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Direction of Pollination Affects Seed Productivity in (Shortleaf x Loblolly) x Loblolly Hybrids

by Timothy La Farge and Davie L. Hunt[1]

ABSTRACT.— In reciprocal crosses between shortleaf × loblolly pine hybrids and loblolly pines, seed production per pollinated flower was higher when the loblolly pine was the mother tree. We therefore recommend that loblolly pines be favored as mother trees in such work, even though storage of pollen for 1 year is required.

Keywords: Interspecific hybridization, *Pinus taeda, P. echinata,* seed yields.

Hybrids of loblolly *(Pinus taeda* L.*)* with shortleaf pine *(P. echinata* Mill.*)* show promise of combining the superior growth of former species with the latter's resistance to fusiform rust caused by *Cronartium quercuum* (Berk.) Miyabe and Shirai f. sp. *fusiforme.* Backcrosses of the hybrid with loblolly pine appear particularly promising in these respects. Although we have not yet progeny tested reciprocal crosses, we believe that selection of the hybrid or the loblolly as the female parent in the backcross yields identical genetic results, but it is of considerable practical significance. In a large breeding program, it is important to make backcrosses in the direction that will yield the most seeds for a given amount of bagging and pollination effort.

This Note describes the results of pairs of reciprocal backcrosses. Seed yields and efforts to obtain these yields are described. In each pair of backcrosses, one member is loblolly × (shortleaf × loblolly) and the second is (shortleaf × loblolly) × loblolly. In this standard notation, the female parent is always listed first.

METHODS

From 1972 through 1977 eight (shortleaf × loblolly) × loblolly hybrid crosses and their reciprocals were made and their seeds collected. Data collected included: (1) the number of flowers in each bag at the time of pollination, (2) the number of sound cones collected for each bag, and (3) the total number of sound seeds extracted from each cross.

Variables for analysis were: (1) the percentage of pollinated flowers which developed into sound cones, (2) the number of sound seeds per cone, and (3) the number of sound seeds per pollinated flower. Trait 1 was transformed to arcsin $\sqrt{\text{percentage}}$. Values for traits 2 and 3 were transformed to $\sqrt{x - 0.5}$ because they are small whole numbers which tend to conform to the Poisson distribution.[2]

The study design contained randomized complete blocks in which the two reciprocal backcross types in the paired comparisons constituted the randomly chosen blocks (from Sokal and Rohlf 1969). The *F*-ratio so produced equals the square of the *t*-value obtained in the traditional *t*-test of paired comparisons.

The loblolly parents for the study were in the Arrowhead Seed Orchard of the Georgia Forestry Commission in Pulaski County, Georgia.[3] The hybrid parents were 45 miles to the north on the Hitchiti Experimental Forest in Jones County. It would have been best to make each pair of

[1]Plant Geneticist and Forestry Technician, respectively. Macon, Georgia 31208.

[2]Sokal, Robert R., and F. James Rohlf. 1969. Biometry. 776 p. W. H. Freeman and Co., San Francisco.

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reciprocal crosses in the same year, but logistical problems precluded this approach. As a result, results may be confounded somewhat by year effects. Also, because the hybrids flower later than loblolly pine, all hybrid pollen used on loblolly trees had to be stored for 1 year. We used fresh loblolly pollen on the hybrids. Despite these possible sources of bias, the data presented are useful to tree breeders interested in hybridization.

RESULTS AND DISCUSSION

Breeding efficiency is best measured by determining the number of seeds recovered per pollinated flower (Bayne Snyder, personal communication). Although number of sound seeds per pollinated flower may be somewhat confounded with year of pollination, a breakdown of these results indicates a degree of consistency. Results of eight reciprocal crosses are shown in table 1. In

Table 1.—Summary of pollination, cone-yield and seed-yield data collected from 1972 through 1977 on (shortleaf × loblolly) × loblolly hybrids and their reciprocals

