The results of this trial suggest that Areca palm seedlings are highly tolerant of adverse conditions during transplanting. The most detrimental factor in this study was desiccation of roots at transplanting. Best results were obtained when the roots received minimum disturbance (when seedlings were removed from the medium, potted and watered immediately).

Plant losses can be further minimized by transplanting at an early stage, either at the spike-leaf or 1st-leaf stage rather than the recommended 2nd-leaf stage. Growth reduction and mortality of seedlings increased as seedling age at transplanting increased.

Significance to the Nursery Industry

Palms are considered slow growing plants which require considerable time to reach salable size. To reduce this time and maximize profits, growers should avoid situations which stress the plants during the production cycle. This study suggests that growth reductions and plant losses can be minimized when transplanting is done at the spike- or 1st-leaf stages, and when root disturbance and desiccation are minimized.

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Douglas Fir Seed Sources Tested for Christmas Trees in Connecticut[1]

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Abstract

Douglas fir, *Pseudotsuga Menziesii* (Mirb.) Franco, is a popular Christmas tree in the Northeast. In 1976 trees from 11 geographic sources ranging from British Columbia to southern Arizona and New Mexico were planted in a replicated design and managed as a commercial plantation. Information was also obtained on 10 seed sources grown on a commercial tree farm. All sources were hardy in the Connecticut plantings. In general, trees from southern Rocky Mountain sources were bluer, and grew faster than those from northern sources, but they were also more susceptible to attack by Cooley gall aphid, *Adelges cooleyi* (Gill), and rhabdocline needle cast fungus, *Rhabdocline pseudotsugae* (Syd.)

Index words: Douglas fir, *Pseudotsuga Menziesii,* Christmas trees, seed sources, *Rhabdocline pseudotsugae, Adelges cooleyi*

Introduction

Douglas fir has long been a staple of the timber industry in the West. It is native from Alaska to Mexico and found from sea level to 3300 m (10,000 ft). It is also an excellent Christmas tree and is widely grown in plantations in western and eastern United States. Genetic variation within the species is great, and is related to geographical source (1,2,3,4). For instance, rapid growth and bluish foliage have been reported to be characteristic of southern seed sources in contrast to the slower growing, more yellow green foliage of northern sources. Different seed sources might well respond differently when grown in widely separated geographic areas, on different soils, or even when managed differently. Data comparing several Douglas fir sources under southern New England growing conditions were not available. We report the results of a replicated trial of 11 sources of Douglas fir grown at two locations and a commercial planting of 10 sources at a third location, all in Connecticut.

[1]Received for publication December 28, 1983; in revised form June 4, 1984. We gratefully acknowledge the following for their assistance in supplying seedlings, growing trees, cultural care, or recording and evaluating data: Peter Cumpstone, Nancy DePalma, Claude Heit, Phillip Jones, Gerald Walton.

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Materials and Methods

In 1974, 2-0 seedlings from 11 geographic seed sources of Douglas fir were grown in a transplant bed for 2 years. In 1976, 10 trees of each source were field planted in each of 4 replications at two locations; on Cheshire fine sandy loam at Lockwood Farm, Hamden and on Birchwood fine sandy loam and Merrimac sandy loam at the Valley Laboratory, Windsor, CT. Because of wet soil and frost heaving at the Windsor site a second planting was made in the spring of 1977 with 2-3 transplants, using plants from the first planting. Thus the Windsor 1 planting had 4 replications of 3 trees each and the Windsor 2 planting 3 replications of 3 trees. Both the Hamden and Windsor plantings included one source of white spruce, *Picea glauca* (Moench) Voss., for comparison, since this was the most popular species grown in Connecticut when the plots were established.

In addition, we report on the results of an unreplicated commercial planting of 10 Douglas fir seed sources on a Hollis-Charlton rock outcrop in Shelton, CT. Five of these seed sources were the same as those used in the replicated trials. The trees were field planted as 2-2 transplants in the spring of 1979 on an east facing hillside with 100 or more trees per source. The rows ran up and down the slope; the site was uniform from north to south.

