Douglas-Fir Planting Stock Performance Comparison After the Third Growing Season

Philip F. Hahn and Allen J. Smith
Director of Forestry Research and Development and Research Forester, Georgia-Pacific Corporation, Cottage Grove, Oreg.

Three different types of containerized and bare-root Douglas-fir seedlings planted on north- and south-slope sites in Oregon are compared. Containerized seedlings exhibited superior survival rates on all sites, good height performance on the harsh south exposure, and considerably lower reforestation costs.

Millions of various types of bare-root and containerized nursery-grown Douglas-fir seedlings *(Pseudotsuga menziessi* (Mirb.) Franco) are planted annually in routine reforestation in the Pacific Northwest. Various types of bare-root seedlings have been used for this purpose for decades, while the use of containerized seedlings is relatively new.

This experiment provided some answers relating to the performance of the "new" containerized seedlings as produced by Georgia-Pacific Corporation in Oregon. Performance of the containerized seedlings was also compared to that of some bare-root seedlings. Comparisons were made of survival rates, height growth, and reforestation costs on two extremely exposured sites.

Materials and Methods

Location. The two sites chosen for the experiment are located at latitude 40° N. and longitude 122°45' W. near Eugene, Oreg. The sites represent two extreme reforestation conditions. One is a dry and warm south slope considered fairly harsh for Douglas-fir. The other is a more favorable (moist and cooler) site. Each site presents a special reforestation problem. The south slope provides a summer moisture stress, while the north slope generates severe vegetation competition for the newly planted seedlings.

Both the north and south exposure test units were located in clearcut areas, which were logged in 1978. The test plots were in regular reforestation units that did not receive land preparation or protection treatments. The test areas are in a 1,900-millimeter annual precipitation zone. There are no marked differences in precipitation between the sites. The soil series are Peavine on the north slope and Honeygrove on the south.

Seeds and seedlings. The seeds used to produce all the seedlings were from a commercial seedlot. This seedlot matched the seed and elevation zone of the experimental area. The different seedling types were initiated in various years and nurseries; therefore, they greatly varied in age and size at planting time. The containerized seedlings were produced by Georgia-Pacific Corporation in a shelterhouse growing facility in the three most commonly used polystyrene (styroblock) containers. The shelterhouses provide unique growing conditions for seedling production in this area. The houses are equipped with automatically controlled heaters and vents. Therefore, they promote rapid germination and seedling development during the spring. Later, the same facility converts into a nearly natural growing area to aid seedling growth.

The shelterhouse facility interacts well with the styroblock containers. The insulating capacity of the containers protects the roots against heat in the summer and against frost during fall and winter. The containers also provide a good means for hardening and chilling the seedlings, while maintaining an active root system during the dormant season.

The containerized seedlings used in this experiment were produced in the three most commonly used block cavity sizes. These are the 40-cubic-centimeter cavity size (type 2 containers), the 75-cubic-centimeter size (type 5 containers), and the 125-cubic-centimeter size (type 8 containers). The sizes of the produced seedlings are usually very closely linked to the container cavity sizes; the larger the cavity, the larger the seedling. The seedlings were initiated during the early spring of 1978 and were reared for one growing season with the growing regime routinely used.

The plug-1 stock was also initiated in the Georgia-Pacific container nursery facility 1 year earlier in 1977. Type 2 containers were used for the plug production. The seedlings were grown in the containers for one growing season and were transplanted to the bare-root nursery in late summer of the same year. Here, they were reared for another year to develop a stronger top and large fibrous root mass, which is typical for plug-1 seedlings.

The 3-0 stock was initiated in the Industrial Forestry Association's (I.F.A.) bare-root nursery in 1976. These seedlings stayed in the same seedling bed for 3 years before they were outplanted.

The 2-1 stock was also initiated in the I.F.A. nursery in 1976 as 2-0 stock. After the second growing season, they were lifted and transplanted for another year for added stem and root growth.

Design and layout. Both north and south exposure planting sites contain replicated parallel rows of 50 trees for each seedling type. Each seedling type is replicated four times on each site except the 2-1 seedlings. These are replicated only twice. The tree rows are located 2 meters apart, and the distance between seedlings is 1.5 meters. Each planting site contained 1,100 seedlings at planting time for a total of 2,200 seedlings for the entire experiment. The entire experiment was installed in February 1979, considered a favorable time in the region for field planting all the seedling types involved.

