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FIELD LEVELS OF INFECTION OF PROGENIES OF WESTERN WHITE PINES SELECTED FOR BLISTER RUST RESISTANCE

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ABSTRACT

Western white pine trees resulting from crosses of parents selected for phenotypic resistance to Cronartium ribicola *J.C. Fisch. ex Rabenh., the white pine blister rust, were inspected for rust infection after 11 to 15 years in two field plots. When compared to controls and to natural reproduction, the progenies of crosses involving trees that exhibited general combining ability for resistance transmission in nursery tests were much less heavily infected (20 percent on the average, as opposed to 58 and 71 percent for controls and natural reproduction, respectively).*

Nursery testing to determine levels of resistance in western white pine seedlings to the blister rust fungus, *Cronartium ribicola* J.C. Fisch. ex Rabenh., has been conducted by the USDA Forest Service for 20 years (Bingham and others 1953; Bingham and others 1969). A study designed to test levels of resistance of first and second generation progenies in the field was established in 1969, but will not yield results for several years. However, considerable quantities of first-generation seed are now being produced in an experimental grafted seed orchard (Bingham and others 1963). Also, second-generation seed is being produced in a breeding arboretum.

This paper will present data gathered from first-generation progenies planted for another study that give an early indication of field levels of resistance after 11 to 15 years of natural exposure to the rust disease.

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The young trees examined were grown from seeds that were in excess of those needed for nursery tests of transmission of blister rust resistance in first-generation progenies from crosses among phenotypically resistant "candidate trees." The young trees were outplanted to assess the heritability of growth and quality traits. Statistical interpretation and extraction of heritability estimates are difficult and of doubtful value because the original crossing program was unbalanced, and the number of crosses containing excess seed varied from year to year as did the number of seeds per cross. Detailed analysis of the blister rust infection data was unjustified for the same reasons. Nevertheless, we feel the gross data are of value as indicators of possible future progress and as possible justification for interim use of first-generation seed in reforestation.

MATERIALS AND METHODS

Three-year-old seedlings were planted at two locations in northern Idaho [Priest River Experimental Forest (P) and Deception Creek Experimental Forest (D)] during 1955, 1956, 1957, and 1959. The plantations included trees resulting from: (1) Crosses of rust-free trees (phenotypically resistant candidates) in natural stands; (2) self-pollinations of rust-free trees; (3) wind-pollinated seed from the same rust-free trees; and (4) control lots of seed from presumably nonresistant trees. The number of lots planted per year varied from 22 to 45 and the number of seedlings per lot ranged from two to 24 on each site.

Casual observations of obvious blister rust cankers and blister rust mortality have been recorded over the years, but a systematic examination was not made until the summer of 1970--after the trees had been exposed to natural infection for 11 to 15 years. In addition to the plot trees, we also examined a number of naturally reproduced trees of about the same age within the plots or around their borders.

The infection data were grouped in the following ways on the basis of progeny type: (1) Seedlings from crosses where both candidates were subsequently rated as exhibiting general combining ability (GCA) for a high level of resistance transmission in the nursery trials; (2) seedlings from crosses between candidates rated below average for resistance transmission (non-GCA); (3) seedlings from crosses of GCA X non-GCA candidate trees; (4) seedlings from wind-pollinated GCA trees; (5) seedlings from wind-pollinated non-GCA trees; (6) seedlings from control lots (wind-pollinated infected trees); and (7) naturally reproduced seedlings growing within or around the plots.

RESULTS AND DISCUSSION

Efforts were made to control blister rust by eradicating the alternate host, *Ribes* spp., in the general area of the plantations prior to, during, and after plantation establishment. Even so, the present infection levels of nearby natural reproduction suggest that most trees have undergone fairly high levels of exposure to *Cronartium ribicola* since outplanting (table 1). The most encouraging aspect of the data was that the regular progression of resistance for progenies in various categories on both plots paralleled that expected from their nursery performance.

Thus, the progeny from crosses of parents subsequently rated as possessing GCA for resistance transmission were the least infected (table 1). Crosses of non-GCA parents produced progenies that showed about 1-1/2 times as much infection as GCA X GCA crosses, whereas the GCA X non-GCA progenies exhibited an intermediate amount of infection.

