PERFORMANCE OF CONTAINER-GROWN DOUGLAS-FIR ON DROUGHTY SITES IN SOUTHWEST OREGON

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Abstract.--First-year growth and survival data from two plantations of container-grown and bare-root Douglas-fir *(Pseudotsuga menziesii* [Mirb.] Franco) seedlings on hot, dry sites in southwest Oregon are discussed. The container-grown plants demonstrated better shoot and root growth and had higher survival than the bare-root seedlings in both plantations.

Résumé.--La croissance et la survie de semis de Douglas taxifoliés cultivés en récipients ou à racines nues dans deux plantations au climat chaud et aride du sud-ouest de l'Oregon sont discutées. Dans les deux cas, la croissance de pousses et des racines et la survie des semis en récipients sont plus grandes que chez les semis à racines nues.

INTRODUCTION

Southwest Oregon is an area of diverse environments and complex geology. Its flora combines elements from northern California, eastern Oregon, and the Douglas-fir *(Pseudotsuga menziesii* [Mirb.] Franco) forests to the north as well as many indigenous species (Franklin and Dyrness 1973). The climate is moderate; winters, during which most of the precipitation occurs, are mild, and summers are hot and dry. An exception is a narrow coastal belt where the climate is characteristically cool and moist. The region itself has a land area of 3,296,985 ha, of which approximately 2,480,327 ha are considered commercial forest land (Bassett 1979).

The Siskiyou Mountains, occupying the western half of the region, have severe regeneration problems. The ecology of these mountains has been described in detail by Whittaker (1960), Waring (1969), and Franklin and Dyrness (1973). Summer drought can be particularly prolonged, with only 18% of the annual precipitation occurring between April and September (Gratkowski 1961) and mean maximum air temperatures for July in excess of 29°C (Anon. 1960). The topography is characterized by steep mountains whose slopes range from 40 to 80% and elevations up to 2,296 m. Many of the soils are typically shallow (< 1 m); coarse fragment contents account for over 35% of the soil volume. Competition for moisture from a variety of sclerophyll brush and grass species is intense, and site-prepared areas are rapidly dominated by unwanted vegetation if newly planted trees fail during the first 5 years. Sites with southern exposures in steep terrain are particularly resistant; repeated operational plantings with the widely used 2-0 bare-root Douglas-fir seedling on such sites have produced disappointing results. A matter of increasing concern is that this regeneration failure has caused the recent withdrawal of more than 68,300 ha of commercial forest land from the timber production base (Anon. 1978, 1979b).

Poor seedling survival can be attributed to a wide variety of causes ranging from poor nursery practices to inadequate site preparation. Recently, however, it has been suggested that 2-0 bare-root Douglas-fir seedlings may not be the most appropriate stock type for the environments normally associated with droughty sites in southwest Oregon. This paper reports on the preliminary results of two separate Douglas-fir stock type comparisons involving bare-root, container-grown, and pulp-pot seedlings on droughty sites in southwest Oregon.

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BARE-ROOT, CONTAINER-GROWN, AND PLUG-1 COMPARISON

Three Douglas-fir stock types were outplanted in a randomized complete block experimental design with five replications on a severe site at Soldier's Camp Saddle in March 1980. Located at an elevation of 1,067 m, with a southeast exposure and a 75% slope, the test site is typical of many hard-to-regenerate areas in the Siskiyou Mountains. Mean annual precipitation is from 178 to 203 cm (Anon. 1979a). The soil is a loamy-skeletal, mixed, mesic Dystric Xerochrept (Anon. 1975) with a surface mantle of loose rock, gravels, and vegetative debris; soil depth is <1 m. Logged in the early 1970s, the site had been planted several times with 2-0 bare-root Douglas-fir and spot-seeded once with sugar pine *(Pinus lambertiana* Dougl.), but in 1980 remained unstocked.

Dominated by several species of sclerophyll brush, the test site was handslashed with chainsaws to prepare it for planting. Stock types planted were: (1) 2-0 bare-root seedlings, (2) 1-0 container seedlings grown in 164-cm^3 Leach single cells, and (3) plug-1 seedlings initially grown in 66-cm^3 Leach single cells and then transplanted to the nursery bed as bare-root seedlings for an additional year. Two hundred seedlings per stock type were hoe planted and protected from deer browsing by flexible Vexar tubes. Seedling height and diameter were measured immediately after outplanting and again in November 1980.

