for failure, with swelling and a continuous groove around the stem at the point of union. Some of the unions which showed symptoms of delayed incompatibility were tested mechanically and proved quite strong. All of the older trees were grafted 8 in. or more above the ground, but Girard reports that he is now grafting as close to the root collar as possible, which seems to limit swelling at the union.

By this point, it must be obvious that I have a bias toward placement of grafts low on the rootstock. Although oddities such as I have described are of interest, I believe that it should be the goal of every propagator to produce graft unions that are as nearly invisible as possible. It is one manifestation of the art of our profession.

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DEVELOPMENT OF DOUGLAS-FIR CLONES FOR CHRISTMAS TREES

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Coastal Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) var. *menziesii* is the major Christmas tree species in the Pacific Northwest. An estimated 3.7 million trees were harvested in Oregon in 1987, most of which were genetically unimproved planting stock. As a result, there is considerable variation in such important characteristics as vigor, form, needle color, and budbreak, which profoundly affects tree quality, length of rotation, and culture. Genetic improvement of seed parents has been explored by Oregon State University and the Northwest Christmas Tree Association. Because of the long commitment required for seed orchard development, however, this approach has seen only limited application.

Asexual propagation of selected, superior trees is being studied as a more rapid method to realize genetic and economic gains. Development of superior Douglas-fir clones for the Christmas tree industry has been underway in the Department of Horticulture at Oregon State University for about 15 years. We have identified promising clones, developed selection criteria for new clones,

developed propagation guidelines, and explored commercial propagation and culture. Utilizing net present value analysis, an increase in value per acre is expected for Douglas-fir clones (Table 1).

Table 1. Comparison of net present value per acre for Christmas trees established with improved Douglas-fir clones and unimproved seedling stock (4).

Planting stock	Cost (each)	Rotation time	Grade[1]	Net present value[2] per acre
C-1 clones	$ 0.35	7 yrs	100%	$ 1,655
C-1 clones	0.50	7	100	1,448
2-1 seedling	0.26	7	80	1,444
2-0 seedling	0.15	8	80	1,205

[1]percent of harvested trees that grade number one or better.
[2]net present value calculated using 12 percent interest rate, harvesting 1,094 trees per acre.

SELECTION OF CLONES

In any plantation of seedling Douglas-fir there will be genetic variation (3). Only a small percentage of the trees will have phenotypic traits that are outstanding for Christmas trees. While these traits, such as vigor, form, and color are influenced by the environment, they can also be inherited. When an "elite" tree is selected as a possible clone other traits, not visually expressed, must also be evaluated. Two very important traits that can be inherited are rooting potential and orthotropic (upright) leader growth (2).

Young plantations are well-suited for selecting trees; the more vigorous trees are easy to locate, and cuttings from the juvenile trees are easy to root (1,5). In addition to vigor, form, needle color and quality, branch habit and bud set are also evaluated. Fifteen cuttings are collected from each tree, beginning in January. In May, cuttings are evaluated for rooting percentage and root quality. Acceptable rooting is defined as the presence of three or more large, actively growing roots. Five or more large, actively growing roots are rated good. Only field selections with an acceptable rooting percentage of 80 or better are retained. Rooted cuttings are lined into either transplant beds or containers in May and June. Most of the cuttings are well-rooted and have high survival. The cuttings are grown under conditions common to commercial conifer seedling production. Currently two growing seasons are required to increase plant size and improve the root:shoot ratio.

After growth in the nursery for two years, five trees of each clone are planted at the Oregon State University Horticulture Farm and cultured as Christmas trees. Many of the selections are discarded during this period, usually for failure to grow orthotropically. Clones which show sufficient promise are pruned heavily for cutting production and commercial testing. Plots are

located in Oregon and Washington to observe the effects of different environments on tree performance. Each clone is evaluated annually for height and form and will be graded at harvest age for value. Comparisons with seedling populations are also being made. Characteristics of seven of the most promising clones to date are presented in Table 2.

