SCHEDULING IRRIGATION TO INDUCE SEEDLING DORMANCY [1]

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ABSTRACT

The dormancy of seedlings can be induced by increasing plant moisture stress in early summer to midsummer. Each nursery should tailor its irrigation schedule to achieve early seedling growth, then dormancy induction, and finally dormancy deepening to produce planting stock with high survival potential.

A seedlings's ability to survive in the field is closely linked to its state of dormancy (Tinus 1974; Lavender and Cleary 1974; Cleary, Greaves, and Owston 1978). When fully dormant, seedlings can easily tolerate frost, brief exposure of roots to the atmosphere during lifting, root pruning, and cold storage. Because nursery practices invariably influence seedling dormancy, knowledgeable foresters now wisely demand that nurseries insure dormancy in every seedling crop.

In Oregon's Willamette Valley, seedling top growth must be stopped by late summer or early fall to avoid fall and winter frost damage. To prevent such damage and promote both morphological and physiological quality, seedling dormancy must be induced by late summer. Although the onset of dormancy may be hastened by decreased photoperiods and reduced nutrient levels, the desired effect is most easily and consistently achieved by increasing plant water stress. The nursery irrigation schedule is, therefore, the key to inducing dormancy.

Of course, no single "magic formula" exists. Irrigation schedules must accommodate specific nursery climates and particular cultural regimes to produce plantable seedlings. This paper describes the development of optimum irrigation schedules for the Dwight L. Phipps State Forest Nursery at Elkton, Oregon.

PROCEDURES AND RESULTS

To determine optimum water regimes for 2-0 Douglas-fir, various irrigation regimes were tested annually for three years.

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1974 Trial

Plant moisture stress (PMS) was measured with a pressure chamber[3] for three different water regimes (wet, 5 bar PMS; medium, 8 bar; dry, 15 bar) established for comparison with standard nursery practice. Treatments were begun in spring of the second growing season. The seedlings' internal moisture stress was monitored to determine the time to water and water applied when predawn PMS in seedlings exceeded the assigned treatment value.

The medium (8-bar) and dry (15-bar) regimes induced seedling dormancy in summer. Under the wet (5-bar) and standard nursery regimes, seedling tops still were growing in the fall and remained succulent in November. The dry regime reduced growth such that the resulting seedlings were too small. Predawn PMS in the dry regime did not reach 15 bar until mid-August, although average predawn PMS was much less because a week or more was required after each irrigation to again reach 15 bar. Predawn PMS of standard nursery practice closely approximated that of the wet regime and did not exceed 5 bar until late summer.

1975 Trial

Two regimes were tested in the second trial but differed from the first in that predawn PMS was increased during the growing season. Standard nursery practice was unchanged.

Treatment	Predawn PMS (bar)			
regime	May 1	Jul 1	Jul 15	Aug 15
Wet	5	5	5	10
Dry	10	15	15	15

Seedlings in the wet regime were not sufficiently dormant in fall. Seedlings in the dry regime went dormant in summer but were again too small to meet the minimum size standards for plantable seedlings. If dormancy is to be regulated, size of seedlings must be controlled by the conditions during spring and early summer.

1976 Trial

The results of the 1975 trial indicated that, for 2-0 Douglas-fir, an intermediate water regime would strike a good balance between seedling size and dormancy in fall. That intermediate regime and its modifications for 1-0 and 2-1 Douglas-fir were tested in 1976.

[3]PMS Instrument Co., Corvallis, OR 97330.

Seedling class	Predawn PMS (bar)		
	Until Jul 1	Jul 1-Aug 1	After Aug 1
1-0	5	5	10
2-0	5	7	12
2-1*	5	10	15

*On hot days, seedlings were watered as needed for cooling.

These regimes allowed adequate seedling growth in spring and early summer and induced early dormancy to virtually eliminate shoot growth in fall.

DISCUSSION

The irrigation nursery schedules developed at Elkton were adopted as standard practice to insure seedling dormancy in fall and eliminate the potential for frost damage. Subsequent nursery and field experience generated a few refinements, which were incorporated into the 1979 irrigation schedules (Table 1).

Our experience reinforced the following:

Table 1.--*Generalized irrigation schedules for various seedling classes of Douglas-fir in the Phipps Nursery, 1979*

Seedling class	Predawn PMS *(bar)*			
	Until Jul 9	After Jul 9	Aug 3	Aug 20
1-0	5	10	12	15
	Until Jun 1	Jun 1-15		After Jun 15
2-0	5	8-10		15[1]
	Until Jul 1	Jul 1-Aug 1		After Aug 1
2-1	7	10		15

[1]In seedlings held for 2-1, keep predawn PMS between 10 and 15 bar.

