Tables 2 *and* **3** show that trees from seed sources N and P were consistently poor in height growth. Trees from seed source C were generally superior in total growth, particularly if its poor performance at location Q is ignored. There is considerable consistency with results concerning growth at age three presented previously (CHING, 1965). Six common locations are included in this report, and for these locations the same four seed sources (B, C, D, and G) produced the tallest trees, and trees from seed sources L, A, N, and P are still four of the five shortest at age nine. Furthermore, most seed sources maintained their relative ranking at a given location. There are notable exceptions, of course. Sources D at location B, G at location K, and H at location O rank considerably lower at age nine than they did at age three. In all of these three examples, their growth at the particular location is now unusually low with respect to their growth at other locations. Source K at location O has improved its relative position and now ranks near what might be expected from its growth at all locations. There is ample evidence (IRGENS-MOLLER, 1967; MUNGER and MORRIS, 1936; SILEN, 1964) that a long-rotation species, such as Douglas-fir, no doubt will be subjected to a great variety of climatic changes as well as biological disturbances that will alter the growth pattern. Surprisingly little change has occurred in the relative ranking of the seed sources of this provenance study.

The fitting of second-order response surfaces of planting-site elevation and latitude appears to account almost completely for the interaction between seed sources and locations. Six sources showed statistically significant preferences for sites of particular latitude and/or elevation. A wide variety of contours and optimums are represented among the six sources. Other sources showed less interaction and less indication of a preference for a particular site as typified by elevation and latitude.

One must bear in mind that height growth at any age is only one of the many criteria in the total evaluation of any provenance study. The assessment of height at an early age is necessary for the consideration of juvenile-mature correlations.

Key words: Douglas-fir, provenance, genotype-environment interaction, response surface.

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Variation in Rooting of Pinus strobus L. and P. griffithii McClelland × P. strobus L. Trees*)

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White pine vegetative propagation trials were initiated to preserve the genetic gain achieved in the selection of blister rust resistant trees. The trials aimed at detecting easily-rootable trees of P. strobus and P. *griffithii* X *strobus*. The latter is a vigorously growing, blister-rust resistant hybrid.

Published Data

According to NIENSTAEDT et al. (1958), genotypic variation in rooting is common. Species within a genus vary in this respect, as do individuals within a species. ZUFA (1972) observed variation in rooting between and within populations of P. strobus and P. griffithii X strobus. Clonal variation in rooting of P. strobus was reported by SNOW (1940), DORAN (1957), and PATTON and RIKER (1958). However, a fluctuation in rooting of the same clones in different years was also noticed. In fact, THOMAS and RIKER (1950) observed more variation in rooting of cuttings between years, than between clones.

ZUFA (1972) evaluated the various propagation techniques used in his trials and concluded that, (i) coarse sand was a good rooting media, (ii) December, January and March cutting collection and planting dates showed similar rooting, (iii) rooting decreased with age, but no significant difference was noted with propagules taken from trees up to 10 years of age, (iv) cuttings placed in rooting beds rooted as well as cuttings in polystyrene tubes, and (v) needle fascicles rooted as well as cuttings.

Materials and Methods

The rooting trials were established in the period of 1968 to 1971 with stem cuttings of P. strobus and P. griffithii X

*) Forest Research Branch contribution No. 71-6.

Table 1. — Technical data for rooting trials.

Trial No.	No. of cuttings set per tree	Technique employed
1	26	Tented rooting beds
2	26	Tented rooting beds
3	30	Mist bed, tubelings
4	12	Mist bed, tubelings
5	5	Mist bed, tubelings
6	50	Mist bed, tubelings
7	20	Mist bed, tubelings
8	30	Mist bed, tubelings
9	30	Mist, rooting beds

strobus trees ranging in age from 3 to 15 years. The cuttings were taken from lateral branches over the entire crown of the small trees and from the basal part of the crown of the large trees. They were placed in coarse acid sand in rooting beds or in slit, polystyrene tubes, 3/4 in. (2 cm) diameter and 3 in. (7.5 cm) long and kept either under transparent polyethylene tents or in mist beds. Both of these conditions had similar effects on rooting. Replicated designs were utilized in these trials. The technical data for the trials are presented in *Table 1*.

The final tallies were taken 12 months after planting. The number of cuttings established in the trials and the resultant number of rooted cuttings were arranged in contingency tables and submitted to χ^2 tests.

Results

Large differences in rooting were found in most cases *(Tables 2 and 3)*. In fact, individual trees of *P. strobus* and of *P. griffithii* × *strobus* rooted from 0% to 100%. Variation in rooting of the same trees in different trials was also observed. Some variation in rooting of the trees in these

Table 2. — Rooting of the same *P. strobus* trees in different trials.

Tree No.	Age[1]) Yrs.	Established in trials	Rooting %	χ^2 Test[2])	Mean Rooting %
WP863-4	6	3 and 6	87 and 22	**	43.7
WP863-8	6	4, 6 and 7	17, 42 and 50	N.S.	40.2
WP863-12	6	4, 6 and 7	25, 52 and 15	**	39.0
WP864-15	6	4 and 6	42 and 30	N.S.	32.3
WP865-4	6	3, 6 and 7	83, 67 and 55	N.S.	59.0
WP874-2	6	4, 6 and 7	70, 28 and 50	*	39.0
WP874-4	6	4, 7 and 8	30, 55 and 60	N.S.	40.2
WP418-1	12	1, 2, 6 and 7	15, 23, 2 and 0	*	7.3
WP418-2	12	1, 6 and 7	15, 2 and 10	N.S.	7.3
WP418-3	12	1, 2, 6 and 7	11, 8, 14 and 35	N.S.	16.5
WP418-4	12	1, 2, 7 and 8	15, 38, 45 and 55	*	7.7
WP418-5	12	1, 2, 6, 7 and 8	4, 0, 0, 0 and 15	*	3.1
			Mean Rooting		27.9

[1]) Age at the beginning of the trials.
[2]) ** significant at 0.01 level.
 * significant at 0.05 level.
 N.S. non-significant.

