Susceptibility to Brown-Spot Needle Blight and Fusiform Rust in Selected Longleaf Pine and Hybrids

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Fusiform rust (Cronartium quercuum *(Berk.) Miyabe ex Shirai f. sp.* fusiforme (Hedgc. & Hunt) Burdsall & Snow) *collected on loblolly pine* (Pinus taeda *L.*) *was used to inoculate progeny from 15 longleaf pine* (P. palustris *Mill.*) *controlled crosses, 7 longleaf* x *slash pine* (P. elliottii *Engelm.) hybrids, 5 longleaf* x *Sonderegger (natural longleaf* x *loblolly hybrid) hybrids, 3 longleaf* x *loblolly hybrids, and wind pollinated progeny from each of the parent trees. Field plantings also were established to compare fusiform rust in green house inoculations with field incidence of fusiform rust as well as brown-spot needle blight* (Mycosphaerella dearnessii *Barry. There was no relationship between fusiform rust infection in the greenhouse and brown-spot needle blight after 3 years in the field in the longleaf crosses and the hybrids. There was also no relationship between nursery height and brown-spot needle blight in the longleaf crosses, but there was a negative relationship in the hybrids. The results indicate that resistance to brown-spot can be incorporated into long leaf breeding programs without changing susceptibility to fusiform rust.* Tree Planters' Notes 47:11-15; 1996.

The area of longleaf pine in the southern United States has declined from 12.2 to 3.8 million acres (4.94 to 1.54 million hectares) over the past 30 years (Kelly and Bechtold 1990). In many ways, longleaf is the most valued of the southern pines (Croker 1990), and there is now renewed interest in restoring longleaf pine to its historical commercial and ecological prominence.

One of the primary reasons that the acreage of longleaf pine has declined has been the lack of successful reforestation. Natural regeneration is sporadic, and planting is difficult. The species has a "grass" stage lasting one to several years during which height growth is delayed. Early survival and growth are often severely affected by brown-spot needle blight (Wakeley 1970). Breeding programs have been underway for more than 35 years to improve brown-spot resistance and height growth of longleaf pine (Bey and Snyder 1978).

Fusiform rust is generally considered not to be a problem in longleaf pine management (Hepting 1971) but it is the most damaging disease of slash pine as well as loblolly pine in the southeastern United States (Powers and others 1981). Fusiform rust susceptibility is heritable in longleaf pine (Snyder and Namkoong 1978) and occasionally causes substantial losses (Kraus and Sluder 1990). Wakeley (1968) has suggested that plant breeders, selecting for early height growth and brown-spot resistance, may also select for susceptibility to fusiform rust because the genes for early height growth and brown-spot resistance may occur in longleaf pine as a result of hybridization and introgression with loblolly or slash pines.

Restoration of the longleaf pine ecosystem will necessarily require a great deal of planting (or perhaps direct seeding) of longleaf pine. Choosing the proper seed source will be essential to ensure long-term success of restoration plantings. It is necessary to understand the implications of breeding programs not only on disease susceptibility but also on retaining those traits that make longleaf such a desirable species. The present study was initiated to examine the relationship between height growth, fusiform rust infection, and brown-spot needle blight in longleaf pine and its hybrids.

Materials arid Methods

Ten longleaf pines were selected from a brown-spot breeding program representing a range from moderate to good resistance to brown-spot needle blight (Snyder and Derr 7972). These trees were crossed with 6 other pines: a longleaf pine that was susceptible and a longleaf that was resistant to brown-spot; 2 slash pines and 1 loblolly pine that were resistant to fusiform rust; and a Sonderegger pine (natural longleaf (loblolly hybrid, Chapman 1922) that was susceptible to fusiform rust (table 1). Wind-pollinated seed were also collected from each parent tree. Sufficient seed were available from 46 families for use in the study.

