

Resistance of Pitch × Loblolly Pine Hybrids to Fusiform Rust (*Cronartium quercuum* f. sp. *fusiforme*)

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ABSTRACT

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Hybrid seedlings of pitch pine (*Pinus rigida*) × loblolly pine (*P. taeda*) were inoculated with the fusiform rust pathogen (*Cronartium quercuum* f. sp. *fusiforme*). The incidence of rust infection in three groups of hybrids was significantly less than in susceptible or resistant loblolly pine check groups. Resistant hybrids may be useful for areas of the midsouth where freezing temperatures and/or rust produce unacceptable damage to loblolly pines.

Species hybridization can be a useful technique to combine the best traits of two or more species, or if desirable, to capture a single valuable trait of one species even at the possible expense of maximum growth or some other trait in the second species. Such a trait could be insect or disease resistance within the natural range where growth and overall adaptation of the species is not a concern, or it could be a trait such as cold hardiness if the breeder wished to extend a species beyond its natural range. There is also the possibility of obtaining hybrid vigor, in which case the progeny outperform either of the parent species. There are examples of hybrid vigor in forest trees, but with few exceptions, such growth is restricted to special "hybrid habitats" (7).

Within the past few years, a number of species hybrids of forest trees have been developed, and most have exhibited useful traits. Hybrids between shortleaf (*Pinus echinata* Mill.) and loblolly (*P. taeda* L.) pines appear more resistant to the fusiform rust fungus (*Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme*) than the loblolly parents. However, the hybrids may be equally susceptible to the rust that attacks shortleaf pine (*C. quercuum* f. sp. *echinatae*), although this is the less serious of the two diseases (4). The comparative growth rates of the hybrids versus the parent species have not been reported.

Shortleaf and slash pines (*P. elliotii* Engelm. var. *elliotii*) were hybridized to

produce a rust-resistant tree. After 10 growing seasons, growth and survival of the hybrids was not as good as in the loblolly checks. Relative growth of the hybrids, when compared with shortleaf and slash pine checks, varied by test location and origin of parental stock. Growth was not sufficient to recommend this as a replacement for other species in a reforestation program. The useful trait exhibited by this hybrid, as with the shortleaf × loblolly hybrid, was increased resistance to rust. This could be a valuable source of germ plasm for breeding programs with a goal of producing rust-resistant slash pine (6).

A hybridization program involving pitch pine (*P. rigida* Mill.) and loblolly pine initiated by the Northeastern Forest Experiment Station and Westvaco (then the West Virginia Pulp and Paper Company) in the early 1960s had as its primary goal the development of a hybrid suitable for planting in areas of the northeastern United States north of the natural range of loblolly pine. This area included many marginal to poor sites and disturbed lands created by strip-mining. A hybrid with the growth rate and stem form of the southern hard pines and the cold hardiness of the northern species was desired.

Tests conducted in the East and Midwest in the 1940s and 1950s with hybrids produced from "unselected" parents suggested the potential suitability of the pitch × loblolly pine hybrid. In a series of nine plantings in Indiana, Iowa, Illinois, and Ohio (N 37° to N 41° latitude) in which hybrid seed supplied by the Institute of Forest Genetics of the Republic of Korea was used, Bey and Lorenz (2) found that north of 39° latitude, the hybrid outgrew both of the parent species, was as hardy as pitch pine, and had excellent form. The use of more carefully selected parents should have resulted in even better progeny.

Container-grown seedlings of hybrids from the Northeastern Forest Experiment

Station-Westvaco program were planted on coal spoils in Alabama and Tennessee to test the effects of *Pisolithus ectomycorrhizae* on growth and survival on these severely disturbed sites. By 30 mo after planting, the loblolly pine was not significantly larger than the hybrids and both were larger than pitch pine at the Alabama site. At the Tennessee location, the hybrids were significantly taller than either loblolly or pitch pine (1).

MATERIALS AND METHODS

Pitch × loblolly hybrid seed lots were sent to the USDA Forest Service's Resistance Screening Center at Asheville, NC, for testing. The screening center included two check stocks that it uses in all of its tests: loblolly pine from Livingston Parish, LA, which has low susceptibility to fusiform rust, and loblolly pine selection 11-23 from South Carolina, which is highly susceptible.

