

COMPARATIVE LEADER GROWTH OF DOUGLAS- FIR GRAFTS, CUTTINGS, AND SEEDLINGS

Use grafts for early cone production on large crown surfaces because they grow fastest. Growth of cuttings and seedlings is about equal.

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Tree improvement workers often must decide whether to establish seed orchards from cuttings, grafts, or seedlings. One of the variables that should be considered is the number of years after propagation until seedlings, cuttings, and grafts grow large enough to permit adequate seed production. Thus, relative growth rate of each becomes a major consideration when propagation methods are selected.

Forest managers are also considering the advantages and disadvantages in the use of clones in reforestation, but information on growth rate and form of cuttings under field conditions is rare. Whether Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) cuttings will grow as rapidly as seedlings is not known, nor whether plagiotropic growth will be a persistent problem. The same questions are asked by seed orchard managers.

In this report, annual leader growth of grafts, cuttings, and seedlings was compared during the first 4 years after propagation and the first 4 years after field planting. The study emphasizes the advantages in time and relative growth that can be obtained from grafts on established rootstocks and supports the similarity in growth of cuttings and seedlings in the field

Methods

The grafts, cuttings, and seedlings examined in this report were originally grown for four separate studies labeled A, B, C, and D. Studies A and C dealt with cuttings. Study B examined the growth of grafts, and study D involved the growth of seedlings. Comparisons between studies were not planned when each was initiated, but such large differences were found between types of propagules that between-study comparisons were warranted to provide insight into the attributes of each. Growth was evaluated 4 years after propagation and 4 years after field planting. The plant types used for the propagation comparison were cuttings from study A, grafts from study B, and seedlings from study D. The field growth comparison was made with cuttings from study C, grafts from study 11, and seedlings from study D.

Propagation methods, source of propagules, and specific conditions governing propagules in each of the four studies are described below

Study A-Cuttings

In March 1970, 10- to 15-cm cuttings and scions were collected from 7-year-old coastal Douglas-fir trees growing in several Oregon Christmas tree plantations. Several days after field collection, the cuttings were placed into 21" C bottom-heated and sand-filled

rooting beds under intermittent mist.

The cuttings remained in the beds until roots formed in the summer or fall of 1970. The rooted cuttings were transplanted and grown for the next 2 years in a raised nursery bed filled with sandy loam soil. Field planting was done during the winter of 1972-73. At that time, 300 cuttings were planted at 1.8- by 3.7-m spacing at an outplanting site near Monmouth, Oregon. The cuttings were 3 years old and averaged 0.55 m tall when planted.

Study B-Grafts

Scions from the same trees used for study A cuttings were field grafted onto 263 large, well-established rootstocks several days after the cuttings were placed in the rooting beds. The rootstocks receiving grafts had been field planted as 2-0 seedlings at 3.7- by 3.7-m spacing in February 1964. This planting site was located 8 km from the Monmouth site. Soil type, aspect, and site class were similar to those at Monmouth. Rootstocks were leader pruned in 1968 and 1%9 to reduce tree height so the terminal leaders could be grafted upon them. Cleft grafts were made in April 1970 on the 1969 terminal leaders. Unions were placed an average of 1.3 m above the ground.

Study C-Cuttings

Cuttings for this test were collected in March 1967 from 4- to 8-year-old coastal Douglas-fir trees, rooted in sand-filled rooting beds, and transplanted into gallon containers later that same year. The potted cuttings were grown in a shade house during the 1968 and 1969 growing seasons. In November 1969, 187 cuttings were field planted at 1.8- by 3.7-m spacing at the Monmouth site. At that time, the cuttings were 3 years old and averaged 0.34 m tall.

Study D-Seedlings

Growth potential of seedlings was determined from a random selection of 100 trees. Seed source was similar to that of many of the cuttings (A) and grafts (B). The trees were grown from seeds in 1968 in raised nursery beds filled with sandy loam soil. They were field planted at the Monmouth site in January 1970 at 3.7- by 3.7-m spacing. The seedlings were 2 years old and 0.25 m tall when field planted.