The study consisted of 2 tests. The first was done in the greenhouse for fusiform rust inoculations, and the other was done in the field to evaluate brown-spot infection and fusiform rust. For both tests, seed were

Table 1—*Mating design and family identification numbers for interspecific and intraspecific longleaf pine hybrids*

	Longleaf pine females											
	Resistant to brown-spot					Moderately resistant to brown spot						
Males	Abe	27-168	5-77	14-346	15-366	16-300	11-467	3-356	22-214	10-434	8-144	Wind
Longleaf Abe Br-spot-resistant		43	2	5	8	11	15	20	26	40		32
Longleaf 12-13 Br-spot-susceptible	49	44	39				38			41	47	37
Slash pine 8-7 Rust-resistant			1		33	10	13	17	22			28
Slash pine 9-2 Rust-resistant									23			29
Loblolly B-144-L Rust-resistant							36	18	24			30
Sonderreger 2-7 Rust-susceptible				4	7		14	19	25			31
Wind-pollinated	32	45	3	6	9	12	16	21	27	42	48	

germinated on vermiculite at 20 °C in a growth chamber. After germination the seedlings were transferred to 2.8- x 21.6-cm plastic tubes containing a 1:1 mix of vermiculite and peat moss. They were then maintained in a greenhouse under a 16-hour day length.

In the greenhouse test, 3 replications each of 10 seedlings from each of the 46 families were inoculated with a composite culture of fusiform rust. The rust culture had been derived from 5 galls collected from loblolly pines in Harrison County, Mississippi. The seedlings were inoculated when they were 10 weeks old with a forced air system (Snow and Kais 1972). After inoculation, seedlings were grown in a greenhouse and maintained for 3 months. They were then planted in a nursery bed and maintained for 9 months. The seedlings were then lifted and measured for height, diameter, and presence of galls. Each seedling was cut in half to verify gall readings.

A field planting was established on the Johnson Tract of the Palustris Experimental Forest near Alexandria, Louisiana. Sufficient seedlings were available to plant 39 of the 46 families in 10-tree row plots in a randomized complete block design of 5 replications. The planting site was prepared by scalping 30-cm-wide strips 3 m apart for each row using a fire plow. Seedlings were planted 2 m apart within the rows using a wheel-driven tree planter.

All seedlings were measured yearly for 5 years and again at age 7 for brown-spot infection (percentage needles affected), height, ground-line diameter, and fusiform rust galls. SAS (1985) GLM procedure and Duncan's multiple range test were used to test for significance among family means. Linear regression was also used to explore relationships among the variables.

Results and Discussion

Fusiform rust. Fusiform rust infection varied greatly among the 47 families inoculated in the greenhouse (figure 1; table 2). Longleaf pine is generally considered to be resistant to fusiform rust, but this is not evident in the inoculation test. Infection in the longleaf families actually averaged higher (46.7%) than the other species and hybrids (43.7%), although it should be pointed out that the slash and loblolly pines used in this test were

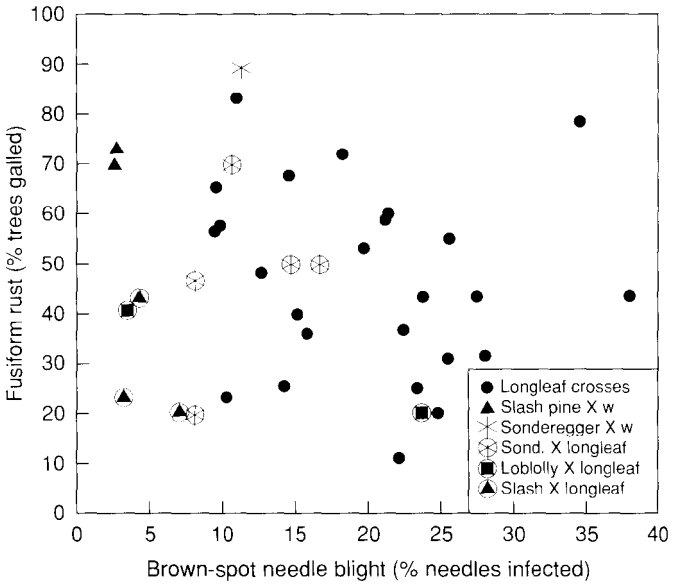

Figure 1—*Scatter plot of fusiform rust infection (greenhouse inoculation) versus brown-spot infection after 3 years in the field for slash, loblolly and longleaf pine crosses and hybrids. Based on individual cross means.*

all considered resistant to fusiform rust; only the Sonderegger pines were considered susceptible to the disease in the field.