Measurements

The initial height measurements for each seedling type were taken immediately after planting and are shown in table 1 and figure 2. This initial measurement showed a great deal of variation in average height among seedling types because of their age difference and the way they were produced. At first glance, it would appear that this comparison is unfair. But it was assumed that each seedling type, regardless of original height differences, would have a built-in ability to compete based on how they were produced. The ability of a seedling type to survive and to grow well while overcoming brush competition and other adverse conditions is of paramount importance and is manifested by superior overall performance. (See the survival and height increment performance in table 1.)

During each measurement period, survival and height growth data were routinely collected. Each, in itself, is a good measure for evaluating seedling performance. However, if the two results are multiplied, a single, total performance factor is produced. This factor provides a more comprehensive measure for comparing seedling performance, especially when other factors like cost are also related to performance.

Results

Seedling survival after the third growing season was generally good on both sites (table 1). Only the initially tall 3-0 seedlings showed relatively poor performance on both sites, especially on the south exposure (65%). The plug-1 seedlings survived well on the north exposure (89%), but more poorly on the south exposure (80%). The 2-1 seedlings did relatively well on both exposures (north 86%, and south 92%). Overall, however, the containerized seedlings had the highest survival rate on each exposure, especially on the "harsh" south exposure (type 2-north 89%, south 94%; type 5-north 92%, south 97%; type 8-north 93%, south 97%). Survival results in graphic form are shown in figure 1.

It appears that the survival rates of the initially smaller containerized seedlings are superior because of their root characteristics and physiological makeup. They were also able to combat planting shock considerably better during the establishment phase than the larger and older bare-root seedling types were.

Height growth. During height measurements, restrictions on height growth such as animal damage to seedlings and vegetation competition were also monitored. Animal damage on both areas was considerably less than normal in freshly planted areas. In general, the damage that did occur was the heaviest on the south-facing slope-about twice the rate of the north-facing slope. Bare-root seedlings were definitely more heavily and frequently browsed than containerized seedlings. Again, the ratio was about two to one. The overall height growth reduction due to browsing was not serious on either exposure or for any seedling type. On the average, it was not more

Table 1.—*Seedling* type *survival and growth increment comparison on the north and south exposure test sites*

Exposure and seedling types	Average height / tree		Survival rate (12/81)	Growth Increment / average tree
	Original ht. (2/79)	Present ht. (12/81)		
	Cm	Cm	%	%
North slope				
2-1(bare-root)	46	135	86	193
3-0 (bare-root)	59	109	80	85
P-1 (bare-root)	36	108	89	200
Average[1]	49	111	84	127
Type 2 (container)	17	74	89	335
Type 5 (container)	22	82	92	273
Type 8 (container)	33	96	93	191
Average	24	84	91	250
South slope				
2-1 (bare-root)	48	97	92	102
3-0 (bare-root)	61	102	65	67
P-1 (bare-root)	38	106	80	179
Average	50	103	74	106
Type 2 (container)	17	95	94	459
Type 5 (container)	25	100	97	300
Type 8 (container)	33	112	97	239
Average	25	103	96	312

[1]Each average represents 200 trees except for 2-1 averages, which represent 100 trees.

than 1 centimeter per tree for any seedling type.

It appears that vegetative competition on the "moist" north slope may have had a significant influence on height growth. This is expressed by the relatively poor height performance of the initially smaller containerized seedlings.

Third-year height growth measurements indicate that the tall 3-0 seedlings did not maintain their original height superiority on either site. Tall 2-1 seedlings, however, performed well on the north-facing slope, while their performance on the south slope was considerably poorer. The plug-1 seedlings had reasonably good height performance on both slopes. Height growth performance of containerized seedlings was proportional to their cavity size; the smallest cavity size produced the smallest tree and the largest cavity size, the largest tree. Their height growth performance was considerably behind that of the bare-root seedlings on the north slope. Performance of containerized seedlings matched that of bare-root seedlings on the south slope, despite their initial height disadvantage.

Total performance. The combined seedling performance (average height of surviving seedlings multiplied by the survival rate) was calculated for each seedling type (fig. 2). A combined bare-root and containerized seedling total performance was also calculated (fig. 3).

