EFFECTS OF WRENCHING ON DROUGHT AVOIDANCE OF DOUGLAS-FIR SEEDLINGS

Wrenching at a depth of 8 inches increased the ability of 2-0 Douglas-fir seedlings to avoid drought.

Kenneth B. Koon, Tharon O'Dell
Graduate Research Assistant and Assistant Professor of Forestry
Humboldt State University, Calif.

Seedling mortality on droughty sites is a persistent obstacle to successful reforestation. Wrenching is a nursery practice that has increased the drought hardiness of bareroot Monterey pine seedlings *(Pinus radiata)* in New Zealand (*2*). This technique involves periodically undercutting nursery seedlings during the growing season prior to lifting and has resulted in greater survival of outplanted Monterey pine seedlings (*4*). The purpose of this experiment was to determine if wrenching would increase the survival of 2-year-old (2-0) Douglas-fir seedlings *(Pseudotsuga menziesii)* when outplanted on a droughty site.

Materials and Methods

Wrenching was performed during August and September 1974 at the U.S. Forest Service, Humboldt Nursery, located at McKinleyville, Calif. Nursery beds were undercut at the depths and intervals indicated in table 1.

The experimental seedlings were from a southwest Oregon seed source. Nursery bed densities averaged 5.8 seedlings per square foot. The (2-0) Douglas-fir seedlings were lifted in January 1975, and placed in cold storage. Sample seedlings used in subsequent experiments were randomly selected from these stored seedlings.

Root/shoot ratio was selected as one indicator of a seedling's ability to cope with severe drought. Large root/shoot ratios indicate greater ability to avoid drought (*1*). These ratios were calculated based on the dry weights of 50 seedlings from each treatment. In addition, stem caliper and height were measured.

Internal water deficit and percent survival of outplanted seedlings were selected as additional indicators of drought avoidance. One hundred seedlings from each treatment were outplanted on a south facing, rangeland site in mid-April 1975. The site was located on the west side of the California coast range, 10 miles east of Arcata. The south aspect, heavy grass and forb vegetation and the rainless summer months typical of California create a very droughty environment from June through September. Four seedlings were outplanted per square meter, one from each treatment. Fencing, deer repellent, fungicide, and rodenticide were used to prevent mortality from sources other than drought. In addition, seedlings that showed signs of damage not caused by drought, were eliminated from sampling. Internal water deficit was measured at 2-week intervals during the first summer after outplanting by the relative turgidity method (*3*). Percent survival was calculated at the end of the summer.

Data and Results

Analysis of variance tests indicated that root/shoot ratios of wrenched seedlings were significantly ($\alpha = .01$) greater than unwrenched seedlings (table 2). Shoot weight, stem caliper, and height were significantly ($\alpha = .01$) reduced in wrenched seedlings while root system weights remained largely unaffected. Therefore, the nearly 100 percent increase of root/shoot ratio was the result of decreased top size. Wrenching also created a noticably more fibrous root system which should increase the water-absorbing surface area of wrenched seedlings. These data suggest that wrenched seedlings are more capable of avoiding internal water deficit during periods of drought because the fibrous root system can more effectively meet the moisture requirements of the smaller shoot.

Table 1.—*Undercutting depths and time intervals between undercutting for wrenched* 2-0 *Douglas-fir seedlings*

Unwrenched-control seedlings		
Treatment Designation	Undercutting depth	Time interval between undercutting
	(inches)	*(weeks)*
8/4	*8*	*4*
8/2	*8*	*2*
6/2	*6*	*2*

Drought is an internal water deficit severe enough to reduce growth in plants and is caused primarily by the unavailability of soil moisture (*1*). Therefore, seedlings able to avoid drought should show low internal water deficits during periods of drought. Mean internal water deficits of treatments wrenched at an undercutting depth of 8 inches (treatments 8/4 and 8/2, table 1) were significantly less ($\alpha = .01$) than mean internal water deficits of the control (UW) for a period of 45 days after outplanting. Consequently, the results suggest that for nearly 7 weeks after outplanting, seedlings undercut at 8 inches avoided drought more effectively than seedlings from the unwrenched (control) treatment.

Percent survival data indicated that seedlings undercut at a depth of 8 inches were better able to survive their first

Table 2.—*Shoot-and root-system size data for wrenched and unwrenched 2-0 Douglas-fir seedlings, n=50*

Parameter		Treatment			
		UW	8/4	8/2	6/2
Shoot length (cm)	$\bar{X}$	47.2**	36.5	36.6	37.6
	SD	10.3	10.9	9.5	11.3
Stem caliper (cm) [1]	$\bar{X}$	.87**	.62	.66	.69
	SD	.23	.16	.16	.17
Shoot weight (gm)	$\bar{X}$	19.2**	11.4	16.2	11.4
	SD	12.5	6.0	7.7	5.8
Root system weight (gm)	$\bar{X}$	5.2	5.9	8.5	6.2
	SD	3.2	2.9	4.2	3.8
Root/shoot ratio [2]	$\bar{X}$	.28**	.53	.54	.56
	SD	.05	.14	.19	.21

[1] Stem caliper measured at the base of the shoot.
[2] Root/shoot ratio based on dry weight.
**Significant difference between wrenched and unwrenched treatments. (α = .01).
$\bar{X}$ = mean
SD = standard deviation

Table 3.—*Percent mortality of wrenched and unwrenched 2-0 Douglas-fir seedlings at the end of the first summer after outplanting*

Treatment	Sample size	Mortality
	(n)	*(percent)*
UW	96	69
6/2	97	56
8/4	98	47*
8/2	98	44**

**Significantly less than treatment UW (α = .01).
*Significantly less than treatment UW (α = .025).

summer of outplanting (table 3). Mortality was due primarily to moisture stress; therefore, this data provides additional evidence that wrenching did increase the ability of 2-0 Douglas-fir seedlings to avoid drought.

Summary and Conclusions

The data gathered suggest that wrenching at a depth of 8 inches increased the ability of 2-0 Douglas-fir seedlings to avoid drought. All wrenching treatments significantly increased (α = .01) the root/shoot ratios of the experimental seedlings. Seedlings undercut at 8 inches showed reduced internal water deficits and improved survival when compared to unwrenched (control) stock. Therefore, wrenching may be an effective tool for increasing the survival of Douglas-fir plantations when drought is likely to be severe.

A nursery bed density of 5.8 seedlings per square foot was low for most bareroot stock. As a result, the test seedlings were larger than 2-0 bareroot stock normally outplanted. Although the 8-inch undercutting depth appeared to be most effective for increasing drought avoidance, the same results may not be obtained from seedlings raised in nursery beds of greater densities. Additional work should be performed to determine the influence of nursery bed density on survival of wrenched seedling

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