All the Douglas fir seed sources (Table 1) in this study came from inland Rocky Mountains because Coastal sources are not hardy in Connecticut. At each site prior to field planting lime was applied as necessary to raise the pH to 6.0-6.5 and sod and weeds were eliminated in planting strips by spraying with paraquat. Tree spacing for the respective plantings was Hamden, 120 x 180 cm (4 x 6 ft); Windsor 150 x 150 cm (5 x 5 ft) and 150 x 180 cm (5 x 6 ft); and Shelton, 150 x 150 cm (5 x 5 ft). After planting, weeds were controlled by annual spring applications of the pre-emergence herbicides Princep (simazine) plus Surflan (oryzaline) and/or Dacthal (DCPA). Persistent perennial weeds were eliminated with directed sprays of Roundup (glyphosate) applied in the summer or early fall. Trees were fertilized in April with 28 g (1 oz) of 10N-4.3P-8.3K (10-10-10) per tree the second year after field planting and 56 g (2 oz) of 10N-4.3P-8.3K (10-10-10) per tree each year thereafter.

Trees were sheared in the summer (usually July) to a predetermined height growth (30-35 cm, 12-14 in) and/or to a standard taper. At both Hamden and Windsor one person sheared all the trees in a planting any given year to minimize bias from having different seed sources treated differently by different people. Height of each tree at Hamden and Windsor was measured annually after shearing. At Shelton the first 50 trees of each source were measured once after 4 years.

In all plots the systemic insecticide, Temik (aldicarb), was used some years to control Cooley gall aphid, *Adelges cooleyi* (Gill), and Sevin (carbaryl) was applied to control gypsy moth, *Lymantria dispar* L., during a severe outbreak.

Each tree in the Hamden and Shelton plantings was evaluated for shape, density, and merchantability irrespective of height and given a quality rating of 1 (bad) to 5 (best). To evaluate bud break, a date was chosen in the spring when most of the trees had begun to flush and each tree was rated on a scale of 1 (buds little swollen) to 5 (buds flushed and needles separated). The difference in bud break from earliest to latest was about 10 days.

The number of leaders that required straightening (tied) was recorded for the trees in the Hamden planting for 4 years, 1979-82. In addition, needle color of all trees was rated on a scale of 1 (yellow-green foliage) to 5 (silvery blue).

Injury caused by the Cooley gall aphid was rated for each tree in the replicated trials on a scale of 0 to 10 using a scale that corresponded with the percentage of needles damaged: 0 = none, 1 = 10%, and 10 = 100% injured.

Significant rhabdocline needle cast injury occurred only on the trees in the Hamden planting, a low site with poor air drainage. In May 1983, the north and south sides of each tree were rated separately on a scale of 0 (no damage) to 6 (severe damage).

Results and Discussion

Growth differences among seed sources in the seedling stage were maintained and magnified with age (Fig. 1). Seedling height when field planted was highly correlated with tree height 4 years ($r = 0.55$, $p < 0.0001$) and 7 years ($r = 0.50$, $p < 0.0001$) later. All but two of the Douglas fir seed sources grew at least as fast as the white spruce. Four of the southern seed sources (Coconino NF, AZ, Apache NF, AZ, Lincoln NF, NM, and Santa Fe NF, NM) were 240 cm (8 ft) or more after 7 years compared to 180 cm (6 ft) for two of the slower northern sources (Shuswap Lake, BC and Coville NF, WA).

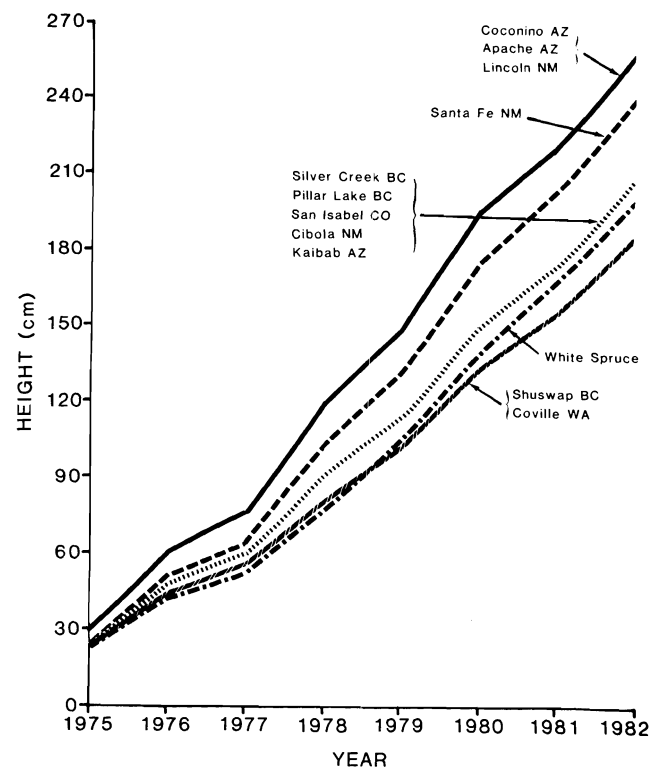

Fig. 1. Heights of 11 Douglas fir seed sources and one white spruce source during 1975-82, Hamden planting. Seed sources with similar growth rates were combined. Heights were taken at the end of each growing season.