Annual leader growth was measured in the winter of 1974-75 for the A, B, C, and D studies. Leader growth during the preceding years was determined from internodal measurements made from bud tips, bud scale scars, or from the top branch in each main whorl of branches.

Data pertaining to height of grafted trees have had the heights of the rootstocks or union subtracted, so all reported heights relate only to the scion.

Results

Three kinds of comparisons were possible: (1) a direct comparison of grafts and cuttings from the same clones, (2) comparison of cuttings and seedlings of the same general size at planting, and (3) growth comparison of grafts, cuttings, and seedlings in the field over 4 years.

Comparison of cumulative leader growth 4 years after propagation showed grafts to be four- to five-times taller than cuttings or seedlings. At that age, grafts were 3.2 m tall, whereas cuttings of the same clones were only 0.67 m tall (figure 1). An even greater difference in crown size or potential cone-bearing surface existed between grafts and cuttings or seedlings (figures 2 and 3) Four-year-old seedlings were only slightly taller than similar age cuttings (0.82 vs. 0.67 m, respectively). This insignificant difference resulted because cuttings required 3 years of nursery care before field planting and had only 1 year of field growth when the measurements were taken after 4 years. Seedlings required only 2 years of nursery care before field planting, so they had 1 more year

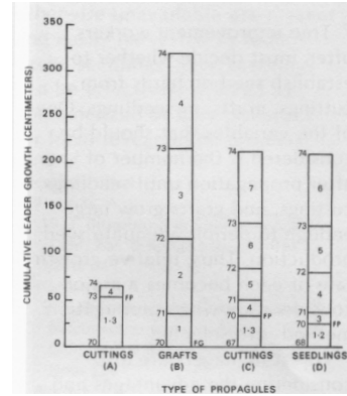


Figure 1. Histogram comparing cumulative leader growth after propagation of cuttings, grafts, and seedlings. Numbers within the rectangles denote tree age in years. Numbers outside the rectangles identify the year. FP signifies the approximate period when the trees were field planted or grafted.

of field growth than did cuttings when the measurements were recorded.

After 4 years in the field, grafts were approximately one-third taller than seedlings or cuttings (figures 2, 4, and 5). Seedlings and cuttings averaged 2.1 m tall, and grafts averaged 3.2 m. It should be noted that, because of differences in propagation methods, grafts were only 4 years old at that time, but seedlings and cuttings were 6 and 7 years old, respectively. Crown size or



Figure 2. A Douglas-fir graft is shown 4 years after grafting. The graft union is located about 1.5 m above the ground where the ribbon can be seen tied around the bole. Note the large crown surface for cone production.

potential cone-bearing surface of grafts was still two to three times larger than crown areas of cuttings and seedlings.

Annual field growth rates of cuttings and seedlings were similar (figure 6). Growth during the first, third, and fourth years was almost identical. One minor deviation occurred the second season after field planting when seedlings grew 43 cm and cuttings grew only 34 cm. Besides



Figure 3. A 4-year-old Douglas-fir cutting is shown. This is the same clone shown as a graft in figure 2. Note the small crown surface for cone production.

similarity in growth rate, the form, or phenotype, of cuttings was similar to that of seedlings. During the first 2 years after rooting, more than 90 percent of the cuttings grew plagiotropically, but the incidence of plagiotropic growth had gradually decreased to less than 15 percent when the cuttings were 7 years old. Most 7-year-old cuttings resembled normal, orthotropic trees.

Leader growth of grafts exceeded that of cuttings and seedlings in each of the 4 years (figure 6). Grafts reached near



Figure 4. A typical 6-year-old Douglas-fir seedling is shown after 4 years of field growth.

maximum growth in the third or fourth year after being grafted, but seedlings and cuttings were approximately 2 years behind in comparable growth. Greater height growth occurred in grafts than in cuttings or seedlings because scions had been grafted upon rootstocks that were well established and capable of promoting good growth.

Rootstock size was not directly measured, but in 1974 the height of the graft union above the ground was recorded. Graft union height measurements were used to estimate approximate rootstock size in 1970. Graft unions made on large rootstocks were placed higher above the ground than were graft unions made on small rootstocks. The correlation between union height and 4 years of cumulative leader growth was $r = 0.67$ ($p < 0.01$).