Half of the seedlings were subsequently used for plant moisture-stress measurements. Every 3 weeks over a 4-month period in the summer of 1980, predawn measurements for each stock type were taken with a Pressure Bomb (Waring and Cleary 1967) according to a method developed by Scholander et al. (1965). On each measurement date, 10 seedlings per stock type were selected at random and destructively sampled to determine plant moisture stress.

Survival of container-grown and plug-1 seedlings was significantly greater than that of bare-root stock (chi-square = 48.62, 2 d.f.) in July 1981 (Table 1). Bare-root seedlings suffered 37% mortality during the first year whereas container-grown and plug-1 seedlings had losses of only 5 and 7%, respectively. During the first half of 1981, population levels of all stock types showed signs of stabilization.

First-year growth performance of 2-0 bare-root seedlings was poor; average height increased only 4.44 cm. The 1-0 container-grown seedlings gained an average of 6.72 cm and plug-1 seedlings an average of 7.24 cm (Table 2). Diameter increases of 0.48, 0.70, and 0.42 mm for 2-0 bare-root, 1-0 container, and plug-1 seedlings were recorded during 1980. On a relative basis, the percentage increases in height and diameter of 1-0 container-grown seedlings far exceeded those of the other two stock types, although both were larger in terms of total height and diameter.

Table 1. Percent survival of three Douglas-fir stock types at Soldier's Camp Saddle.

Stock type	1980 August	1980 November	1981 May	1981 July
2-0 bare-root	74	63	57	57
1-0 container	100	95	93	92
Plug-1 bare-root	97	93	91	91

Predawn plant moisture stress was consistently lower in 1-0 container seedlings from May through September except for one measurement period in which weather conditions were unusual (Table 3). Mean plant moisture stress in 2-0 bare-root seedlings was higher than that of 1-0 container or plug-1 seedlings except as previously noted. Higher levels of plant moisture stress in 2-0 bare-root seedlings, particularly from May through July, were reflected in poorer survival and growth.

BARE-ROOT, CONTAINER-GROWN, AND PULP-POT COMPARISON

In 1978, three Douglas-fir stock types were outplanted at Brummet Creek, approximately 80 km north of Soldier's Camp Saddle. In 1977 a prescribed burn was carried out on the test site, which was located on a 6.47 ha clearcut. Characterized by a southeast aspect and 30% slopes at an elevation of 396 m, the site has deep soils (>1 m) classified as either a fine-loamy mixed, mesic Typic Haplumbrept or a fine-loamy mixed, mesic Umbric Dystrochrept (Anon. 1975). Mean annual precipitation is between 203 and 254 cm (personal communication from Craig Garland, Coos Bay District, USDI, Bureau of Land Management).

Over 2,000 seedlings of each of three stock types were planted in randomly assigned parallel rows that ran across contours. The stock types were: (1) 2-0 bare-root seedlings, (2) 1-0 container seedlings grown in 164-cm^3 Leach single cells, and (3) 1-0 seed-

Table 2. Mean height and diameter of three Douglas-fir stock types 1 year after outplanting at Soldier's Camp Saddle.

Stock type	Mean ht, 1980 (cm)		Height increase (cm)	Mean diam, 1980 (mm)		Diam increase (mm)
	March	November		March	November	
2-0 bare-root	19.13(±5.10)[a]	23.57(±6.01)	4.44	5.48(±1.43)	5.96(±1.30)	0.48
1-0 container	14.27(±3.10)	20.99(±3.81)	6.72	2.71(±0.60)	3.41(±0.64)	0.70
Plug-1 bare-root	33.10(±6.53)	40.34(±7.43)	7.24	6.71(±1.06)	7.13(±1.03)	0.42

[a]Standard deviations within parentheses.

Table 3. Mean predawn plant moisture stress of three Douglas-fir stock types at Soldier's Camp Saddle (May through September, 1980).

Stock type	Measurement date					
	28 May	8 July	29 July	19 Aug	9 Sep	30 Sep
2-0 bare-root	13.15(±7.93)[a]	9.41(±5.83)	20.11(±13.83)	11.74(±3.85)	20.56(±13.87)	19.35(±11.42)
1-0 container	5.98(±1.03)	5.46(±1.02)	8.85(±0.96)	13.08(±7.32)	13.29(±6.23)	16.90(±7.71)
Plug-1 bare-root	9.74(±3.61)	8.04(±2.99)	13.61(±10.20)	13.96(±7.23)	17.08(±9.49)	18.97(±9.84)

[a]Standard deviations within parentheses.