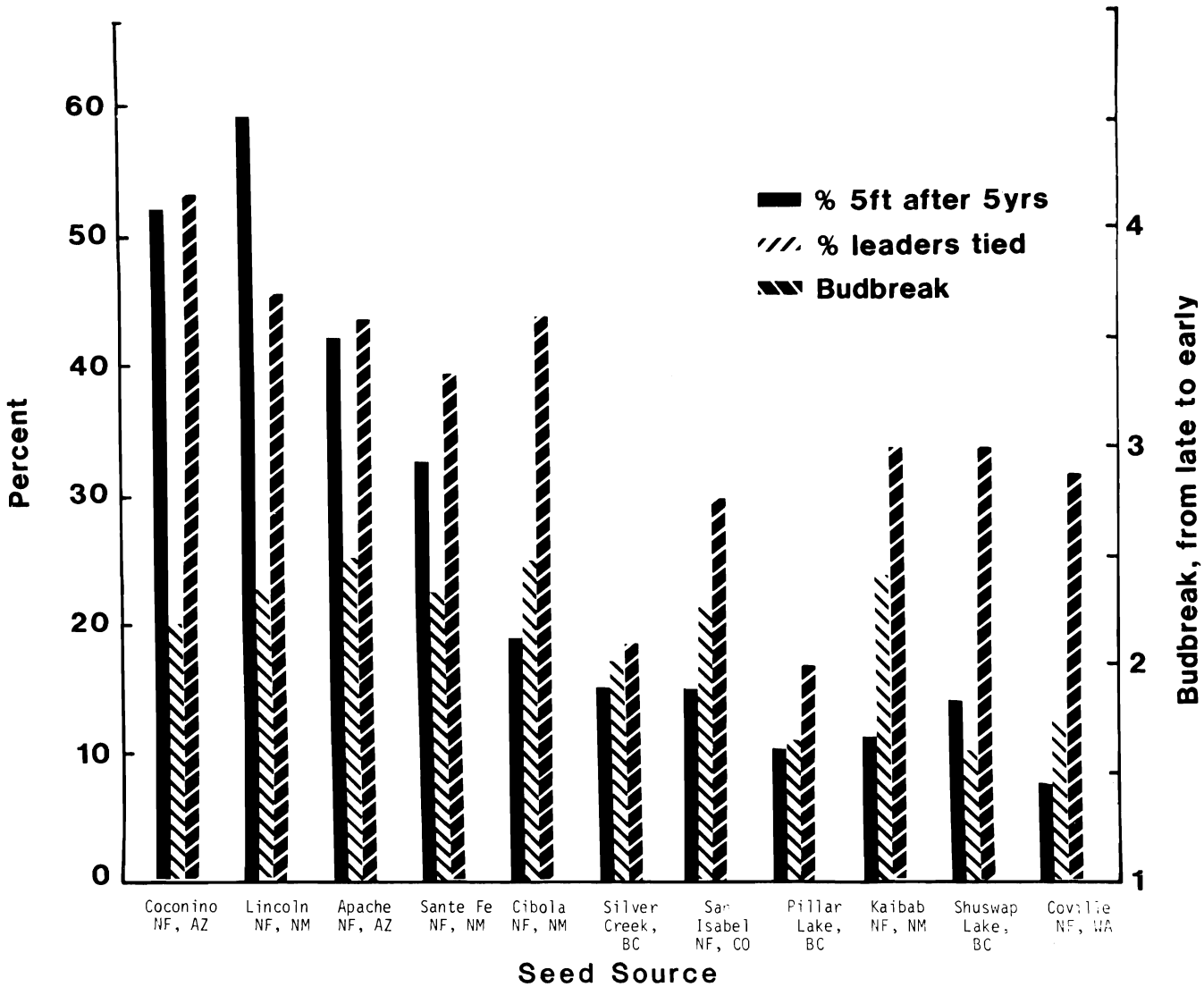

Fig. 2. Percent trees reaching 150 cm (5 ft) after 5 years, percent leaders requiring tying, and budbreak for 11 Douglas fir seed sources, Hamden planting.

