Effect of Differential Selection Pressure on Fusiform Rust Resistance in Phenotypic Selections of Slash Pine

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ABSTRACT

Progenies (families) or open pollinated *Pinus elliottii* var. *elliottii* representing high and low selection pressure for resistance to *Cronartium fusiforme* were evaluated in a high-rust incidence planting. Frequency distributions of percent rust by family show that these two populations are distinctly different with regard to rust susceptibility. The population of families from selections of the tree improvement program (low selection pressure) is mostly highly susceptible and is approximated by an increasing exponential function with an average disease percentage of 85.1. The population of families from rust-free selections from a heavily infected plantation is relatively resistant and is normally distributed with an average disease percentage of 61.2. These data suggest that phenotypic selection of rust-free trees from areas of high rust incidence can provide significant gains in resistance of slash pine to fusiform rust.

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Southern fusiform rust (caused by the fungus *Cronartium fusiforme* Hedgc. & Hunt ex Cumm.) is the most important disease of slash pine (*Pinus elliottii* var. *elliottii* Engelm.) and loblolly pine (*P. taeda* L.) throughout much of their ranges. The incidence and distribution of the disease are summarized (11,14). There is evidence that the disease is increasing rapidly (14) and that this increase is confounded with intensive management practices that increase fiber productivity of pine woodlands (3, 10).

Abundant preliminary information indicates that genetic resistance to *C. fusiforme* exists in slash (5,6,16) and loblolly pines (7,8), and that significant gains can be made through the utilization of the resistance (1,12). In view of the 25-year-long crop rotations and the open-pollinated nature of the southern pine seed orchard programs, the value of phenotypic selection for rust resistance is of prime concern as it relates to the establishment and utility of rust-rogued seed production areas for immediate improvement of resistance. In the long term, resistant phenotypic selections can be included in breeding programs.

This paper presents results of a field progeny test of phenotypic selections from parent material having differential selection pressure for rust resistance.

METHODS AND MATERIALS.—Population A consisted of 146 open-pollinated progenies (families) from slash pine selections made in the Cooperative Forest Genetics Research Program at the University of Florida and located in orchards belonging to forest industry cooperators. These selections were made from natural stands within the commercial range of slash pine, and include trees from Florida, Georgia, Alabama, Mississippi, and South Carolina. Primary emphasis for selection was placed on growth characteristics (15). Trees with fusiform rust galls were not accepted; however, a few parent selections developed rust galls subsequent to the collection of scion material for orchard establishment. More important, selections were not taken intentionally from areas where rust incidence was high (in fact, areas of high rust incidence were likely avoided). As such, the progenies of these selections represent a population having relatively low selection pressure for fusiform rust resistance.

Population B consisted of 147 open-pollinated progenies (families) from slash pine selections. These parent selections were the rust-free residuals of a 4.05-hectare (10-acre) "old-field" plantation (seed source unknown) in which more than 90% of the original trees had fusiform rust galls. This phenotypically rogued plantation is maintained as a seed production area by Brunswick Pulp Land Company and is located in Wayne County, Georgia. It is isolated among young plantations which produce small amounts of pollen, and presumably receives pollen primarily from within. Progenies (seed collected 3 years after roguing) from these selections represent a population having a relatively high selection pressure for fusiform rust resistance.

Seedling progeny were grown in nurseries for 1 year and then out-planted in January of 1971 in Webster County, Georgia. A survey (14) of 51 slash pine plantations in the surrounding area indicated that the percentage of trees infected with rust ranged from 32 to 100, and averaged 66. As such, this planting location was considered a high rust incidence site. The site, which was previously a field, was prepared for planting by harrowing several times. Seedlings were planted at 0.6-m (2-ft) intervals in rows 2.4-m (8-ft) apart. Thirty seedlings per family were planted and the design was one ten-tree-row plot randomly located in each of three blocks.

Data were taken in January of 1974 after three seasons of exposure to sporidia of *C. fusiforme* and were recorded as percent rust per family. This percentage is the number of trees with at least one rust gall expressed as a proportion of the total number of surviving trees in the family. In addition, the number of rust galls per tree was recorded for each family.

RESULTS.—The frequency distribution data (class interval = 5) of percent rust by family and curves fitted by nonlinear least squares regression for populations A and B are shown in Fig. 1. Rust incidence in families of population A ranges from 30 to 100% and averages

85.1%. The distribution is nearly exponential: $y=e^{bx}$; where y = the number of families within the class interval; e = 2.718, the base of the natural log; b = 0.0356, the regression coefficient; and x = percent rust expressed as the midpoint of the class. While this function explains 92.4% of the observed variation, it overestimates the number of families having low percentage rust and underestimates those having a high percentage of rust. Most of the families in population A are highly susceptible, and only a few families appear to have resistance to *C. fusiforme*.

Rust incidence in families of population B ranges from 25 to 100%. The distribution of percent rust by family is approximately normal, having a mean of 61.3, and a standard deviation of 15.3. Because the area under the curve is greater than 1.0, the function,

$$y = \theta_1 \, e^{\dfrac{-(X-\theta_2)^2}{\theta_3}}$$

was used to fit the data, where the constants θ_1, θ_2, and θ_3 are 18.40, 61.74 and 526.31, respectively. This function explains 93.1% of the observed variation. In contrast to population A, most families in population B are moderately resistant, and only a few are highly susceptible. In addition, population B had an average of 3.2 galls per infected tree, in contrast to 4.9 galls per infected tree for population A. While individual trees were disease free, no family in either population was immune.

DISCUSSION.—It is apparent that the two populations represented in these data differ with respect to resistance to *C. fusiforme*. Progenies of rust-free parents selected from areas of low rust incidence are mostly highly susceptible. In contrast, progenies of rust-free parents selected from areas of high rust incidence are relatively resistant.

That the progenies of selections from low or random rust incidence sites possess little resistance to *C. fusiforme* is well documented (4,8,9,13). Previous reports on effectiveness of phenotypic selection for fusiform rust resistance are variable in their conclusions. Some (2,7) indicate potentially good gains in resistance through phenotypic selection. Others (1,4,9,13) suggest low-to-moderate heritability of rust resistance and the need for progeny tests to identify resistant lines.

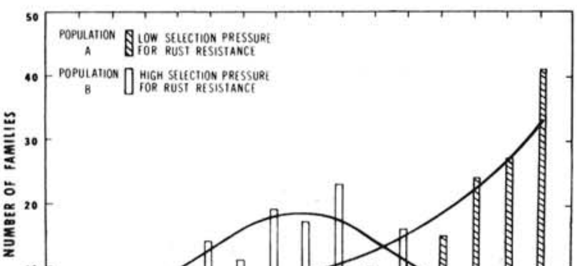

Fig. 1. Frequency distribution of percent *Cronartium fusiforme* on open-pollinated families of rust-free phenotypic selections of slash pine.

The present study indicates that a primary factor affecting genetic gain is the amount of rust in the original population. Phenotypic selection appears most effective when done in a population which has been exposed to a high incidence of *C. fusiforme*. For immediate gains, emphasis should be placed on creating seed production areas by eliminating diseased trees from plantations having a very high incidence of rust. Further gains in resistance should be attained by progeny testing disease-free selections from high-rust-incidence sites.

In experiments prior to the test reported here, progenies of populations A and B were artificially inoculated at 6-8 weeks of age. The relative resistance of progenies from population B was disappointing (5) and did not reflect the gain in rust resistance predicted on the basis of the present data from natural inoculations. Perhaps the poor performance of these progenies in artificial inoculations was related to age or field resistance of the pine, or to pathogenic variation in the fungus.

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