Seeds were germinated and transplanted into flats for treatment. The standard design of the screening center, which consists of 20 seedlings (4 × 5) per tray and three trays of each seed lot in each of two tests, was followed. When 4 wk old, the seedlings were inoculated by passing the trays under an aqueous spray of basidiospores (5 × 10⁴ spores per milliliter in 8-ml aliquots) derived from four sources in North Carolina (Table 1). Immediately after inoculation, the seedlings were placed in a mist chamber and held at 21 C for 24 hr, then grown in a greenhouse for 9 mo. Galls were counted at the end of 5 and 9 mo.

RESULTS AND DISCUSSION

Analysis of variance revealed significant ($P < 0.01$) variation among seed lots and between tests but not for test × seed lot interactions. Duncan's multiple range test on seed lot means indicated clear separation of groups based on parentage involved (Table 1).

The three hybrid groups with the least rust, from loblolly pine parents from South Carolina (11-9, 11-10, and 11-20) (Table 1) and pitch pine parents from Massachusetts, New Hampshire, New York, and West Virginia (58, 62, 71, 77), averaged 19% infection, whereas the loblolly parents averaged 41% infection (Table 1). By contrast, the infection rate of the "resistant" Livingston Parish loblolly was 58%. Hybrids with the Virginia loblolly pine parent (20-517) were as susceptible (65% infection) as the

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Table 1. Percentage of seedlings with fusiform rust galls 5 and 9 mo after inoculation^v with *Cronartium quercuum* f. sp. *fusiforme*

Seed log ID ^w	Seedling infection rate (%)						9-mo Av. for loblolly parent
	5 mo			9 mo			
	A ^x	B ^x	Av.	A	B	Av.	
71 (MA) × 11-20 (SC)							
77 (NH) × 11-20 (SC)	41	9	25	25	9	17 a ^y	
62 (NY) × 11-9 (SC)	30	11	20	22	16	19 a	
58 (WV) × 11-10 (SC)							
77 (NH) × 11-10 (SC)	31	17	24	29	14	22 a	19
11-20 (SC) Lob × WP ^z	55	30	43	48	27	38 b	
11-10 (SC) Lob × WP	49	27	38	51	27	39 bc	
11-9 (SC) Lob × WP	57	44	51	50	43	46 bcd	41
Livingston Parish lob check × WP	57	28	45	69	47	58 cde	58
51 (VA) × 20-517 (VA)							
71 (MA) × 20-517 (VA)							
54 (VA) × 20-517 (VA)	81	45	63	82	43	65 def	65
20-517 (VA) Lob × WP	83	43	67	86	48	67 ef	67
11-23 Lob check × WP	83	56	69	88	65	77 f	77

^vInoculum from Johnston, Wake, Wilson, and Wayne Counties, NC.

^wAll specific crosses are pitch × loblolly hybrids. Numbers designate parent trees; letters in parentheses designate states.

^xInoculation trial B occurred 15 days after trial A.

^yAverages followed by the same letter are not significantly different at $P = 0.01$ according to Duncan's new multiple range test.

^zWP = cross made by wind pollination.

loblolly parent (67% infection) but less susceptible than the South Carolina loblolly pine check (11-23, 77% infection). There was a wide range in infection (17–77% galled) and a significant difference between the resistant (Livingston Parish) and the susceptible (11-23) checks. The seed lot rankings were similar for each test.

Four seed lots had fewer galls at 9 than at 5 mo (Table 1). It is not uncommon for an infected seedling to display a slight swelling (gall), and then several months later, after the stem tissue has enlarged slightly, to have no sign of an abnormal swelling. Many galls in these families were of this type, especially those of the pitch × loblolly crosses. This is probably

one type of resistant reaction. It is likely that these same seed lots, grown under field conditions, would show little fusiform rust infection because the laboratory procedure of inoculation and the growing conditions after inoculation are far more conducive than natural conditions to rust infection (3,5).

These observations indicate that adequate levels of rust resistance in field plantings can be achieved by hybridization of pitch and loblolly pine provided parental combinations are carefully screened.

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