours (e.g., Lavender 1985).

In contrast to the findings of this trial, Tinus et al. (1986) reported no chilling requirement for ponderosa pine. They used a high elevation (7000 ft) Arizona seed source and raised seedlings in containers under greenhouse conditions.

Chilling hour data were retrieved from the weather station with only minor problems. Installed recently (June 1986) for the USDA Forest Service Reforestation Improvement Program (see Rietveld, this proceedings), the weather station immediately showed its potential use in collecting beneficial information for the nursery. Nonetheless, determination of chilling

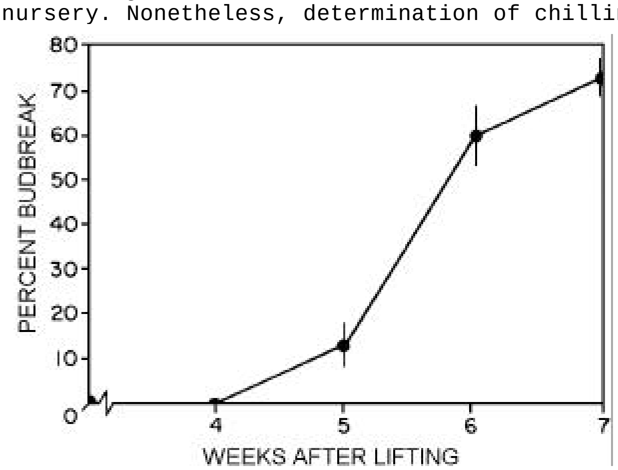

Figure 3.--Percent budbreak (± SE) for seedlings from seed source 3500 ft assessed for seven weeks after lifting February 19, 1987.

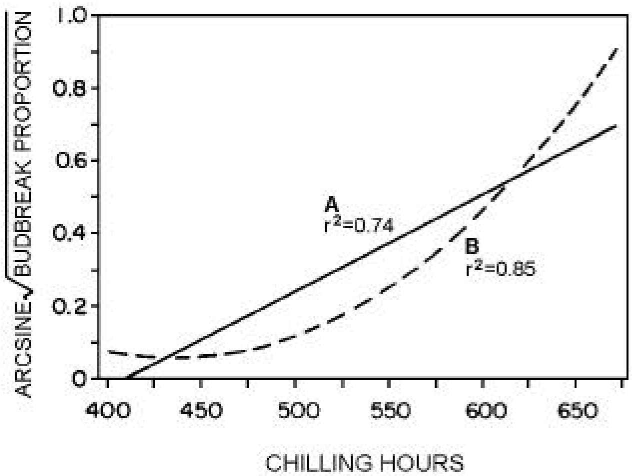

Figure 4.--Relationship between budbreak proportion (transformed) and chilling hours for seed sources (A) 3000 and 4000 ft, and (B) 3500 ft.

requirements poses numerous problems. Not all chilling temperature hours below a specified quantity are equally effective in releasing seedlings from dormancy (Ritchie et al. 1985). In addition, the chilling period may be interrupted by warm temperatures. The relationship between chilling hours and release of seedlings from dormancy under controlled environments will be more intensively studied during fall 1987. In addition, investigations of the interaction between dormancy intensity of fall-lifted trees and the ability to tolerate long-term storage, as well as of effects of fall lifting and long-term storage on seedling carbohydrates and outplanting performance, are planned for 1987.

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