IMPACT OF SEED INSECTS ON CONTROL-POLLINATED SLASH PINE CONES

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Abstract.--Screening to exclude insects greatly increased the seed yields from self-, polycross-, and wind-pollinated slash pine cones. The sample cones were dissected and the cone scales identified as fertile or infertile. Based on radiographic examination, all ovules and seeds on the fertile scales were classified as (1) first-year aborted ovules, (2) second-year aborted ovules, (3) empty seed, (4) filled seed, (5) seedbug-damaged seed, or (6) _Laspeyresia_-killed seed. Caged wind-pollinated cones produced an average of 116 filled seeds per cone compared to 20 filled seeds produced by uncaged cones. Self- and polycross-pollinated cones produced 6 and 16 filled seeds per cone with screen wire cages but only 2 and 11 filled seeds per cone without cages. Most seed loss occurred as aborted ovules before seedcoat formation (wings but without seed). Both insect damage and pollination problems contributed to the high seed losses.

Additional keywords: Leptoglossus corculus, ovule abortion, _Pinus elliottii, Tetyra bipunctata._

Poor seed yields from control-pollinated slash pine, _Pinus elliottii_ Engelm., cones have plagued tree improvement workers for years. Snyder and Squillace (1966) reported an average of 28 sound seeds per slash pine cone from many years of controlled pollinations at Olustee, Florida, and Gulfport, Mississippi. Self pollination yielded one-eighth to one-sixth as much seed, while wind pollinations produced an average of 46 sound seeds per cone. Wakeley (1954) found that slash pine cones produced from 60 to 70 sound seeds per cone in good years and about half these numbers in poor years.

In a recent study DeBarr and Ebel (1974) demonstrated that the leaffooted pine seedbug, _Leptoglossus corculus_ (Say) (Hemiptera: Coreidae), and the shieldback pine seedbug, _Tetyra bipunctata_ (H.-S.) (Hemiptera: Pentatomidae), cause extensive seed losses in loblolly and shortleaf pines. The study described here was designed to determine how much seed yields from various types of slash pine pollinations might be increased by protecting against insect damage. In 1973 Squillace and Goddard began a study at Olustee, