

A SELF-POLLINATION EXPERIMENT IN *PINUS EDULIS*

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ABSTRACT.— Controlled pollinations were performed on four pinyons (*Pinus edulis* Engelm.) to compare the results of selfing and outcrossing. Final cone size was the same under both treatments. There was no significant difference in number of seeds per cone. Filled-seed yields averaged 14.4 percent in selfings and 90.5 percent in outcrossings. Relative self-fertility averaged about 15 percent, a level comparable with that of other pine species studied.

The breeding system of pinyon (*Pinus edulis* Engelm.) has received little study. In several particulars pinyon resembles other members of *Pinus*. For example, it is generally monoecious (Lanner 1975) and the sexes are usually segregated with the upper crown tending to be more female than male and vice versa, though there may be broad overlap. Pollen shed and conelet receptivity are limited to a short period in the spring (Lanner 1970). Meiosis leading to microspore formation is temperature sensitive during metaphase and anaphase, and temperatures below 4 C may result in inviable polyploid pollen grains (Chira 1967). Pinyon crosses readily with singleleaf pinyon (*P. monophylla* Torr. & Frém.) and natural hybrids and introgressants are widely distributed where their ranges overlap (Lanner 1974, 1975).

Though pines are generally considered to be outcrossing species, many studies have shown that self-fertilization is usually at least marginally successful in producing sound seeds. This paper reports the results of a controlled pollination experiment in which selfing was compared to outcrossing.

METHODS AND MATERIALS

Isolation bags of nonwoven cloth with celluloid windows were placed over female branches of four pinyon pines of unknown seed source on the campus of Utah State University 4 June 1976. Pollen extracted the previous year and stored in a freezer was applied with a hypodermic syringe 8 June 1976, shortly after conelets emerged from their

covers of bud scales. Table 1 summarizes the crosses made. Pollination treatments were self-pollen and outcross pollen. Most of the outcross pollen was a bulked mix from all the seed trees except tree 3, plus an additional tree. Tree 3 was outcrossed with trees 9 and 28. Isolation bags were removed 22 June 1976. Cones were inventoried 13 July 1976 and in June 1977; they were harvested 25 August 1977 prior to cone dehiscence. Seeds were extracted in the laboratory as cones dehiscid at room temperature. Seeds were tallied as filled or empty on the basis of weight and seed coat color: empty seeds are easily detected in handling and by their light-colored seed coats.

RESULTS

1. *Cone survival.*— Within 2 weeks of pollination 12 of the 31 selfed cones and 2 of the 35 outcrossed cones had aborted. By 15 June 1977, a year after pollination, one more selfed cone and 4 more outcrossed cones had aborted and been shed. No further losses oc-

TABLE 1. Distribution of pollination treatments among trees.

Tree	Pollination treatment	
	Selfed	Outcrossed
	Number of conelets	
3	—	16
4	7	5
36	12	8
58	12	6
Total	31	35

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curred prior to maturity. Final survival rates were 57 percent for selfed cones and 83 percent for outcrossed cones.

2. *Cone size*.—Lengths of 14 mature selfed cones ranged from 3.3–3.9 cm ($\bar{x}$ = 3.6 cm). Lengths of 16 outcrossed cones showed identical ranges and mean.

3. *Seed yield*.—Yields of seeds per cone are summarized in Table 2.

In all three trees that were both selfed and outcrossed the yield of seeds per cone was slightly higher under selfing, but the differences were nonsignificant in all cases.

Yield of filled seed and relative self-fertility are summarized in Table 3. Filled seed percent averaged 14.4 percent in selfings and 90.5 percent in outcrossings. Relative self-fertility, a statistic designed to neutralize variation not associated with embryo genotype but which can influence seed yield (Sorensen 1970), ranged from about 10 to 21 percent and averaged about 15 percent.

DISCUSSION AND CONCLUSIONS

It is unclear why survival of selfed cones was exceeded by that of the outcrossed cones. All losses of selfed cones occurred by 13 July 1976, just five weeks after pollination. Fer-

TABLE 2. Number of seeds per cone after selfing and outcrossing.

Tree	Pollination treatment	
	Selfed	Outcrossed
3	—	13.9
4	5.8	4.8
36	10.4	9.4
58	5.2	3.7
Total	7.76	10.52

TABLE 3. Yield of filled seed by pollination treatment and relative self-fertility of seed trees.

Tree	Pollination treatment and yield of filled seed		Relative self-fertility ¹
	Selfed	Outcrossed	
	Percent		
4	8.7	89.5	9.72
36	15.7	74.2	21.2
58	15.4	100.0	15.4
MEAN	14.4	90.5	15.4

¹Relative self-fertility (Sorensen 1970) is computed as:

No. of filled seed/total number of seed in selfings
No. of filled seed/total number of seed in crossings

tilization does not occur in pines until about one year after pollination and cones are made up entirely of female parent tissue, so early cone abortion is not related to such genetic causes as homozygosity of recessive genes. The most likely explanation of a lower average level of cone set among selfed cones is a lower level of pollination. Pollen of individual trees was in shorter supply than bulked pollen, and may have been used too sparingly in a few cases, resulting in close to zero pollination of ovules. Sorenson (1970) has reported 75 percent cone set in outcrossed cones of ponderosa pine (*P. ponderosa* Laws.) and 70 percent in selfed cones, but the difference was not statistically significant.

Reduction in filled seed per cone by selfing as compared to outcrossing is a common finding among pines. Sorenson (1970) found that filled seed yields in ponderosa pines average 23.7 percent for self and 66.5 percent for outcrosses; in Scotch pine (*P. sylvestris* L.) selfing produced 13.4 percent filled seed and outcrossing 71.4 percent (Johnsson 1976). Bramlett and Pepper (1975) reported average filled seed yields of 16.4 percent and 90.7 percent for selfed and outcrossed cones of Virginia pine (*P. virginiana* Mill.). Squillace and Kraus (1962) found that selfing slash pine (*P. elliotii* Engelm.) resulted in 9 sound seeds per cone, and outcrossing produced 34 seeds per cone. Snyder (1968), also working with slash pine, generalized that selfing yields about 15 percent as many seeds as wind pollination. In this experiment, the filled-seed yield of selfed pinyon was about 15 percent that of the outcrosses.

The reduced sound-seed yield in selfed pines and other conifers is due to the enhanced homozygosity of embryonic lethal alleles. The results of the crosses reported here suggest that the number of lethals in pinyon is comparable to that in other species of *Pinus*.

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