Seedlings resulting from wind-pollinated GCA or non-GCA parents were infected about twice as often as GCA X GCA or non-GCA X non-GCA progenies, respectively.

Table 1.--*Field levels of blister rust infection of progenies of western white pines after 11 to 15 years of exposure to* Cronartium ribicola

Types of crosses	Number of parents	Number of crosses	Location[1]	Number of trees inspected	Percent infected	Cankers per infected tree
GCA[2] X GCA	16	40	D	453	20.9	2.3
			P	460	18.5	1.7
GCA X non-GCA	25	30	D	298	31.9	1.8
			P	261	21.1	1.6
Non-GCA X non-GCA	5	7	D	55	33.2	1.6
			P	48	26.4	2.0
GCA X wind	13	?	D	269	44.4	2.3
			P	253	34.3	2.0
Non-GCA X wind	16	?	D	152	55.3	2.2
			P	158	47.1	2.0
Controls	[3]13	?	D	138	68.0	2.4
			P	113	48.4	2.1
Natural reproduction	?	?	D	196	80.1	2.0
			P	131	62.5	2.5

[1]D = Deception Creek Experimental Forest
P = Priest River Experimental Forest

[2]Parents were rated in subsequent nursery tests as exhibiting general combining ability (GCA) for transmission of above average levels of resistance or, as not exhibiting such ability (non-GCA).

[3]Thirteen collections, each containing seed from five to 10 trees.

When compared to the control seedlings and to those naturally reproduced, progenies of the GCA X GCA crosses were noteworthy. They were infected only one-third or one-fourth as much as control progenies and natural reproduction, respectively. However, comparison of GCA X GCA progenies with natural reproduction could lead to an overestimate of resistance. Planted trees were not exposed to the disease during their first 3 years in the nursery, but some naturally reproduced seedlings were exposed during those early years. On the other hand, early infection might have led to early death; so the infection level of surviving natural reproduction might underestimate actual damage. In fact, among planted trees, postestablishment mortality that can definitely be attributed to blister rust has been less than 1.5 percent, but losses to natural reproduction trees appear to be much higher.

Individual infected trees of the best crosses averaged approximately the same number of cankers per tree as infected trees among the controls or the natural reproduction.

To relate results of this study and those following artificial inoculations of the same progenies in earlier nursery trials, we calculated the correlation between the percent still uninfected in the field and the percent survival in the nursery. The calculations yielded a correlation coefficient of 0.33, which is just significant at the 5 percent level. Thus, the correspondence between nursery and field results for individual progenies is rather poor. Factors that could have contributed to the low correlation include: (1) The combination of low numbers of individuals per progeny (a maximum of 81 in the nursery and 48 in the field, and mean numbers of about 40 and 24, respectively) and minor variations in amounts of inoculum could have changed either nursery or field data several percentage points; (2) nursery tests involved inoculation at age 2 or ages 1 and 2, when seedlings were highly susceptible, but planted seedlings in the field tests were not exposed to inoculum until they were at least 3 years old; and (3) infection (or the absence of infection) might not be directly related to survival since resistant trees might overcome infection.

The first generation progenies of crosses involving two rust-free trees known to exhibit GCA for resistance transmission were much less infected (20 percent for GCA crosses as opposed to 58 percent for control crosses and 71 percent for natural reproduction). Whether or not this degree of improvement will be sufficient to make economical plantings of first-generation materials remains to be seen. If healthy trees in the plantations are infected at the average annual rate (ca. 1.5 percent/year) recorded for these first 11 to 15 years, then 90 percent will have become infected at 60 years. However, the percentage of trees infected is usually far greater than the percentage of trees killed by the rust (MacLeod 1940; Slipp 1953). We will have to follow the incidence of the rust and of rust mortality in the plantations for many years to see how many trees are harmlessly infected and whether most future infections occur on currently healthy or on currently infected trees. Nevertheless, these preliminary results are sufficiently encouraging for the Northern Region of the USDA Forest Service to commence interim planting of first-generation nursery stock from a grafted orchard of GCA-parents at Sandpoint, Idaho (Bingham and others 1963).

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