Figure 2 (north) shows the initial average height of each seedling type. The curves indicate that the initial height difference pattern was maintained fairly well until the end of the third growing season by each seedling type except the 3-0 seedlings. The drop in the 3-0 seedling performance is mainly because of their poorer survival rate. In figure 2 (south), the total performance of the

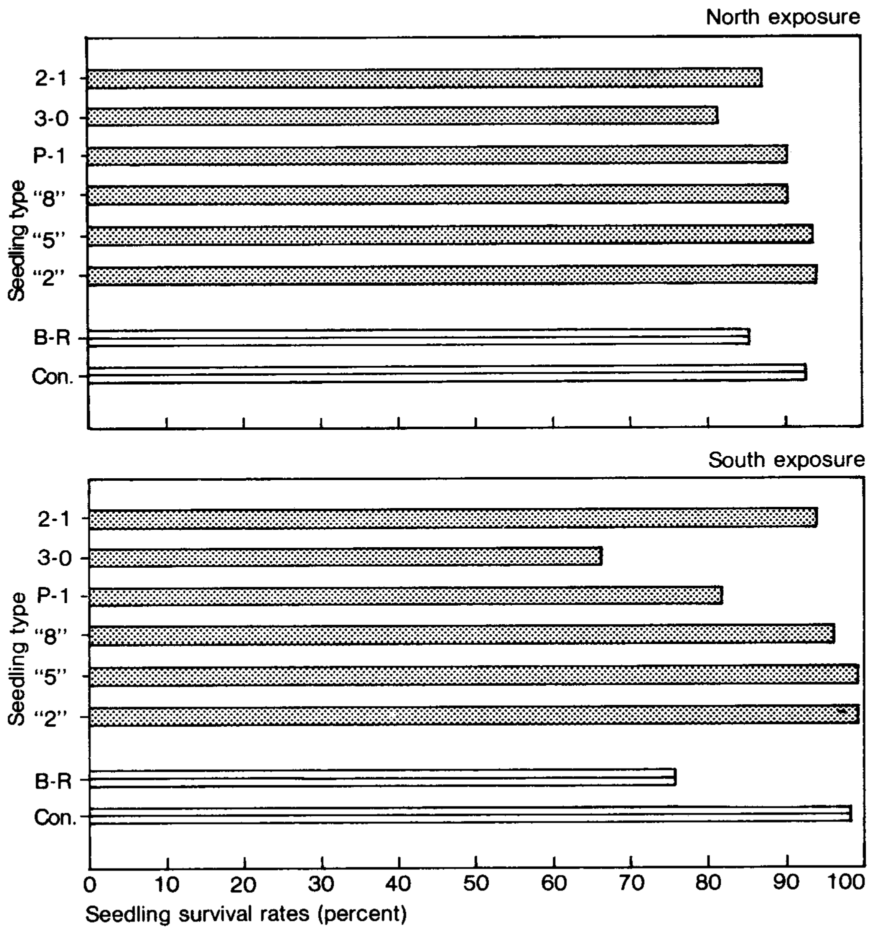

Figure 1.—*Survival rates of the various types of planting stock.*

initially tallest 3-0 seedlings dropped even further, while the other two bare-root types fell behind all three containerized seedling types.

Combined containerized and bare-root seedling performance comparisons (fig. 3 (north)) show superior performance for the initially taller bare-root seedlings, but the difference is being slowly closed by the containerized seedlings.

Figure 3 (south) shows a complete domination in total performance by the initially smaller containerized seedlings. These differences, on both exposures, were statistically significant at the 0.05 level.

Cost comparison. Commercial, large-scale reforestation cost figures for each seedling type were used to predict stand establishment costs based on the results of this experiment. A cost/benefit ratio for each seedling type was calculated by dividing the cost per thousand for planting each seedling type by the totsl performance of each type.

The result of this calculation showed a straight-line correlation in cost/benefit for containerized seedlings on each planting site. The cost of reforestation for the type 2 seedlings was the lowest, but so was the performance; while the type 8 seedlings represented the other end of the scale. The total variation among the containerized seedlings in cost/benefit ratio was about plus or minus 2 percent.

The cost/total performance or cost /benefit ratio varied greatly for the bare-root seedlings. Since the 3-0 seedlings showed the lowest performance rate among the bare-root group, they became the most expensive reforestation stock in spite of their initial lower cost. The seedling cost/total performance benefit ratio for each bare-root seedling type is compared to the containerized seedling cost/total performance benefit ratio in figure 4. The combined figure for bare-root seedlings indicates that the cost of using them is about twice the cost of using containerized seedlings on the south-facing slope. This difference drops to 25 percent on the north exposure.

