BROWN-SPOT RESISTANCE AMONG PROGENIES OF LONGLEAF PLUS TREES

Harold J. Derr 1/

Abstract.--Forty wind-pollinated seedlings from each of 227 longleaf pine (Pinus palustris Mill.) plus trees on national forests in Texas, Louisiana, Mississippi, Alabama, Florida, South Carolina, and North Carolina were planted at Alexandria, Louisiana, to test susceptibility to brown-spot infection (Scirrhia acicola (Dearn.) Siggers). After 2 years, family means ranged from 4 to 59 percent of dis.eased needle tissue. There was strong evidence of resistance among the selected parents, and evidence also of geographic influences. Nearby sources tended to be more susceptible than distant ones.

The study of resistance to the brown-spot needle blight has a long history at the Southern Forest Experiment Station and in the Mid-Gulf region, where the disease has commanded more attention over the years than elsewhere in the range of longleaf pine. By defoliating seedlings the blight retards growth, thus extending the grass stage of the trees and often causing heavy mortality.

Wakeley (1970) probably gave the first serious recognition to variation in host susceptibility when in 1928 he classified all seedlings in a planted stand according to their degree of infection. Some of his better trees are still identifiable and are being used for breeding. A few years later,Dr. A. F. Verrall observed resistant individuals in natural stands and made needle resin extractions to determine if resistance had a physiological base (Verrall 1934). Then in 1937 Dr. Paul V. Siggers, who later published results of a thorough study of the disease (Siggers 1944), found a highly resistant individual growing in a heavily infected, abandoned nursery in Louisiana, and he transplanted it to an experimental forest where it could be protected and preserved. Wind- and control-pollinated progeny of this tree have demonstrated that resistance is heritable (Derr and Melder 1970).

The search for resistant strains has been slowed by the necessity of screening progenies under field conditions, since the causal fungus, Scirrhia acicola, has not yet proved amenable to culture and inoculation.

1/ The author is Principal Silviculturist at the Alexandria Forestry Center, Southern Forest Experiment Station, USDA Forest Service, Pineville, Louisiana.

Despite this difficulty, progenies of more than 900 trees have been field-tested, and some promising ones retested. Here I will report initial results of the latest test, which included the progenies of 227 trees growing throughout the longleaf pine range from Texas to North Carolina.

MATERIALS AND METHODS

The parents are superior-tree selections on southern national forests. It is generally assumed that screening for brown-spot resistance will be most profitable if confined to large dominants in even-aged stands. The premise is that superior growth is related to exceptional seedling vigor bestowed by resistance. Superior trees generally meet the requirement of dominance and are chosen for a number of other desirable traits.

Longleaf selections on the national forests total upwards of 450 trees, but only 227 bore seed in 1967, when the study was initiated. The 227 are distributed geographically as follows:

	No. of trees
Texas	42
Louisiana	33
Mississippi	22
Alabama--north	33
Alabama--south	22
Florida	25
South Carolina	37
North Carolina	13

Seeds were collected by ranger district personnel. In late March of 1968, approximately 44 seeds from each tree were sown in each of four nursery replications, which were arranged in a complete randomized block design. Seedlings received normal nursery culture, including one midsummer spraying with Bordeaux mixture for prevention of brown-spot. Seedlings were lifted in mid-November, potted, and stored outdoors until they were planted in early March.

The field test is on an unburned open site with a sandy, well-drained soil. It is approximately 20 miles southwest of Alexandria, Louisiana--on the Longleaf Tract of the Palustris Experimental Forest. An earlier longleaf planting adjacent to the test site indicated a moderate to severe brown-spot hazard. Seedlings were planted in shallow furrows to insure full exposure to spores; the furrows, in effect, accelerated the rate of disease build-up. A test plot contains 10 seedlings, and is replicated four times in a complete randomized block design. Post-planting culture was limited to control of pocket gophers and removal of silt from seedlings that had been planted too deep.

After two growing seasons each survivor was examined to determine the proportion of its 1970 foliage that was infected or destroyed by brown spot. Estimates were made to the nearest 10 percent except that seedlings regarded as resistant--i.e., those with 5 percent or less needle loss--were estimated to the nearest 1 percent. Seedling heights were recorded to the nearest 0.1 foot. These data were analyzed for differences among families in:

Average percent of diseased needle tissue

Proportion with 5 percent or less infection (Freeman-Tukey arcsine transformation)

Proportion surviving (F-T transformation)

Average height

Similar analyses were made for geographic differences; in these analyses States, or location within State in the case of Alabama, were taken as sources.

All tests of significance were at the 0.01 level.

RESULTS

After 2 years of field exposure, the half-sib families differed widely in percentage of needle tissue dead or infected, in proportion of seedlings with needle loss of < 5 percent, and in survival and average height (table 1).

