Performance of Progenies of Single Trees in a Provenance Plantation[1])

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Summary

Single Douglas-fir trees in a provenance plantation were crossed with different pollen sources in 1966 and 1968. Sources and seed trees significantly affected height of progeny. Low correlation of provenance heights of 1966 and 1968 crosses is believed due to experimental error and to use of different trees in each year's crosses.

Key words: hybridization, Douglas-fir, provenance, genetics.

Zusammenfassung

In den Jahren 1966 und 1968 wurden in einem Provenienzversuch Einzelbäume von *Pseudotsuga menziesii* (Mirb.) Franco mit verschiedenen Pollenherkünften gekreuzt. Die Herkünfte und die Einzelbäume beeinflußten die Gesamthöhe der Nachkommenschaften im Alter von 7 Jahren signifikant. Die geringen Korrelationen zwischen den Höhen der Herkünfte in den Jahren 1966 und 1968 werden dem Versuchsfehler und der Verwendung unterschiedlicher Bäume für die Kreuzungen in beiden Jahren zugeschrieben.

Introduction

Of the many ways to produce interprovenance hybrids, the most common and practical are to pollinate ovulate strobili of trees from different populations with pollen mixes from different provenances, or to cross individual trees from different populations. This note summarizes research on Douglas-fir crosses made in 1966 and 1968 by the Forest Research Laboratory in Corvallis, Oregon, U.S.A.

Methods

In 1966, seed trees were selected from a 16-provenance Douglas-fir test planted in the Willamette Valley of Oregon in 1959 (Ching and Bever 1960). Female strobili production was spotty, but sufficient to provide one tree from each source (see Ching and Bever 1960, *Table 1)* for controlled crossing. Plantations trees were used only as seed parents. Fresh pollen was collected from a plus tree from British Columbia and a selected tree from Wolf Creek in southern Oregon. Open-pollinated seed from each seed tree were used as controls.

In 1968, a different tree was selected from each of the 16 provenances in the Willamette Valley Provenance Plantation for open and controlled pollination. Mixtures of equal amounts of fresh pollen of four trees from each of five provenances, C, D, K, L, and O (see Ching and Bever, *Table 1)* were used to cross with selected seed trees. The original design was modified to a partial mating scheme in field planting because some crosses did not produce enough viable seeds.

Hybrid seeds of the crosses were sown in cold frames at the Forest Research Laboratory, Corvallis, Oregon. The 1966 crosses were raised as 2—0 seedlings, the 1968 crosses as 3—0 seedlings. Both were outplanted in fourtree plots (12 × 12 foot spacing) in a site 7 miles north of Corvallis. Each cross was represented by three to twelve plots, the unequal replications due to variation in seed production and low germination of some crosses. The four-tree plots were in incomplete and unbalanced blocks also due to shortage of seedlings for some crosses. Crosses with an abundance of seedlings were replicated more than once per block. The 1966 crosses were planted in five blocks in one area of the site and the 1968 crosses in three blocks in another.

Height of surviving and undamaged trees was measured at age 9 (1966 crosses) and age 6 (1968 crosses). Plot averages were analyzed after those with fewer than two trees remaining were discarded. Paternal and maternal effects and the effect of paternal-maternal interaction were tested by analysis of variance for 1966 and 1968 crosses *(Table 1).* Because of lack of viable seeds and undamaged seedlings at the source of variation representing male and female interaction has 18 of a possible 30 degrees of freedom (36 of 48 crosses) in 1966 material and 18 of a possible 72 degrees of freedom in 1968 material. The mean height of trees representing different pollen mixes and seed trees from different geographic areas was estimated by least squares, the estimates based on a model containing. We used least squares because of the unequal number of plots representing each combination of male and female sources. The standard deviation of each mean height was obtained from the variance-covariance matrix of least squares estimates.

Results and Discussion

Differences among mean heights of progenies representing the three pollen sources for the crosses were sig-

Table 1. — Analysis of variance of height for 1966 and 1968 Douglas-fir hybrids.

Effect	d.f.		M.S.	
	1966	1968	1966	1968
Blocks	4	2	22864	4144
Male	2	6	15985**	849*
Female	15	12	5467**	1032**
Male x female	18	18	2525 N.S.	408 N.S.
Residual	167	83	2386	307

N.S. Not significant at P = 0.05.
* Significant at P = 0.05.
** Significant at P = 0.01.

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Table 2. — Paternal and maternal influence on height growth of Douglas-fir.