Table 2. Characteristics of seven Douglas-fir clones for use as Christmas trees.

Clone	Height[1]	Form[2]	Rooting[3]	Comments
Douglass 8	1.48m	5.1	91.3%	Vigorous, somewhat woody.
Douglass 13	1.41	6.9	77.4	Good overall.
Hofert 3	1.41	6.0	88.5	Somewhat plagiotropic.
Douglass 15	1.37	5.6	86.0	Straight, narrow, excellent color.
Douglass 12	1.32	5.4	76.3	Good overall.
Kintigh 21-2	1.28	6.4	57.5	Good overall.
Douglass 10	1.26	4.7	88.4	Weak growth.

[1]average tree height (in meters) of two field plots measured in May, 1988, after three growing seasons.
[2]average tree form of two field plots rated from 1 to 10 (1=poor, 10=excellent) evaluated May, 1988, after three growing seasons.
[3]average acceptable rooting percentage, based on 1983 and 1985 through 1988 rooting performance at OSU, Corvallis.

PROPAGATION GUIDELINES

Guidelines for cutting propagation of Douglas-fir clones have been developed through both research and observations made with commercial propagators. The period of highest rooting potential is from January to mid-March. Cuttings consist of 15 cm of current season's growth with a terminal bud. The needles are stripped from the basal third of the cutting which is then dipped for 5 sec. in a solution of 1000 ppm NAA plus 2000 ppm IBA. The preferred rooting medium consists of five parts perlite to one part peat, but others, including sand may be acceptable. The medium is maintained at 18° to 21°C, while air temperature should be 10° to 18°C.

Douglas-fir cuttings benefit from relatively dry conditions. Overwatered cuttings and saturated media greatly reduce rooting and experiments are being conducted to determine the optimum mist interval. Grey mold (*Botrytis cinerea*) can be a serious problem when excessive moisture is present. Alternate weekly sprays with vinclozolin and chlorothalonil are suggested to help protect the buds and foliage.

COMMERCIAL PRODUCTION

Clones as a group may require slightly different shearing and basal pruning techniques than currently used for seedlings. New

plots are established nearly every year to test more recent selections, modify cultural procedures and acquire a progressively better comparison between clones and seedlings.

Cutting-one (two years-old) plants have been successfully lifted and field-planted in both fall and spring. Site preparation, care, handling, and planting are similar to those methods used for bareroot seedlings. A commercial field plot, using one year-old cuttings, was mechanically planted in March, 1988, and had 98% survival.

In the spring of 1988, data were collected from a plot near Corvallis consisting of 18 clones, 10 trees each. The plot is adjacent to a field of seedlings the same age. Each field had completed three growing seasons at the time. The height of the clones and 18 groups of 10 seedlings was measured, averaged and ranked. Sixteen clones had greater average height than the tallest group of 10 seedlings. The six highest ranked sets of clones and seedlings are compared in Figure 1.