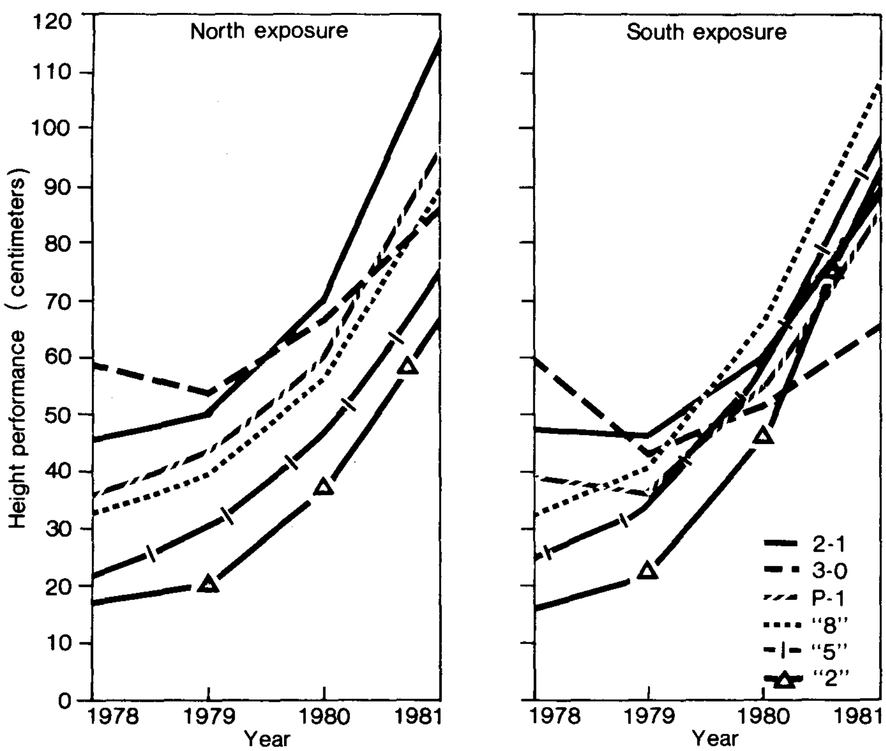

Figure 2.—*Total (average height x survival rate) performance comparison of the various seedling types*

Conclusion

The 3-year test results of this experiment are indicative of the performance of the six chosen seedling types. The same seedling types were used in general reforestation on Georgia-Pacific land when this experiment was installed. Each of the two test sites represents a large acreage of the company's reforestation land either on the coastal and north-slope, cooler, "wet" sites or on the south-slope, warmer, "dry" sites.

In the final analysis, it was found that the three bare-root seedling types followed a similar trend within each site, but performed quite differently when compared between sites. Similar trends were also observed for the containerized seedling types.

The originally taller bare-root seedling types showed a clear performance superiority on the north slopes (or cooler "wet" sites). On such sites, the "top-heavy" seedlings were not exposed to rapid drying after planting. Consequently, they were not subjected to typical dry-site planting shock, which results is lower survival rates and height growth. Under these conditions, the tall bare-root seedlings were able to stay above the brush and maintain good height growth. The adverse south-slope effect on survival and height growth for the tall bare-root seedlings was well documented (fig. 3). Here the performance trend was exactly opposite the north-slope trend.

Containerized seedlings performance turned out to be quite different. Containerized seedlings maintained higher survival rates on both sides than bare-root seedlings did. This is thought to be because of superior root quality and physiological makeup. Short containerized seedlings had a hard time growing up through north-slope brush. They apparently overcame this handicap on the south slope (figs. 2 and 3).

The observed growth trends are experienced in the company's large-scale reforestation program when seedling performance on relatively "wet" and "dry" sites is compared. The company's coastal areas in the Toledo division definitely show better reforestation results with large bare-root seedlings. On the other hand, containerized seedlings perform better on drier sites near Coos Bay and Eugene, Oreg.

Cost/ benefit ratios favor containerized seedlings on all sites. The difference in cost/benefit ratio is not large between plug-1 transplants and containers on the "wet" sites,

