

## Pathogenic Variability in Isolates of *Cronartium fusiforme* from Five Southern States

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### ABSTRACT

Five pine progenies were inoculated with *Cronartium fusiforme* from five geographic sources. Two of the progenies were slash pine (*Pinus elliottii* var. *elliottii*), two were loblolly (*P. taeda*), and one was shortleaf (*P. echinata*). On the basis of previous tests, one progeny of slash pine and one of loblolly pine were regarded as resistant to the disease, while the other progenies of these species were considered susceptible. Shortleaf pine is naturally resistant to

*C. fusiforme*. Susceptible slash and loblolly became uniformly infected by all isolates, and shortleaf seedlings were completely resistant to all isolates. Resistant slash pine showed moderate resistance to Mississippi, Texas, and North Carolina isolates, but was highly susceptible to isolates from Alabama and Florida. These results indicate that pathogenic variability occurs in *C. fusiforme*. Phytopathology 60:1730-1731.

*Additional key words:* resistance, pathogenic variation, *Cronartium fusiforme*, *Pinus elliottii*, *Pinus taeda*, *Pinus echinata*.

The probability that pathogenic variation occurs in *Cronartium fusiforme* Hedgc. & Hunt ex Cumm. has been recognized for some time, and was strengthened by the recent discovery of variability in *C. quercuum* (Berk.) Miyabe ex Shirae (1, 5), a less important pine-oak rust fungus found within the range of *C. fusiforme*.

The study reported here was made to determine if two selections of pine which had shown moderate resistance to *C. fusiforme* isolates from southern Mississippi were also resistant to isolates from other geographic areas. Differential reactions of trees to the isolates can be regarded as confirming pathogenic variation in the fungus. Preliminary results have been reported (7).

**MATERIALS AND METHODS.**—Five pine progenies were inoculated with 15 isolates of *C. fusiforme*. Two of the progenies were slash pine, two were loblolly, and one was shortleaf. Shortleaf is naturally resistant to the disease, and the progeny was from a bulk collection of seed in Tennessee. The two slash pine progenies were from two trees in south Mississippi, one regarded as susceptible to the disease and one as resistant. These trees had been wind-pollinated, and the progeny of each were therefore half-sibs. The two loblolly pine progenies were from one resistant and one susceptible tree in Livingston Parish, south Louisiana; the parents had been control-pollinated and the seedlings of each were therefore full sibs. The Institute of Forest Genetics at Gulfport, Miss., had originally determined the degree of susceptibility of the slash and loblolly progenies by inoculating similar progenies with *C. fusiforme* collected locally.

Three separate isolates of *C. fusiforme* were obtained from fusoid galls on loblolly or slash pines at each of five locations: Nacogdoches, Tex.; Saucier, Miss.; Perry, Fla.; Auburn, Ala.; and Raleigh, N. C. Eighteen 5- to 7-week-old seedlings of each pine selection were inoculated with each of the 15 rust isolates. Inoculation was accomplished with an apparatus that closely con-

trolled spore deposition on each plant (6). Seedlings were grown in the greenhouse and examined for galls at 3-month intervals for 12 months after inoculation. Data from the 12-month readings are presented here. An analysis of variance was made for a split-plot design with isolates treated as replications.

**RESULTS.**—The susceptible slash and loblolly progenies became uniformly infected by all rust isolates (Table 1). The shortleaf seedlings were completely resistant to all the isolates.

Resistant loblolly appeared to be moderately resistant to all sources of inoculum when the results with the three isolates/source were averaged; on this basis, differences between sources were not significant. Susceptibility to individual isolates, however, ranged from moderate to high within each source (Table 2).

Resistant slash pines were moderately resistant to the Texas, Mississippi, and North Carolina isolates, but were highly susceptible to isolates from Alabama and Florida (Table 1). The response to individual isolates within sources varied less than with the resistant loblolly.

Mortality resulting from rust infection also varied among the host-isolate combinations (Table 3). More of the susceptible selections of slash pine were killed by the Texas and Alabama isolates than by the other isolates. The greatest mortality in resistant slash pine was caused by the Alabama and Florida isolates. The Mississippi isolates caused little mortality in susceptible loblolly and in both slash pine progenies, but they killed the largest number of resistant loblolly seedlings.