In Figure 2, height growth of these same trees grown in Hamden is expressed as a percentage of trees of each seed source that obtained a marketable height (designated as 150 cm, 5 ft) by the end of four growing seasons. The rankings are slightly different from those in Figure 1, but the overall trends are similar. Although not detailed here, the results from the two plantings at Windsor were essentially the same.

At the Shelton site the rate of growth and quality were not closely correlated (Fig. 3). The fast growing Lincoln NF, NM seed source had very good quality compared to the equally fast growing but lower quality Coconino NF, AZ source. Quality of the slow growing sources varied at least as much, e.g., the slow growing Flathead NF, MT source had good quality compared to the fair quality of the similarly slow growing Jefferson Co, CO source.

Bud break is related to rate of growth; the faster-growing southern sources begin growth earlier (Fig. 2). Despite the differences in bud break we have noted no differences in frost resistance of seed sources at the three sites.

The number of leaders requiring tying ranged from 10 to 25 percent and was related to amount of height growth (Fig. 2). One notable exception was the Cibola NF, NM seed source which had as many crooked leaders as any other source but only moderate to poor growth. In contrast, in white spruce only 5% of leaders required tying.

Foliage color, although variable from tree to tree, fell into two distinct classes (Fig. 4). All seed sources from or below Colorado had blue-green foliage; the more northern sources were yellow-green. One notable discrepancy in the rating at Windsor compared to Hamden was for the Kaibab NF, AZ source, which was more yellow-green at Windsor than Hamden.

Cooley gall aphid is a common pest of Douglas fir in the East and can seriously deform and discolor needles. Aphid damage is highly correlated with needle color (Fig. 4). The lessened needle damage on the Kaibab NF,

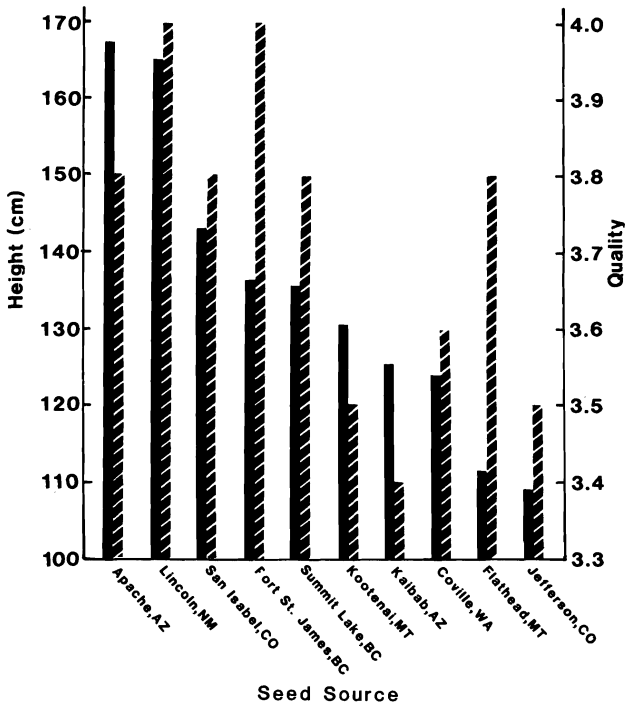

Fig. 3. Height (solid) and quality (bars) of 10 Douglas fir seed sources after 4 years, Shelton planting, fall 1982.

AZ source would indicate that the aphids perceive it as yellow-green or intermediate, as rated at Windsor, rather than equal to the blue-green of other southern sources tested.

Rhabdocline needle cast is a serious problem on Douglas fir. Whether because of wetter than normal springs in recent years or more plantings of Douglas fir, it now ranks as a major pest of Douglas fir in Connecticut. However, to date, only the planting at Hamden has been seriously affected by rhabdocline, and that damage just became apparent in the spring in 1983 (Fig. 4). In general, southern sources are most susceptible, with some exceptions, such as the Sante Fe NF, NM source that appears quite resistant.