Table 1.--Means, ranges, and variances from analyses of 227 wind-pollinated longleaf pine families screened for brown-spot resistance after 2 years of field exposure

Variable	Mean	Range	Error M.S.	Family M.S.	
Average percent diseased	26	4-59	151.9537	536.4150	(significant)
Proportion with < 5 percent infection	37	2-89	196.8594	570.0343	(significant)
Proportion surviving	88	56-100	80.4805	483.7500	(significant)
Average height (feet)	0.43	0.22-.76	2.0153	3.8243	(significant)

D.F. Families = 226 Error = 675 (3 missing plots subtracted)

Brown-Spot Resistance

Brown-spot build-up followed a pattern that has been familiar within the general area of the test site. Seedlings remained relatively free of disease through the first year. Infection developed rapidly in the second year, reaching a mean rate of 26 percent needle loss for all progenies combined. Since spread of infection is never uniform, there is always some doubt whether clean seedlings are resistant or escapes. In many instances, however, relatively clean plots (60-foot rows) were bordered by heavily infected plots. Since brown spot normally spreads concentrically, this pattern indicates fairly adequate exposure.

The best and the poorest 10 percent of the progenies are listed in table 2. Ranking is based primarily on the proportion of survivors with 5 percent or less needle infection, although the relationship between this statistic and the conventional expression of brown-spot severity--average percent of current needle involvement--is close. In the best 10 percent--22 families--72 percent of the survivors were classified as resistant (< 5 percent infection), and the amount of diseased needle tissue averaged 11 percent. In the poorest, or most susceptible, group of 22 families only 8 percent of the survivors were resistant, and loss of current needle tissue averaged 48 percent. Survival of the two groups was nearly alike. Extremes in individual family performance are represented by a South Carolina parent with nearly 90 percent of its progeny classed as resistant, and a Louisiana tree with only 2 percent.

Wind-pollinated seedlings from Siggers' resistant genotype have been planted in many earlier tests, and have consistently yielded 30-40 percent resistant individuals under conditions where nonresistant stock has failed entirely. They performed similarly in the current study; 45 percent were classed as resistant. However, this tree ranked only 78th in the array of 227 means, and it was exceeded by one other Louisiana tree.

Geographic influences are fairly evident in table 2. Parent trees in Alabama, South Carolina, and Florida dominate the most resistant group, while those with least resistance are largely from Louisiana and Texas. Analyses of State means revealed significant differences in all variables tested (table 3). Progenies originating in south Alabama (Conecuh National Forest) excelled all others in resistance, and those from the eastern part of the range, with the exception of North Carolina trees, excelled the local Louisiana source by a 2 to 1 margin.

Families within a State source varied considerably. For example, 51 percent of the progenies from south Alabama trees and 45 percent of those from north Alabama were resistant, but the range for all sources within the State was 12 to 89 percent. The poorest source, Louisiana, averaged only 20 percent resistant, but the parents varied from almost completely susceptible (2 percent) to 62 percent resistant.

Survival and Growth

Survival varied among progenies and geographic sources. However, it is doubtful if the differences have practical significance, since a large but undetermined fraction of the loss was caused by pocket gophers.

Table 2.--Ten percent of 227 longleaf pine half-sib families having highest resistance to brown-spot infection in a central Louisiana test, compared with 10 percent having lowest resistance

Parent tree	Most resistant: Survivors with < 5 percent infection	Most resistant: Average diseased needles	Most resistant: Survival	Most resistant: Average height	Parent tree	Least resistant: Survivors with < 5 percent infection	Least resistant: Average diseased needles	Least resistant: Survival	Least resistant: Averag height
	Percent	Percent	Percent	Feet		Percent	Percent	Percent	Feet
So. Car. 202	89	4	95	0.51	La. 237	2	47	90	0.36
Ala. Con 100	84	8	87	.63	La. 279	3	54	90	.43
Ala. Tal 95	83	6	90	.51	La. 143	3	57	95	.52
Miss. Bx 20	78	9	77	.56	Texas 264	4	57	87	.26
So. Car. 57	78	9	92	.58	La. 130	4	49	69	.27
Ala. Con 68	78	9	92	.44	La. 253	5	49	92	.37
Ala. Con 61	76	10	82	.37	Texas 276	6	57	97	.34
Fla. 129	75	6	92	.76	La. 441	6	55	97	.36
So. Car. 100	73	9	85	.43	La. 412	6	48	95	.39
Ala. Tal 34	72	11	77	.41	La. 450	6	42	85	.48
Ala. Tal 165	71	11	87	.51	Texas 9	8	49	90	.39
Fla. 21	69	8	90	.32	Texas 270	9	46	87	.56
Ala. Tal 78	68	12	87	.44	Texas 273	9	52	93	.45
Ala. Con 47	68	14	95	.37	No. Car. 1006	9	44	60	.29
So. Car. 128	67	13	90	.56	Texas 321	10	46	92	.52
So. Car. 86	67	11	80	.33	Texas 341	11	43	90	.54
Fla. 93	67	13	87	.35	Miss. Bx 25	11	39	88	.61
Ala. Con 36	66	12	97	.47	Texas 76	11	39	84	.52
So. Car. 176	64	12	87	.40	No. Car. 43	11	40	92	.40
La. 149	62	15	82	.43	La. 238	12	45	80	.37
Ala. Tal 160	62	17	92	.32	Ala. Con 4	12	39	85	.35
Texas 358	62	19	56	.41	Fla. 284	18	59	82	.33
Group mean	72	11	86	.46		8	48	87	.41
Grand mean	37	26	88	.43		37	26	88	.43