**DISCUSSION.**—The differential reactions of the slash pines to the geographic sources of *C. fusiforme*, as shown both in susceptibility and in mortality, indicate that pathogenic variability occurs in this rust. There is no evidence yet, however, that the variation is of a magnitude that can be distinguished with different species of pine as is the case with *C. quercuum* (1, 5, 7).

TABLE 1. Percentage of pine seedlings developing fusiform rust galls during 12 months after inoculation with *Cronartium fusiforme* from five geographic sources<sup>a</sup>

Pine progeny	Source of inoculum <sup>b</sup>				
	Tex.	Miss.	N.C.	Ala.	Fla.
	%	%	%	%	%
Slash pine					
Susceptible	94	96	94	98	100
Resistant	40	54	57	98	98
Loblolly pine					
Susceptible	98	100	100	100	100
Resistant	70	74	67	83	65
Shortleaf pine	0	0	0	0	0

<sup>a</sup> Averages for 54 plants: three isolates from each source; 18 seedlings inoculated with each isolate.

<sup>b</sup> By Duncan's multiple range test, means underscored by the same line do not differ significantly at the .05 level.

Since only the resistant slash pines varied in susceptibility to the geographic sources of the fungus, tests are planned to determine if other resistant pines will show similar reactions. The contrasting results obtained with the resistant slash, loblolly, and shortleaf progenies suggest differences in the resistance mechanisms. Perhaps several types of resistance can be found and eventually combined.

As the spores of *C. fusiforme* are airborne, and presumably the aeciospores can be carried for long distances, one wonders how rapidly variants of this fungus would fluctuate in space and time and what selection pressures would exist to influence their predominance. That the isolates from Mississippi did not cause significant mortality in either progeny of slash pine suggests that host and fungus are adapted to each other.

Kinloch & Stonecypher (2) have indicated that the range of heritable resistance of loblolly pine to *C. fusiforme* is consistent with the proposals of Person (4) and Mode (3) for coevolution of hosts and parasites. Person's concept is that coevolution results from the alteration of complementary genes in the host and the

TABLE 2. Percentage of resistant slash and loblolly seedlings developing fusiform rust galls during 12 months after inoculation with the three isolates from each geographic source<sup>a</sup>

Inoculum source	Resistant slash, isolate no.			Resistant loblolly, isolate no.		
	1	2	3	1	2	3
	%	%	%	%	%	%
Tex.	33	44	44	56	61	94
Miss.	39	67	56	78	56	89
N.C.	72	56	44	78	44	78
Ala.	100	100	94	94	67	89
Fla.	94	100	100	67	89	39

<sup>a</sup> Percentages were calculated from 18 plants inoculated/isolate.

TABLE 3. Mortality of pine seedlings 12 months after inoculation with five geographic sources of *Cronartium fusiforme*<sup>a</sup>

Pine progeny	Source of inoculum				
	Tex.	Miss.	N.C.	Ala.	Fla.
	%	%	%	%	%
Slash pine					
Susceptible	39	2	24	35	15
Resistant	6	7	20	48	43
Loblolly pine					
Susceptible	6	0	13	2	11
Resistant	19	28	4	13	7
Shortleaf pine	0	0	0	0	0

<sup>a</sup> Percentages were calculated for 54 plants inoculated in groups of 18 with three isolates from each source.

parasite in response to mutual selection pressures. He developed this idea, in part, from Mode's theory that a parasitic system may reach a state of stable equilibrium, at intermediate gene frequencies, in which survival of both hosts and parasites is assured. If these hypotheses are accepted, the differential reaction of slash pine to geographic sources of *C. fusiforme* suggests that the frequency of complementary genes in hosts and parasite may vary between geographic areas.

Until more knowledge of the extent and nature of variation in *C. fusiforme* is available, it is suggested that geneticists take certain precautions in screening pine selections for resistance to the fungus. The screening should be with mixed collections of inocula from the particular area in which the improved trees are to be planted. In addition, testing the most promising selections with inocula from throughout the southern pine region will better define the potential of such trees as sources of resistance.

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