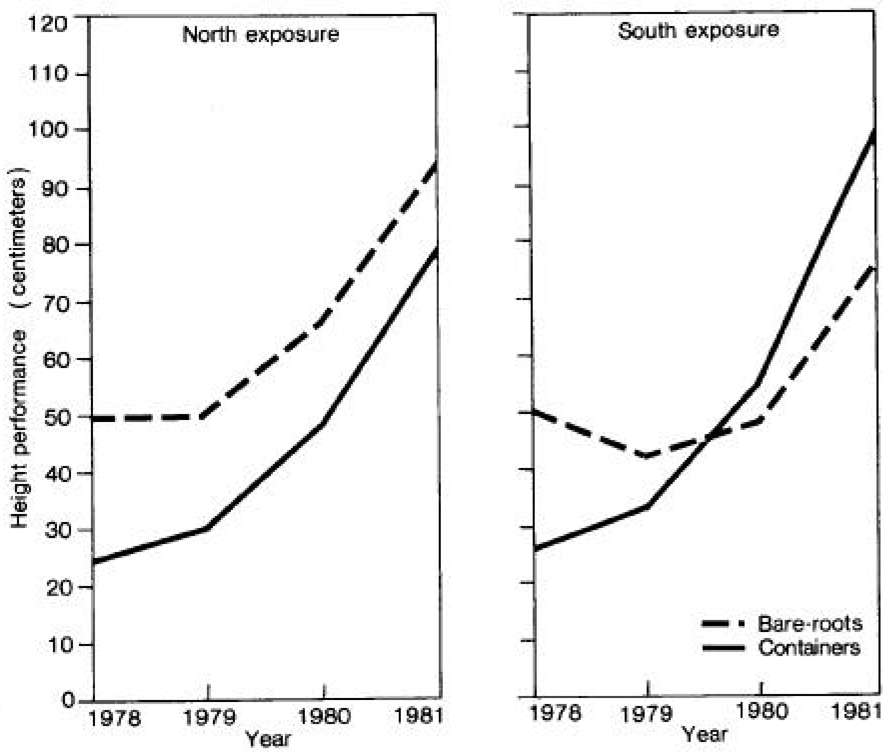

Figure 3.—*Total (average height x survival rate) performance comparison for combined container and combined bare-root stocks.*

and plug-1 transplant use can be justified on such sites.

As a rule of thumb for company lands, we recommend that well developed, hardy, type S containerized seedlings be planted on all sites except on north-facing slopes and "wet" coastal areas (where brush competition becomes severe shortly after planting). Well developed containerized seedlings survive, grow fairly well, and provide a better cost/benefit ratio on all sites. They do very well on drier sites.

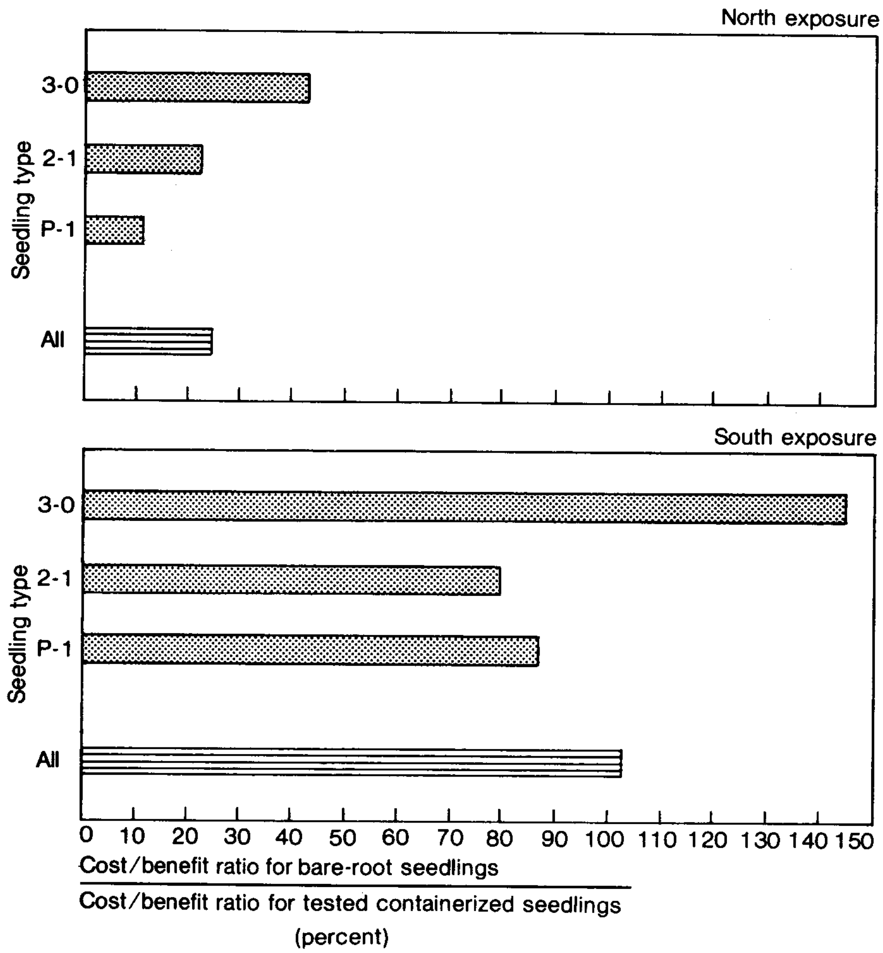

Figure 4.—*Relative seedling cost/total performance benefit for the various types of bare-root seedlings compared to the seedling cost/total performance benefit of all of the containerized seedlings. (Containerized seedling cost/benefit = 0%.)*