Table 3.--Means of progenies grouped by State of origin, and analyses of geographic source differences

Geographic source	Survivors with 5 percent infection	Average diseased needle tissue	Survival	Average height
	Percent	Percent	Percent	Feet
Alabama--south	51	18	88	0.42
Alabama--north	45	20	90	.41
South Carolina	45	21	89	.44
Florida	44	20	85	.46
Mississippi	37	25	90	.45
North Carolina	27	33	84	**.36**
Texas	27	32	86	.49
Louisiana	20	38	86	.40
Mean	37	26	87	.43

Analyses of Variance--Geographic Sources

Variable	Error M.S.	Source M.S.
Proportion with < 5 percent infection	7.0927	186.5058 (significant)
Average percent diseased	7.3129	221.2166 (significant)
Survival	4.1084	16.3195 (significant)
Average height	0.0894	0.7193 (significant)

D.F. Error = 21 Source = 7

Average seedling heights differed significantly among progenies at age 2; they ranged from 0.21 to 0.76 foot. Differences among the geographic sources also were significant, but the range was considerably less. The most vigorous progenies were well into active height growth at the end of 2 years, with little within-plot variation among individuals. Others displayed considerable variation in height initiation, while some were uniformly stemless. Progenies with low brown-spot infection generally grew best, but there were some exceptions. For example, two families with exceptionally light infection ranked 45th and 46th in the array of height means. Also, progeny of the Texas trees were the tallest among the eight geographic sources but ranked high in brown-spot susceptibility.

DISCUSSION

The superior-tree selections have yielded a higher ratio of brown-spot resistant trees than any group previously tested. Seventy-seven of the 227 parents ranked ahead of Siggers' tree. This performance exceeds previous results by a wide margin. If only trees growing west of the **Mississippi River** are considered, seven of 75 parents can be classified as resistant. This, too, is above the average for a routine screening test. So it can be concluded, tentatively, that a dominant tree, selected for superior growth and form, is somewhat likely to have brown-spot resistance.

Geographic differences, or in this test superiority of nonlocal sources, confirm earlier studies in indicating an east-to-west gradient in brown-spot susceptibility, especially for the Gulf Coast States (Henry and Wells 1967). The Louisiana trees as a group did not perform well in this study. When central Louisiana trees have been planted elsewhere, as in the Southwide Pine Seed Source Study, their survival has been good but their growth has been slowed by brown spot (Wells and Wakeley 1970). The current study points out, as others have, the superiority of south Alabama sources.

Mass screening under field conditions is the only method now available for detecting brown-spot resistance in longleaf pine. While laborious, it is apparently effective since all tests completed to date have shown wide variation in susceptibility among half-sib families. Some retesting has been done to confirm earlier results. One such test was made concurrently with this study, on the same site and with identical procedures. It included wind-pollinated seedlings from 80 Louisiana selections gleaned from earlier screening tests. Average needle loss of the 80 selections was 17 percent, and 56 percent were classed as resistant. Comparable values for the superior-tree selections were 26 percent needle loss and 37 percent resistant.

LITERATURE CITED

Derr, H. J., and Melder, T. W. 1970. Brown-spot resistance in longleaf pine. Forest Sci. 16: 204-209.

Henry, B. W., and Wells, O. 0. 1967. Variation in brown-spot infection of longleaf pine from several geographic sources. USDA Forest Serv. Res. Note SO-52, 4 pp. South. Forest Exp. Stn., New Orleans, La.

Siggers, P. V. 1944. The brown spot needle blight of pine seedlings. USDA Tech. Bull. 870, 36 pp.

Verrall, A. F. 1934. The resistance of saplings and certain seedlings of *Pinus palustris* to *Septoria acicola.* Phytopathology 24: 1262-1264.

Wakeley, P. C. 1970. Thirty-year effects of uncontrolled brown spot on planted longleaf pine. Forest Sci. 16: 197-202.

Wells, O. 0., and Wakeley, P. C. 1970. Variation in longleaf pine from several geographic sources. Forest Sci. 16: 28-42.