Table 4. Survival and mean height of three Douglas-fir stock types one growing season after outplanting at Brummet Creek.[a]

Stock type	Survival, September 1978 (%)	Mean ht, 1978 (cm)		Height increase (cm)
		March	September	
2-0 bare-root	82	29.51(±6.86)[b]	37.31(±10.16)	7.8
1-0 container	95	16.28(±3.28)	29.34(±7.39)	13.06
1-0 pulp-pot	100	14.17(±3.61)	32.89(±11.58)	18.72

[a]Data provided courtesy of the Coos Bay District, USDI Bureau of Land Management.
[b]Standard deviations within parentheses.

lings grown in biodegradable pulp-pots fabricated from papier mache. The pulp-pots were approximately 30 cm long, had a tapered cylindrical shape and an upper diameter of 8 cm; the bottom end of each pot was perforated for drainage. Seedling growth and survival data were collected by examining one randomly selected row of 125 seedlings for each stock type.

Survival of all three stock types was high at the end of the first growing season after outplanting (Table 4), although significant differences in survival did exist (chi-square = 31.9, 2 d.f.). Seedlings grown in pulp-pots outperformed 1-0 container and 2-0 bare-root seedlings in terms of survival and increase in height growth (Table 4). The 2-0 bare-root seedlings had the lowest survival rate (82%) and the smallest height increase (7.8 cm) even though they were the largest seedlings outplanted.

DISCUSSION

Douglas-fir 2-0 bare-root seedlings, a stock type frequently planted on dry sites in southwest Oregon, did not perform as well as other stock types the first year after outplanting in two separate trials. Survival and growth of all seedlings at Soldier's Camp Saddle, a site characterized by a thin, skeletal soil, were poorer than those of the seedlings planted at Brummet Creek, evidence that the former is a more stressful site. The much poorer growth and survival of the 2-0 seedlings at Soldier's Camp Saddle suggest that this stock type is less resistant to extreme site conditions in southwest Oregon than container-grown seedlings. This may reflect the poorer physiological condition of 2-0 seedlings, as manifested by significantly reduced needle length on 1978 shoots, or the relatively poor root growth of 2-0 stock compared with that of container-grown seedlings.

When excavating seedlings for plant moisture-stress measurements at Soldier's Camp Saddle, we found that the 2-0 bare-root stock did not produce new root growth to the same extent as the 1-0 container-grown and plug-1 stock types. Although this growth was not quantified, the difference in the number and length of actively growing root tips among stock types was profound. Even at the time of planting, root systems of both the 1-0 container-grown and plug-1 seedlings were obviously better developed than those of the 2-0 bare-root stock. Only a few seedlings were excavated at Brummet Creek, and these were dug in fall during a period of low root activity. Nonetheless, the relative superiority of root development in container-grown seedlings was equally evident in this plantation. Undoubtedly, the stock types with more vigorous root growth were able, as Schubert (1977) suggests, to use deeper sources of soil moisture, particularly as soil dried with advancing summer drought. This point is reinforced by the higher plant moisture-stress values generally encountered in the 2-0 bare-root seedlings (Table 3). Other data collected from four test sites near Soldier's Camp Saddle with 1-0 container-grown Douglas-fir support this hypothesis (S.D. Hobbs, unpublished data).

These preliminary results, which support data reported for the Sierra in California (McDonald and Cosens 1980), indicate that seedlings grown initially in containers may be better adapted to loamy soils than 2-0 bare-root seedlings on southerly sites in southwest Oregon, where moisture is a limiting factor. A well developed, fibrous root system capable of rapid growth seems to be a major factor governing seedling success on well drained, dry sites. Substantial root growth should occur during the first year to meet the high moisture demands placed upon the seedling during prolonged periods of high temperature and little precipitation. In this respect, 2-0 bare-root Douglas-fir seedlings have not done as well as other stock types, particularly on droughty, skeletal soils. These data are in agreement with data on the general performance of bare-root Douglas-fir seedlings, and strongly support the hypothesis that current bare-root nursery regimes do not produce seedlings of the highest vigor.

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