Backcross I.D.[1]	Year pollinated	Flowers pollinated	Sound cones collected	Sound cone survival[2]	Sound seed/cone	Sound seed/pollinated flower
		Number		*Percent*	*Number*	
HH 5 × TRO 2	1972	62	22	35.5	26.3	9.3
TRO 2 × HH 5	1975	57	35	61.4	38.5	23.6
HH 5 × CHA 3	1974	15	5	33.3	18.4	6.1
CHA 3 × HH 5	1975	38	32	84.2	36.8	31.0
HH 6 × CHA 3	1972 & 74	102	30	29.4	20.9	6.1
CHA 3 × HH 6	1975	40	38	95.0	35.9	34.1
HH 13 × CHA 3	1974	20	1	5.0	74.0	3.7
CHA 3 × HH 13	1975	22	19	96.4	35.8	31.0
HH 5 × FLO 32	1974	16	11	68.8	18.8	12.9
FLO 32 × HH 5	1975	45	42	93.3	64.6	60.3
HH 13 × HEA 15	1974	18	6	33.3	60.3	20.1
HEA 15 × HH 13	1975	22	13	59.1	19.6	11.6
HH 6 × HEA 15	1974	26	11	42.3	19.0	8.0
HEA 15 × HH 6	1977	24	14	58.3	2.4	1.4
HH 39 × MER 8	1975	42	22	52.4	1.8	1.0
MER 8 × HH 39	1977	42	34	81.0	42.6	34.5

[1] Parents designated by 3-letter abbreviations for their Georgia counties of origin are loblolly; those with "HH" designations are hybrids.

[2] (Sound cones collected/flowers pollinated) × 100.

terms of sound seed per pollinated flower (last column), use of the loblolly as female parent was more efficient in six of the eight comparisons. Both comparisons in which this result did not hold involved HEA 15 as the loblolly mother tree. This tree may simply be a poor seed producer. In an overall comparison, loblolly female parents produced significantly more sound seeds per pollinated flower (table 2).

the detrimental effect of storage was more than offset by some unknown detrimental effect associated with the hybrid mother trees.

The differences in seed yields between reciprocal backcross types may be attributed partly to difference in seed potential, defined by Bramlett[5] as two times the number of fertile cone scales, or the maximum number of fertile seeds a cone is capable of producing. Bramlett found that the seed potential for loblolly pine cones is 155 seeds, while that for shortleaf is 90 seeds. He therefore hypothesizes (personal communication) that shortleaf × loblolly hybrids might have a seed potential of about 120 seeds. Between reciprocal backcross types, however, differences in number of sound seeds per pollinated flower were much larger, for the most part, than seed potential would seem to account for. Hence, some external factor in addition to seed potential seems to be operating to produce the conelet losses in the hybrid mother trees.

Table 2.—Mean squares comparing reciprocal backcross types for three cone and seed-yield traits

Source	Degrees of freedom	Sound cone survival	Sound seed/ cone	Sound seed/ pollinated flower
Backcross	7	140.74	3.54	1.91
Reciprocal backcross type	1	2,678.06**	1.16	20.09*
Error	7	133.48	4.87	2.76

*Significant at the 5 percent level.
**Significant at the 1 percent level.

Also, the flowers of the hybrids, which resemble the flowers of shortleaf pine more closely than those of loblolly pine, aborted between pollination and cone collection much more frequently than did those of loblolly pine; this difference is significant at the 1-percent level. These abortions probably were, in turn, a major cause of the relatively low number of sound seeds per pollinated flower of the hybrid mother trees. Supporting this conclusion is the lack of a significant difference in the number of sound seeds per cone between the reciprocal backcross types (table 2).

Although the data are confounded by the use of stored versus fresh pollen, conelet losses of the hybrids pollinated with fresh loblolly pollen exceeded those of the loblolly mother trees pollinated with stored hybrid pollen. These results are opposite to those of Snyder and Squillace,[4] who reported considerable reductions in cone survival, seeds per flower, and seeds per cone when stored pollen was used, in comparison with fresh pollen. This is not to say that using fresh pollen in this study had no effect on seed or cone yield or that stored pollen was better than fresh pollen, but rather that

CONCLUSIONS

In hybrid breeding work, it is convenient to use shortleaf or shortleaf × loblolly trees as mother trees because fresh pollen is available from the earlier flowering loblolly trees. To use loblolly as the mother tree, it is necessary to store the shortleaf or hybrid pollen until the following year; consequently, there is some loss in pollen viability. However, the lesson from these reciprocal crosses seems to be that it would be most efficient, for many crossing schemes, to use loblolly trees as mother trees

[4] Snyder E. B., and A. E. Squillace. 1966. Cone and seed yields from controlled breeding of southern pines. USDA For. Serv. Res. Pap. SO-22, 7 p. South For. Exp. Stn., New Orleans, La.

[5] Bramlett, David L. 1974. Seed potential and seed efficiency. *In* Proceedings of a colloquium: Seed yield from southern pine seed orchards. p. 1-7. John F. Kraus, ed. Ga. For. Res. Counc., Macon, Georgia.

whenever possible. When shortleaf or hybrid trees must be used, as in diallel mating schemes, it probably would be best to bag more flowers to obtain the required amount of seed rather than using loblolly as the female parent.

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