Fusiform rust infection ranged from a low of 10.9%, to a high of 83% for the longleaf crosses. The other species and hybrids averaged slightly higher, ranging from 12.5 to 89.3% (table 2; figure 1). The highest infection did occur in the windpollinated Sonderegger seedlings, which were supposed to be susceptible, but infection was nearly as high in the wind-pollinated seedlings of the putatively resistant slash pines (70 and 73%).

Table 2— *Brown-spot needle blight infection, fusiform rust infection, and height growth after 7 years in the field on interspecific and intraspecific crosses of longleaf pine*

Cross type	ID	Brown-spot (%)	Rust greenhouse (%)	Rust field (%)	Height 7-yr (m)
Long × long	47	37.9	43.3	0	1.78
	11	25.5	55.0	0	2.29
	40	14.4	67.7	6.6	2.45
	42	34.5	78.5	0	2.55
	37	28.0	31.5	0	2.69
	48	22.3	36.7	0	2.79
	5	9.3	56.7	0	2.81
	6	12.5	48.3	0	2.90
	32	15.0	40.0	0	2.94
	20	21.1	58.8	0	2.96
	39	18.2	72.1	0	3.10
	2	9.4	65.5	0	3.13
	41	27.4	43.3	6.6	3.17
	3	21.3	60.0	0	3.27
	38	23.3	25.0	0	3.34
	9	23.7	43.3	3.3	3.40
	8	10.1	23.3	0	3.41
	49	9.6	57.8	0	3.46
	45	24.7	20.0	0	3.49
	12	22.1	10.9	0	3.51
	16	14.1	25.4	0	3.61
	27	25.4	31.0	0	3.67
	21	15.7	36.0	0	3.80
	44	19.6	53.1	0	4.28
	43	10.8	83.3	0	4.31
Long × lob	18	23.7	20.1	0	3.55
Long × Sond	7	16.6	50.0	0	3.77
Long × Sond	19	7.9	46.7	6.7	4.53
Long × Sond	25	14.6	50.0	0	4.58
Long × Sond	14	7.9	20.0	0	4.60
Long × Sond	4	10.5	70.0	0	4.98
Sond × wind	31	11.2	89.3	59.0	4.63
Long × slash	13	3.03	23.3	0	4.98
Slash × wind	28	2.4	70.0	0	5.19
Long × slash	17	6.9	20.4	5.0	5.22
Lob × wind	30	3.3	41.0	13.1	5.44
Slash × wind	29	2.6	73.3	29.7	5.77
Long × slash	23	4.1	43.3	4.9	5.81

Long = longleaf pine, lob = loblolly pine, and Sond = Sonderegger pine. See table 1 for family identification numbers.

Overall, fusiform rust infection in the field was low, averaging less than 1% in the longleaf crosses and only 9% in the hybrids (table 2). This result was not unexpected, because all parent trees except for one were considered resistant to fusiform rust. Infection in the one family that was considered highly susceptible, the Sonderegger × wind family, was 59%, indicating that inoculum was present. This family serves as the only fusiform-rust-susceptible control in this experiment.

The resistance of longleaf to fusiform rust is more evident in the field data than in the greenhouse inoculation test (table 2). Galls developed on only 3 of 25 longleaf families. Frequency of galls in the 3 infected families ranged from 3 to 7 %.

In the other species and hybrids, the Sonderegger × wind seedlings (which had the highest infection rates in greenhouse inoculation test) also had the highest infection rates in the field planting, with 59% developing galls (table 2). The second highest number of galls occurred on slash 9-2 × wind, and the third highest number was on the loblolly × wind (table 2). Many of the longleaf hybrids were not galled.

Brown-spot disease and height growth. Brown spot blight varied from 9 to 38% needles infected in the longleaf crosses and from 2 to 24% in the hybrids (table 2; figure 1). The relative ranking of the longleaf crosses paralleled expectations (figure 2). The resistant male crossed with the resistant females produced the most resistant progeny with less than 10% infection. Infection was higher, nearly 20%, in the progeny when the resistant male was crossed with a "moderately" resistant female. The highest infection rate (30 %) was in the progeny produced when the susceptible male was crossed with the moderately resistant female.