1.--Any schedule still is only a guide. In 2-0 seedlings, for example (Table 1), the 8- to 10-bar stress was applied later in the season if seedling growth was not sufficient, that is, beginning June 8 for certain nursery blocks, June 15 for some blocks, and June 22 for still others. Schedules based on predawn PMS also must take into account maximum stress levels reached during the day. Windy conditions and/or low humidities can substantially increase PMS for a given predawn level. Soil texture also can affect maximum water-stress levels. Consequently, each nursery must develop its own guidelines to meet the local soil and weather conditions while considering different cultural practices and seedling size objectives.

2.--What works well at one nursery may not work at another. At the U.S. Forest Service Humboldt Nursery near McKinleyville, California, early frost is not a problem. The nursery goal--a harvest of plantable, dormant seedlings--remains the same as at Phipps, but its attainment requires a different combination of cultural practices. Undercutting seedlings in midsummer of their second year is standard practice. In a 1978 study, the best 2-0 seedlings were produce by combining a single, early July undercut with a 5-bar predawn stress regime [4]. Further, two nursery sowings are now common, one in March-April and the other in May-June (the traditional period). For these reasons, the 1980 irrigation schedules for Humboldt (Table 2) differ from those of Phipps in several respects.

Table 2.--*Generalized irrigation schedules for various seedling classes of Douglas-fir in the Humboldt Nursery, 1980*

Seedling class	Predawn PMS *(bar)*		
	Until Jul 15	Jul 15-Sep 1	After Sep 1
1-0 Early sow	5	5	5
Late sow	5	5	5
	Until Jun 15	Jun 15-Sep 1	After Sep 1
2-0 Early sow[1]	5	6-8 (10)	5
Late sow[2]	5	5	5
	Until May 1	May 1-Sep 1	After Sep 1
3-0[3]	5	6-8 (10)	5

[1]Undercut at 15 cm in March/April and again at 20 cm in July if held for 3-0.

[2]Undercut at 20 cm in July.

[3]Undercut at 20 cm in March/April.

Humboldt's generally lower predawn PMS is effective for two reasons. First, the fall is usually mild--often warm until November; frost damage has not occurred in the nursery's history. Second, for 2-0 seedlings, the midsummer undercut effectively stimulates root growth and stops shoot growth. Midsummer removal of a major portion of the seedling's water-absorbing surface apparently substitutes for high predawn PMS in late summer. Under these cultural regimes, both 1-0 and 2-0 seedlings have consistently survived and grown well in the field (Jenkinson and Nelson 1978; Knight, Nelson, and Jenkinson 1980). At Humboldt, undercutting in early fall and/or predawn PMS over 6 to 8 bar in fall are associated with reduced field survival.

[4]Administrative study directed by William I. Stein, Pacific Northwest Forest and Range Exp. Stn., Corvallis, OR, and monitored by James A. Nelson, Humboldt Nursery.

3.--Plant moisture stress should be reduced in the fall. In another experiment, higher moisture stress applied between mid-July and late August consistently halted shoot growth and increased cold hardiness of Douglas-fir (Blake, Zaerr, and Hee 1979). Delaying onset of the stress period until late August negated the effect on hardiness. A stress level of 10 to 15 bar also induced bud set and prevented late flushing but did not increase hardiness over that of the 0- to 5-bar controls. Seedling moisture stress apparently must be alleviated in fall if the hardening process is to be enhanced.

The dormancy process must be deepened once induced. For this reason, irrigation during early fall may be necessary to insure adequate moisture to complete this phase of the dormancy cycle before temperatures become too cold (Lavender and Cleary 1974). Irrigation should, therefore, be started when firm winter buds are evident and fall rains would normally begin.

CONCLUSIONS

Irrigation control is essential for producing bare-root seedlings of Douglas-fir with high survival potentials. By programming plant moisture stress, the nursery may regulate seedling growth, induce seedling dormancy, and enhance cold hardiness. The principles are simple:

- Monitor predawn PMS in seedlings to schedule irrigation.
- Promote growth early in the season.
- Induce dormancy in late summer by increasing PMS in early summer to midsummer.
- Complete dormancy deepening and enhance cold hardiness (frost tolerance) by reducing PMS in early fall.
- Tailor the irrigation schedule to accommodate the particular nursery soil, climate, seedling class, and cultural practices.

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