Table 1 summarizes much of the information obtained from the 16 different geographic sources of Douglas fir grown at Hamden, Windsor, and Shelton, CT. The most valid comparisons are among seed sources grown at one site, but there were few discrepancies in the evaluations of a seed source grown at the three different sites. Rate of growth of trees was best at Shelton, yet the relative rate of growth of the different seed sources was similar at each site.

The results confirm large differences among geographic seed sources of Douglas fir. Most of the traits examined, including rate of growth, needle color, budbreak, Cooley aphid resistance, and rhabdocline needle

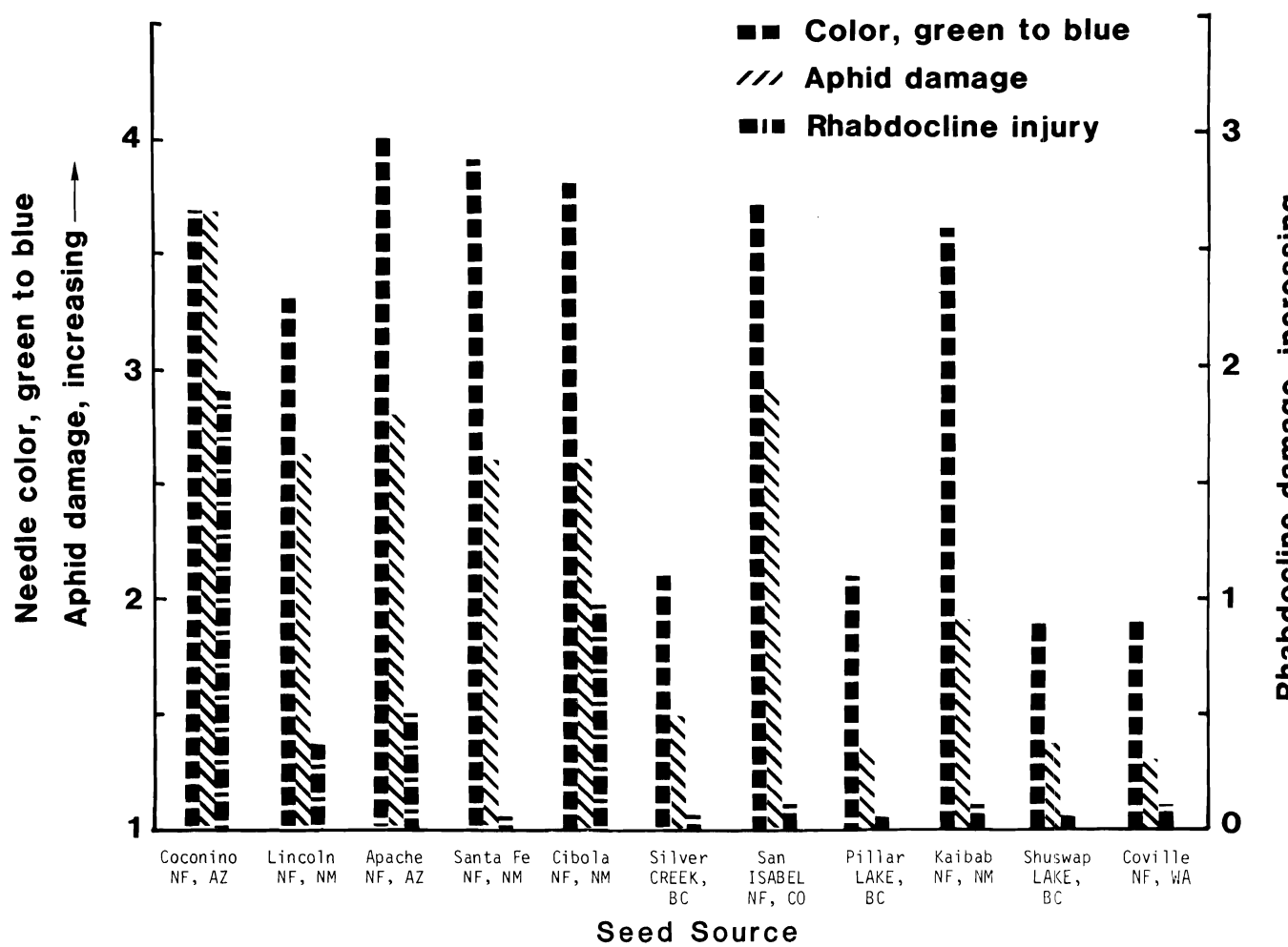

Fig. 4. Needle color, aphid damage, and rhabdocline needle cast injury occurring in 11 Douglas fir seed sources, Hamden planting.