Source	1966 Crosses Height*	s^{+}	$n^{\ddagger}$	1968 Crosses Height*	s^{+}	$n^{\ddagger}$
POLLEN						
Southern Oregon	372	7.2	67			
British Columbia	400	9.6	35			
Open-pollinated	400	6.2	105	146	3.3	48
Provenance C				141	8.8	6
Provenance D				136	6.3	12
Provenance K				141	10.7	4
Provenance L				144	5.9	15
Provenance O				147	5.7	16
SEED TREE						
Provenance A	383	14.6	12	122	11.2	3
Provenance B	369	15.0	12	156	18.5	1
Provenance C	360	16.1	11	121	4.4	24
Provenance D	389	12.7	19	130	6.0	11
Provenance E	430	25.5	4			
Provenance F	415	24.4	8	123	7.0	8
Provenance G	406	11.3	24	131	4.1	30
Provenance H	391	12.7	17	132	4.2	20
Provenance I	403	10.1	26	134	8.7	5
Provenance J	393	12.6	16	156	11.1	3
Provenance K	388	16.5	9			
Provenance L	425	12.9	15	175	13.3	2
Provenance M	407	25.0	4	137	5.9	12
Provenance N	352	15.0	11	171	13.3	2
Provenance O	377	17.6	8			
Provenance P	365	15.0	11	177	18.5	1

* Mean height (cm) estimated using least squares.
\+ Standard deviation of the mean height.
‡ Number of plots.

nificant at P = 0.01 *(Table 2)*. The least significant difference (LSD) can show the importance of the difference in mean height of two pollen sources. In general, this is given by $2\sqrt{S_1^2 + S_2^2}$, where S_1 and S_2 are standard deviations of two sources. For example, the 95 percent LSD between 1966 southern Oregon and British Columbia crosses is approximately $2\sqrt{51.84 + 92.16}$, where 51.84 and 92.16 are the squares of the standard deviations 7.2 and 9.6. This is an approximation because lack of independence among comparisons is not accounted for in calculating the variance of difference; however, the approximation is adequate for most purposes. Progenies of the open-pollinated lot and of those obtained with pollen from the plus tree of British Columbia had equal height growth, but those of the southern Oregon pollen source had trees almost 30 cm shorter, a significant difference as judged by the 95 percent LSD.

In 1966 crosses, the differences among mean height of progeny was influenced by both male and female sources, each significant at P = 0.01 *(Table 1)*. In 1968 crosses, height was influenced by male and female sources at the P = 0.05 and P = 0.01 levels of significance, respectively.

Interaction (specific combining ability) of male and female sources was not significant at P = 0.05 for any of the crosses, which suggests that general combining ability is the major source of genetic variability in height growth.

The correlation of 1966 and 1968 crosses for estimated mean height of the female effect is disappointingly low (r = −0.20) but not surprising considering the relatively large standard deviation of some mean heights. Large standard deviation may imply unreliable ranking of the female origin that results in attenuation of the correlation. Male-by-female or female-by-year interaction could also explain the low correlation. We discount the importance of male-by-female interaction because interaction mean squares were small compared to main effects, but because different individuals were represented each year, a female-by-year interaction could result, which would have the same effect as experimental error on attenuating the correlation. Thus, we believe the most plausible explanation of the low correlation is large experimental error affecting ranking (Hinz *et al.* 1977).

In future studies, ranking of male and female sources can be made more accurate by reducing standard deviations of the means. This can be achieved by increased replication and by experimental design that reduces the influence of environmental variation.

Literature Cited

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Postglacial Migration Pathways of Quercus rubra L., Northern Red Oak, as Indicated by Regional Genetic Variation Patterns[1])

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Summary

Intraspecific genetic variation in *Quercus rubra* L. has been achieved by a combination of selection, gene flow, and possibly genetic drift processes acting upon ancestral genotypes. Initial differences in ancestral genotypes of advancing post-Wisconsinan *Quercus rubra* populations were further accented by differential selection regimes effecting a present day discontinuous pattern of diversity. Explanations of genetic variation in *Quercus rubra* initiated hypotheses of post-Wisconsinan plant movement in the Great Lakes region of North America. Central Canada was initially colonized by plants advancing from the upper peninsula of Michigan. Major initial advancements into mideastern Canada were from the lower peninsula of Michigan and lower New York into southern Ontario between the pluvial Great Lake basins of Huron, Erie, and Ontario. Later advancements into eastern Canada occurred further north after the early St. Lawrence River receded.

Key words: *Quercus rubra*, northern red oak, genetic variation, postglacial migration, Quaternary plant distribution.