SOME FACTORS AFFECTING PROPAGATION OF DOUGLAS FIR

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Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco, is the major softwood timber species in the United States. Although it covers only 7.3% of the commercial forest land in this country, it produces 23.8% of the saw timber (11). Douglas fir is distributed over a north-south range of more than 3,000 miles, e.g., from northern British Columbia to Mexico, and from Colorado and Arizona to the West Coast, occurring from sea level to elevations of 11,000 ft. (11,12). Its wide distribution and uses for heavy structural timber, construction lumber, poles, plywood, pulp, as well as an important ornamental and Christmas tree species has encouraged research aimed at finding improved methods for its production.

Because of the heterozygosity problem involved with seed propagation, there is an immediate need in forest genetics and management research for methods of propagating vegetatively clonal lines of superior phenotypes and genotypes of douglas fir on their own roots. These superior clonal lines, free of rootstock effects and incompatability problems, would be useful in site performance evaluation; and establishment of seed orchards, forest and Christmas tree plantations.

Vegetative propagation has been an important tool in tree improvement programs. Horticulturists have used these methods to perpetuate the desirable characteristics of selected tree fruits and ornamental trees and shrubs. Vegetative propagation of douglas fir on a commercial scale began on the West Coast in the late 1950's with large scale grafting of seed orchards. Problems of scion-stock incompatability (8,9,10) have complicated the establishment of these seed orchards by grafting. Characterization of incompatability, however, is not that distinct. Stock and scion may unite initially, but gradually develop incompatability symptoms with time, due either to failure at the union or to the development of abnormal growth patterns and the grafts will eventually die (14). In a survey conducted at 3 orchards in Oregon and Washington, Copes (9) observed that 78% of the grafts survived after 4 years in one orchard; 46% after 6 years in a second orchard; and 57% after 8 years in a third orchard. For this reason, there has been considerable interest in recent years in establishing douglas fir seed orchards from stem cuttings of selected genotypes.

Although not carried out systematically and in sufficient detail to get basic answers, some work was done in the early 1940's to demonstrate the feasibility of rooting of douglas fir stem cuttings (13,18). Main objectives of our team work at Oregon State University were to study: a) the seasonal periodicity of rooting; b) optimum rooting environment; and the effect of c) physiological condition of the stock plant; and d) auxin, cold-storage, tree age, shearing, etc., on rooting of douglas fir stem cuttings.

MATERIALS AND METHODS

Stem cuttings of current season's growth were taken from field-grown douglas fir. Needles and buds were removed from the lower 4-5 cm of the 12-cm cuttings. Auxin treatment consisted of a 5-sec. dip of the basal 4-5 cm of the cutting in 10% Jiffy Grow in 95% ethanol. After treatment, the cuttings were placed in the rooting medium (Del Monte white sand E1-8: Canadian sphagnum peat moss, 5:1) to a depth of 3-4 cm with a spacing of 4 cm between cuttings in rows and 7 cm between the rows. The cuttings were left in the rooting medium under mist with bottom heat for 90 days, and then examined for rooting response.

RESULTS AND DISCUSSION

Seasonal Periodicity. In order to establish seasonal periodicity of rooting in douglas fir, stem cuttings were taken at various stages of growth and development at regular intervals throughout the year over a number of years and given a 90 day rooting test. This way, we were able to establish fairly consistent seasonal rooting response curves (5,6,23,24).

Rooting was poor in July and August, none occurring in September and October, and then increased monthly thereafter to a peak in March, then dropped again in April (5). Roberts and Fuchigami (24) concluded that bud dormancy was responsible for unsatisfactory rooting during September and October. Furthermore, we concluded that during September-October, bud dormancy reached a point where auxin alone was not sufficient to stimulate rooting and cold treatment or an 18-hr photoperiod combined with auxin application (3,24,25) was required.

Often the effects of timing are merely a reflection of the response of the cuttings to the existing environmental conditions at the different times of the year (14). It is possible that true bud dormancy (September-October) may occur at different times in different geographic locations or years. Thus, for any given plant, emperical tests are required to determine the optimum time of taking cuttings, which is more related to the physiological condition of the plant than to any given calendar date (14).