Table 1. Summary of characteristics of 16 geographic seed sources of Douglas fir grown at Hamden, Shelton and Windsor, CT.

Seed source[z]	Elev.	Needle color	Cooley aphid resistance[y]	Rhabdocline needlecast resistance[x]	Bud break[w]	Quality[v]
Coconino NF, AZ	8500	blue	HS	HS	E	G
Lincoln NF, NM	8500	blue-green	S-HS	S	E	G-E
Apache NF, AZ	8500	blue	HS	S	E	G
Santa Fe NF, NM	9000	blue	HS	R	M	F
Cibola NF, NM	7800	blue	HS	HS	M	P
Silver Creek, BC	3500	green	R	R	L	F-G
San Isabel NF, CO	8600	blue variable	S-HS	R	variable	F-G
Pillar Lake, BC	3000	green	R	R	VL	G
Fort St. James, BC[u]	2700	green (dark)	—	—	L	E
Summit Lake, BC[u]	2400	green	—	—	L	G
Kootenai NF, MT[u]	4000	green	—	—	L	F
Kaibab NF, AZ	9000	blue variable	S	R	L-M	F
Shuswap Lake, BC	unk	green	R	R	L	F
Coville NF, WA	2500	green	R	R	L	F
Flathead NF, MT[u]	3800	green	—	—	VL	G
Jefferson Co., CO[u]	7000	blue variable	—	—	M	F

[z]Combined average of all four plantings after 4 yrs. Arranged in order of decreasing growth. NF = National Forest

[y]Sources grown only at Shelton, CT could not be evaluated because of annual control by insecticides. R = resistant, S = susceptible, HS = highly susceptible.

[x]Needle cast not severe enough at Shelton to evaluate. R,S,HS, as for note 2.

[w]E = early, M = medium, L = late, VL = very late.

[v]Trees subjectively rated on density and form, not height, when given necessary pruning and cultural care. E = excellent, G = good, F = fair, P = poor.

[u]Sources grown at Shelton, CT only.

cast resistance show a strong north to south gradient. However, notable exceptions occur, e.g. some of the southern seed sources, such as Kaibab NF, AZ, were not rapid growing and the overall characteristic of tree quality varied greatly among seed sources having similar growth rates.

Buds broke earlier on the southern, more rapidly growing seed sources, but this did not make them more susceptible to frost. Indeed, on another site the earliest trees to flush growth were able to withstand a late frost as well as the trees just beginning to flush. Others have also reported no relationship between damage by late frost and early flushing (3).

Crooked leaders, and more irregular growth requiring pruning, were more of a problem on the fast growing trees. However, the extra work required per year for these trees may be more than compensated by the fact that they can be marketed one or more years sooner than slower growing trees.

The importance of foliage color in the market place is not as clear as with Colorado spruce where consumer preference is definitely for the blue-green color. In these trials there was little choice among the fast growing seed sources; all had blue-green foliage and were susceptible to Cooley gall aphid. Indeed the distribution was divided in 2 parts; sources from Colorado and the south were predominantly blue-green compared to the more northern yellow-green. Yet, variation within the Colorado and southern sources is considerable and, given efficient clonal propagation techniques, "blue" or "green" needled clones from the southern part of the range could be propagated.

More experience with rhabdocline needle cast on these seed sources is needed to make firm conclusions about susceptibility. Southern sources are more susceptible than northern, but variation among southern sources may allow for selection of moderately resistant strains.

Significance to the Nursery Industry

To grow Douglas fir rapidly in the East requires weed control and often lime and fertilizer applications. Variation in growth rate, branch habit and resistance to insects and disease affect rotation length and need for pest control. Success with Douglas fir from different seed sources could vary greatly with intensity of management. Thus growers have a choice of using slower growing northwestern sources requiring less shearing, tying of leaders and less pest control over a longer rotation or using faster growing southern sources to minimize rotation length, but requiring greater cultural care and pest control.

The Lincoln NF, NM seed source seems desirable for southern New England. It grows rapidly and exhibits some resistance to Cooley aphids and rhabdocline needle cast. However, caution should be exercised in extending the results and conclusions of the tests reported here to areas where the climate, soils, or cultural techniques are different.

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