An even higher correlation would probably have been obtained if the union height-rootstock height correlation had not been weakened by pruning of leaders prior to grafting in 1968 and 1969.

Discussion

This report has two main findings. Grafts made on well-established rootstocks grew much faster than did seedlings or cuttings of the same seed source or clones, respectively. Field growth of cuttings (from young trees) and seedlings was nearly identical.

The finding that grafts were far larger than cuttings or seedlings of similar age is important to seed orchard managers who must select the best propagation methods. Crown areas of 4-year-old grafts were approximately 20 to 40 times larger than the crown areas of 4-year-old cuttings of the same clones; thus, the difference in cone-bearing potential between cuttings and grafts is obvious. If large amounts of seed are needed as early as possible after an improvement program begins, then grafts on large, well established rootstocks will achieve that goal in a much shorter time than rooted cuttings. It is recommended that rootstocks be field planted 2 to 3 years before grafting. If field planting of rootstocks is done several years before plus-tree selection, no delay need follow plus-tree selection.



Figure 5. A typical 7-year-old Douglas-fir cutting showing 4 years of field growth. The cutting is orthotropic and looks like a normal seedling.

The second finding, that field growth of cuttings and seedlings was equal, suggests that cuttings can be planted instead of seedlings when forest managers want to utilize the advantages of clones. This growth equality exists only when cuttings are rooted from juvenile trees. If cuttings from older trees had been used, the growth equality between cuttings and seedlings would not have occurred. Personal observations of cuttings grown from mature Douglas-fir plus-trees have indicated much slower leader growth 4 to 6 years after field planting than is obtained with seedlings or cuttings started from juvenile trees. In similar

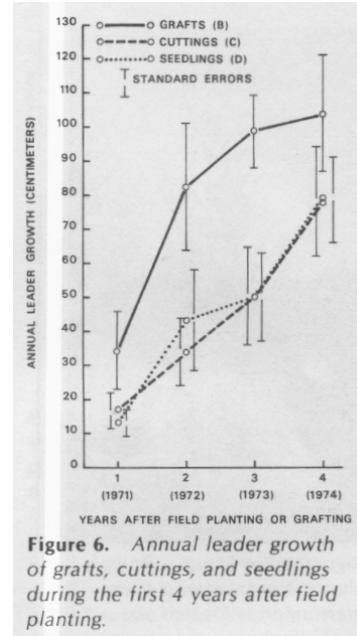


Figure 6. Annual leader growth of grafts, cuttings, and seedlings during the first 4 years after field planting.

findings, cuttings from 1- to 7-year-old Monterey pine ortets grew as well as seedlings after 3 years in the field; but cuttings from 17-year-old ortets gave inferior growth (1). In another study, cuttings from mature Monterey pine ortets grew slower than cuttings from juvenile ortets

(2). Cuttings from juvenile trees resembled normal, vigorous seedlings after 4 years in the field. More than 80 percent of the cuttings were plagiotropic 2 years

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 large seedlings survive and grow better after planting than small seedlings (2,3,5). Time of planting was also a factor. The 1-0 bareroot seedlings were planted in April and therefore had 3 months to develop an already established root system before being subjected to the hottest and driest part of the growing season. On the other hand, the 2month-old containerized seedlings were exposed to stressful growing conditions immediately upon outplanting in July. These severe conditions probably account for most of the early mortality of the containerized seedlings. Observations indicate that later mortality may have been caused by confinement of the roots by the tubes. As the tubes gradually decomposed, root systems were able to develop freely, and mortality decreased.

On the basis of these results, we recommend that cherrybark oak plantations in the Piedmont be established from bareroot seedlings planted during the dormant season. It should be pointed out, however, that many new containers and planting techniques have been developed since this study was installed (4). They deserve consideration and testing as a means of planting hardwoods in late spring and early summer.

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 after rooting, but less than 15 percent grew branchlike leaders when they were 7 years old. The low incidence of plagiotropic growth in 7-year-old cuttings occurred because cuttings had been taken only from young

trees. Other investigators sampled cuttings of young and old Douglas-fir (3) and Norway spruce (4) and they reported that the incidence of plagiotropic growth increased with ortet age.

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