Photoperiod. Photoperiod influences cambial and bud activity as well as rooting of cuttings in woody plants (20). Wareing and Smith (29), concluded that photoperiod affects rooting either by influencing the activity of the shoot apex or the hormone production in leaves.

The literature on the effect of photoperiod on rooting is inconclusive and the results are conflicting; this makes generalization difficult. Baker and Link (1) studied the effect of natural, an 18-hr day and continuous lighting on the rooting of cuttings of 26 woody ornamental species and observed no significant difference in rooting with extended photoperiods. Snyder (22), working with *Taxus cuspidata* cuttings taken in December, reported similar results. Lanphear and Meahl (15) observed that *Juniperus horizontalis* 'Plumosa' cuttings rooted significantly better under 24 (77.8%) and 18-hr (79.2%) photoperiods than under normal-daylengths (40.3%) when rooted during the autumn. Waxman (30) reported summer cuttings of *Cornus florida* produced twice as many roots in an 18-hr photoperiod as in a 9-hr photoperiod and 1½ times as many roots as cuttings under normal daylengths.

We (2,3) observed that an 18-hr photoperiod of 750 ft-c light intensity significantly increased rooting percentage (13%) and quality as compared with similar cuttings propagated under a 9-hr photoperiod of 1,500 ft-c light intensity (6%). Our data indicated that rooting can be expected with cuttings under an 18-hr photoperiod even during the peak dormancy period (September-October). Our results with douglas fir are in agreement with those of Lanphear and Meahl (15) for *Juniperus* and with Wareing and Smith (29) for *Populus x robusta*. Both reported cuttings rooted significantly better under long photoperiods than short photoperiods.

Rooting Medium Temperature. The controversial role of bottom heat in the rooting of cuttings has been reviewed in detail by Nelson (19). In a study conducted under controlled environmental conditions, we (3) found that the effect of rooting medium temperature varied with sampling date. According to our findings, cuttings rooted significantly better under 18 and 26°C rooting medium temperature than under 10°C. It was postulated that 10°C was too low for optimum metabolic activity for callus formation and root initiation.

Auxin. Prior to 1930's, only the easy-to-root species and cultivars were propagated. Thimann and Went's discovery (26) that naturally occurring auxin (indole-3-acetic acid or IAA) generally exerts primary control over root initiation led to a rapid development of the use of rooting hormones in plant propagation. The use of synthetic auxins IBA and NAA in promoting rooting was first reported in 1935 (31).

In douglas fir, Griffith (13) reported the first successful rooting of cuttings taken in February and March (80%) and treated with 25-50 ppm IBA as a 24-hr soak. McCulloch (18) reported similar results with cuttings from 1-year-old shoots of douglas fir treated with IBA. Our results (5) with douglas fir revealed that auxin treatment significantly increased cambial activity at the base of the cutting, which subsequently increased rootability during pre- (August) and post-dormancy (December). Auxin treatment alone was not effective in stimulating rooting during the true dormancy (September-October) and during this peak dormancy period long photoperiods (3) or cold-storage (24) either on the tree or in storage (0±1°) was required.

Age and Juvenility. The age of the stock plant in relation to rootings of cuttings is a very important factor. Cuttings taken from juvenile douglas fir trees (6-year-old) rooted significantly higher than cuttings sampled from adult trees (50-year-old)(4). Similar observations have been reported for *Pinus* (16, 17, 21, 27, 28).

In a study of rooting cuttings of douglas fir (7), it was concluded that rooting declines rapidly at ages beyond 9 years and reached a low at age 24 years. Any treatment which maintains the juvenile phase would be of value in preserving the decline in rooting potential as the stock plant ages (14). The hedging or shearing treatments given *Pinus radiata* trees was quite effective in maintaining the rooting potential of cuttings taken from them as the trees aged, compared to nonhedged trees (17). A comparison of the rooting potential of cuttings from sheared and non-sheared portions of the same douglas fir tree revealed that cuttings taken from sheared portion rooted significantly better than the non-sheared portion (7).

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