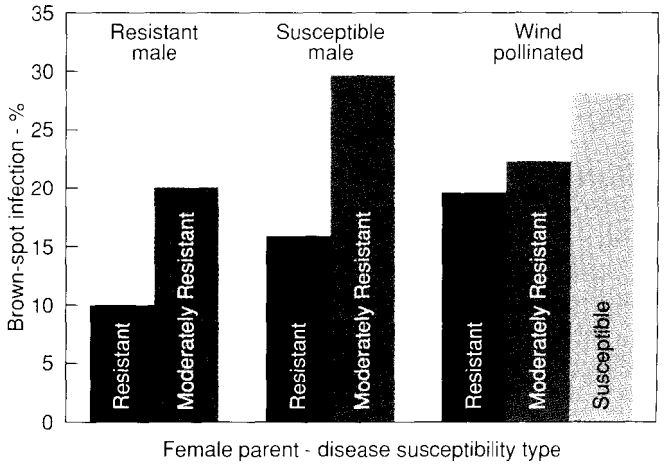

Figure 2—*Brown-spot needle blight infection in controlled-cross longleaf pine families from parents of known susceptibility.*

Brown-spot infection was not related to height growth in the nursery in the longleaf crosses but was negatively correlated with height when the hybrids are included in the regression (figure 3). None of the progeny from the longleaf crosses had started height growth in the nursery at lifting; they averaged between 3 and 12 cm in height, although subsequent brown-spot infection in the field ranged from 9 to 38%. The general lack of height growth in the first year in the nursery is a good indication that the longleaf used in this experiment are relatively pure genetically, because hybrids with other species show height growth in the nursery.

Seedlings of the Sonderegger × longleaf cross, which is a longleaf X loblolly natural hybrid backcrossed to longleaf and is therefore approximately 75% pure longleaf, were all taller than pure longleaf seedlings in the nursery (ranging from 14 to 24 cm in height) and were relatively resistant to brown-spot infection. The tallest trees in the nursery were the pure slash pine, followed by the F_1 hybrids.

Height growth of the longleaf crosses after 7 years in the field varied from 1.78 to 4.31 m (table 2). The hybrids and other species were taller, varying from 3.55 to 5.81 m. Although the tallest trees in the nursery were the slash pine (figure 3), after 7 years the tallest trees were a longleaf by slash hybrid (table 2).

Brown-spot infection in the field was not related to previous height growth in the nursery but did appear to affect growth after 7 years in the field. Although brown-spot infection was not severe, there was a negative correlation between infection and height at age 7 ($r = -0.435$).

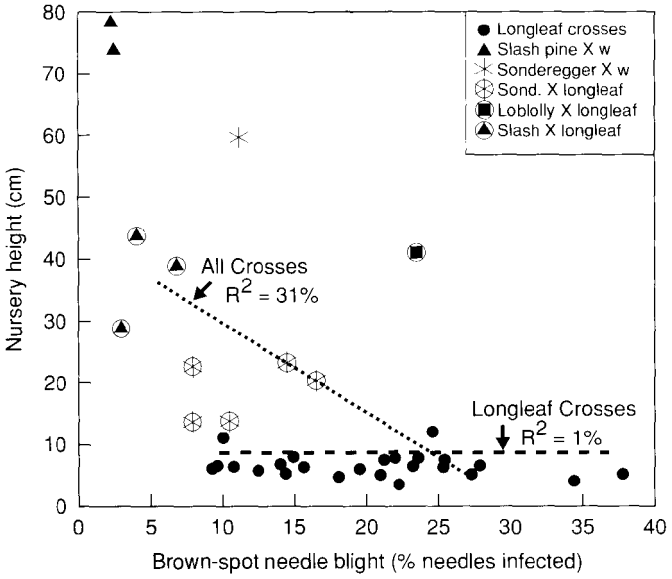

Figure 3—*Scatter plot of height growth after 9 months in the nursery versus subsequent brown-spot infection after 3 years in the field for slash, loblolly, and longleaf pine crosses and hybrids.*

Conclusions and Recommendations

The results indicate that resistance in a general sense to brown-spot can be incorporated into longleaf breeding programs without changing resistance to fusiform rust. Although a hybrid origin for brown-spot resistance in longleaf pine cannot be ruled out, it appears that this trait can be incorporated into improved longleaf pine with little danger of losing "typical" longleaf traits.

Performance of the hybrids in this study indicates that fast growth as well as resistance to disease can be incorporated into a breeding program for longleaf pine. Longleaf would be a good candidate for hybrid back cross breeding using some of the newer molecular methods (Nance and others 1991).

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