Factors Contributing To Genetic Variation In Ice Damage Susceptibility In Shortleaf Pine

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There are differences among species in susceptibility to ice damage (Williston 1974). There is also at least one report on within-species variation, where coastal loblolly pine was damaged more than interior seed sources in an ice storm (Jones and Wells 1969). Of all the maladies affecting the growth and survival of southern pines, damage from ice storms is one of the most erratic and unpredictable. Incorporating resistance to ice damage in any tree improvement program would be extremely difficult, if not impossible. It might be possible, however, to identify useful factors that contribute to genetic susceptibility to ice damage in the event that a progeny test is damaged by ice.

In December, 2000, a major ice storm in Arkansas damaged a controlled-cross shortleaf pine (*Pinus echinata* Mill.) progeny test located near Hot Springs. This provided an opportunity to study genetic variation in ice susceptibility, and examine possible contributing factors.

MATERIALS AND METHODS

The progeny test contained 15 controlled-cross shortleaf pine progenies planted in central Arkansas and south Mississippi in 1992. The field plots were randomized complete blocks of five replications with six-tree plots. Spacing in the plantings was 3 by 10 ft. Only the Arkansas planting was damaged by ice.

In March of 2001, approximately four months after the ice storm, the planting was examined for damage. A score of 0 to 5 was used to quantify damage:

0. No damage apparent
1. Upper stem bent 45^o or less
2. Upper stem bent more than 45^o or tip broken (one inch in diameter or less
3. Upper stem bent between 45^o and 90^o or top broken (up to two inches in diameter) but within the live crown
4. Stem bent more than 90^o or stem broken up to three inches in diameter
5. Tree uprooted, on the ground, or stem broken below live crown.

The scale is meant to reflect the probability of survival or damage. A score of 5 indicates no possibility of survival; a score of 4 might survive but growth would be severely curtailed; a score of 0 indicates a tree unaffected in growth or survival.

Height and DBH (diameter at 4.5 feet) were measured in the fall of 2000, after 9 years in the field. Allozyme data was available on 12 of the female and 10 of the male parents. In 4 of the females, but none of the males, polymorphisms were found at the IDH locus. Polymorphisms at this locus have previously been linked to hybridization with loblolly pine (Huneycutt and Askew 1989). Needle lengths were also measured on 10 needles per tree in the southern planting.

RESULTS AND DISCUSSION

Trees in the highest damage classes tended to have greater diameters. DBH ranged from 4.3 inches in the zero damage class to 4.9 inches in the 5 damage class. Crown size is generally correlated with DBH, and it is logical to assume that larger crowns accumulate more ice and subject trees to more stress. On a family mean basis, however, DBH was not related to ice damage ($r = 0.19$, $P = 0.5$). Similarly, height was not related to ice damage on a family mean basis ($r = 0.09$, $P = 0.8$).

Significant differences were found among crosses in ice damage (Table 1) ($P= 0.038$), as well as needle length ($P < 0.001$). There was also a clear tendency for families with longer needles to suffer more ice damage ($r = 0.52$, $P = 0.047$). Those families whose female parents were heterozygous for the "loblolly" IDH allele had significantly longer needles than those whose parents that did not posses this allele: 70 mm versus 62 mm, even though only half the progeny involving the polymorphic parent would possess this allele. Thus, loblolly genes may predispose shortleaf pines to be more susceptible to ice damage, perhaps because of increased needle area.

Table 1. Needle length, ice damage, height and DBH of 15 controlled-cross families, listed by female parent.

Female	IDH[1] locus	Needle Length mm	Ice Damage	Nine-year Height ft.	DBH in.
207	1	76	2.92	17.8	4.36
243	1	67	2.35	18.8	4.48
228	1	64	2.40	17.8	4.55
205	1	76	3.10	19.0	4.59
322	0	56	2.04	17.4	4.13
237	0	69	2.79	17.4	4.21
229	0	66	2.23	17.7	4.22
315	0	56	2.50	17.8	4.63
213	0	63	1.65	19.9	4.66
320	0	59	2.86	20.5	4.75
218	0	63	2.35	19.2	4.83
136	0	67	2.60	17.8	4.85
319	-	59	2.20	16.0	3.78
124	-	63	2.56	17.3	4.42
313	-	60	2.68	19.3	4.44

[1] Presence of "loblolly" allele at the IDH locus: (1) - present, (0) - not present, (-) - not determined.

The frequency of polymorphisms at the IDH locus, 4 out of 22 clones from the Ouachita orchard, or about 18%, is higher than the 17% found by Raja *et al.* (1997) and the 5% found by Edwards and Hamrick (1995) in western shortleaf pine populations. Raja *et al.* (1997) doubted the assertion of Honeycutt and Askew (1989) that polymorphisms at this locus necessarily indicate hybridization with loblolly pine. The longer needle length found here associated with such polymorphisms supports the hypothesis that the presence of this allele indicates hybridization with loblolly.

Besides having longer needles, loblolly pine is faster growing than shortleaf pine under most conditions. In this study, the families from females heterozygous for the "loblolly" allele were taller than those from non-heterozygous parents at both plantings at ages 4 and 9 years, but the difference was statistically significant only at the southern planting at age 4 (10.0 versus 9.5 feet, P=0.018). The relatively high proportion of orchard clones with the "loblolly" allele may be a result of selection for greater growth relative to comparison trees in the forest stands.

CONCLUSIONS

Ice-damage susceptibility does appear to be inherited. Indirect selection using needle length and the presence of the "loblolly" IDH allele could be used to select for resistance. Because of the sporadic nature of damage, however, it would not appear to be an important consideration in breeding programs.

LITERATURE CITED

Edwards, M.A. and J.L. Hamrick. 1995. Genetic variation in shortleaf pine, *Pinus echinata* Mill. (Pinaceae). Forest Genetics 2: 21-28.

Huneycutt, M. and Askew, G.R. 1989. Electrophoretic identification of loblolly pine-shortleaf pine hybrids. Silvae Genet. 38: 95-96.

Jones, E.P., Jr., and O.O. Wells, 1969. Ice damage in a Georgia planting of loblolly pine from different seed sources. Res. Note SE-126 Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station. 4 p.

Raja, Rajiv G., C.G. Tauer, R.F. Wittwer, and Yinghua Huang. 1997. Isozyme variation and genetic structure in natural populations of shortleaf pine (*Pinus echinata)*. Can. J. For. Res. 27: 740-749.

Williston, H.L. 1974. Managing pines in the ice-storm belt. J. For. 72: 580-582.