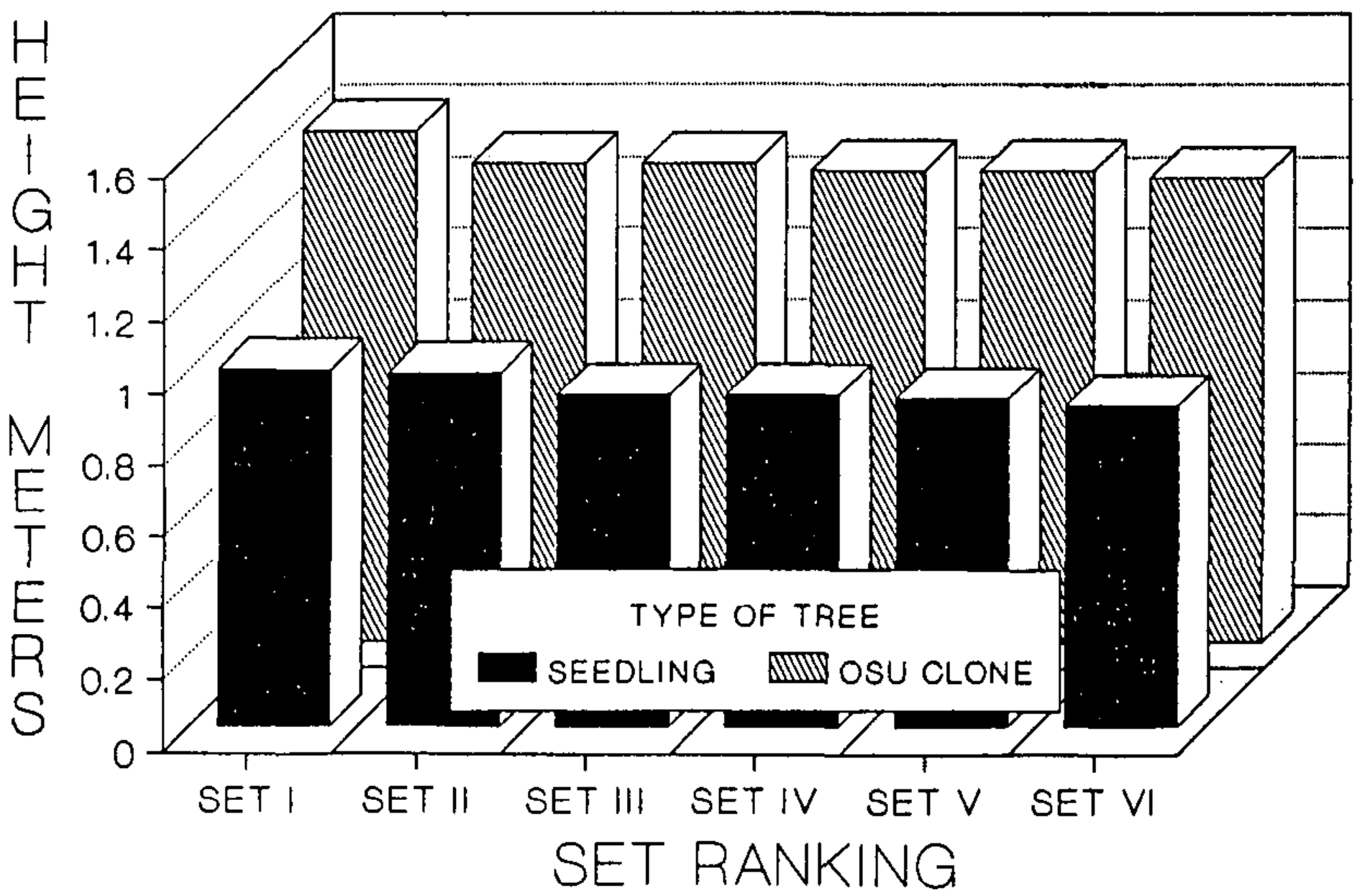

Figure 1. Height comparison of the six top ranked sets of same age OSU clones and unimproved seedlings after three growing seasons.

In summary, Douglas-fir clones have been selected for vigor and ornamental quality in Christmas tree production. Preliminary evaluations in commercial plots suggest that these clones have significantly higher value than seedlings. Additional trials are being conducted to determine the economic and cultural constraints and potential with clones.

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MARTIN MEYER: Stick buds—are they shoved down into a T-cut, or are they put into more of a chip-bud cut?

DON EKSTROM: It is a T-cut in the stock plant with insertion of the stick-bud under the two flaps. You must have good sap flow for success.

VOICE: Fraser, why do you feel the older "burlap cloud" method is so successful?

FRASER HANCOCK: We do fumigate the soil. We caution workers about bringing in contaminated soil on their shoes. We have grass walkways between the rooting beds. We have very few problems. We spray every week or so with an insecticide-fungicide mixture. We have very few losses in the system. But our system is best used as an adjunct to other methods. At Sheridan Nurseries we use the burlap cloud method along with mist beds and standard greenhouse production.