Table 3. — Rooting of the same *P. griffithii* × *strobus* trees in different trials.

Tree No.	Age[1]) Yrs.	Established in trials	Rooting %	χ^2 Test[2])	Mean Rooting %
WP1085-5	3	6 and 7	100 and 87	N.S.	91.2
WP1087-7	3	6 and 7	31 and 60	N.S.	38.1
WP1100-1	3	5 and 7	60 and 60	N.S.	60.0
WP1100-2	3	5 and 7	60 and 80	N.S.	73.3
WP1100-3	3	5 and 7	60 and 20	N.S	33.3
WP1101-1	3	1, 2 and 7	75, 75 and 100	N.S.	84.6
WP1101-2	3	1 and 2	75 and 50	N.S.	62.5
WP1101-3	3	1, 2 and 7	75, 25 and 40	N.S.	53.8
WP1101-5	3	1, 2 and 6	50, 50 and 29	**	36.4
WP980-5	5	6 and 7	20 and 65	N.S.	32.9
WP1000-2	6	1 and 6	63 and 100	N.S.	68.3
WP1001-1	6	1, 2 and 7	33, 17 and 20	N.S.	21.9
5-826	15	3, 7, 8 and 9	23, 75, 83 and 43	**	54.5
5-834	15	3, 6, 7, 8 and 9	57, 47, 30, 50 and 53	N.S.	48.1
5-845	15	1, 2, 3, 6, 7, 8 and 9	4, 0, 13, 8, 15, 7 and 7	N.S.	7.5
5-847	15	1, 2, 6, 7, 8 and 9	8, 0, 2, 17, 7 and 3	N.S.	5.5
5-848	15	3, 6, 7, 8 and 9	57, 38, 55, 73 and 50	*	52.5
5-849	15	1, 2, 3, 6, 7, 8 and 9	0, 0, 29, 1, 0, 10 and 0	**	6.1
				Mean Rooting	46.1

[1]) Age at the beginning of the trials.
[2]) ** significant at 0.01 level.
 * significant at 0.05 level.
 N.S. non-significant.

trials could be anticipated because of the differences in the age of the trees and in the employed rooting techniques. All the same, the results indicated good rooting trees within the same age groups. A number of trees also demonstrated ease of rooting in a series of trials. This was the case especially with *P. griffithii* × *strobus* trees which showed more consistency in rooting and had a better rooting average than *P. strobus*. Thus the possibility of selecting good rooters existed in trees 15-years old and younger, especially in the *P. griffithii* × *strobus* hybrid.

Conclusions

The observed variation in rooting of *P. strobus* and *P. griffithii* × *strobus* trees, and the consistency in rooting of some trees in a series of trials, allowed for the selection of easily-rootable white pines.

Abstract

Several rooting trials were established with cuttings of *P. strobus* and *P. griffithii* × *strobus* trees. Large variation in rooting was observed. The rooting of the same trees in different trials gave a good indication of the ease of rooting and resulted in the selection of easily-rootable types.

Key words: Vegetative propagation, white pine, blister rust, resistance.

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Estimates of General and Specific Combining Ability for Height and Rust Resistance From Single-Crosses of Slash Pine[1]

By John F. Kraus[2]

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Most progeny testing programs for forest trees are designed to obtain information about the breeding value of selected trees used in seed orchards. A high breeding value is usually considered a high general combining ability for the trait being tested.

Selection for high general combining ability assumes that each clone will cross-pollinate with a number of other clones and that the majority of the seed production from the orchard will be from such crosses.

Interest in specific combining ability is usually based on three considerations: (1) high specific combining ability is an indication of a relatively large amount of nonadditive variance affecting the trait under consideration, (2) the relative magnitude of specific combining ability can be important in determining the method of progeny testing used for assessing breeding value, and (3) in some instances high specific combining ability can be used to establish seed orchards which would utilize the dominant gene effects for the production of seed having potential for great improvement in one trait or for the production of special populations for advanced breeding programs.

The data presented here are from two 6-year-old progeny tests of slash pine *(Pinus elliottii* Engelm. var. *elliottii)* in which several trees have been crossed as female parents with five male parents as testers. Estimates are given for general combining ability (GCA) and specific combining ability (SCA) for total height and for the average number of fusiform rust cankers *(Cronartium fusiforme* Hedgc. and Hunt ex Cumm.) per surviving tree.

[1]) Research conducted in cooperation with the Georgia Forestry Commission, the Georgia Forest Research Council, and the Georgia Kraft Company.

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Materials and Methods

The parents used in both tests were selected trees represented as clones in the grafted seed orchards of the Georgia Forestry Commission. The progeny tests were established from seed produced by control-pollination in these orchards.

Test 1 contains progeny of 14 female parents crossed with five male testers. It was outplanted in an 8 by 8 balanced lattice and analyzed as a randomized complete block with nine replications.

Test 2 contains progeny of nine female parents crossed with five male testers. It was outplanted in a 7 by 7 balanced lattice and analyzed as a randomized complete block with eight replications.

Five-tree row plots were used in both tests. The plantings were established on abandoned farmland belonging to the Georgia Kraft Company in Houston County on the upper Coastal Plain in central Georgia.

Sixth-year average total height per plot and average number of cankers per tree per plot were used in an analysis of variance which followed the method of Beil and Atkins (1967).

There were 10 missing crosses in test 1 and four in test 2. Missing plot estimates were calculated for each cross × replication cell. The interaction of male and female effects was used as a measure of SCA.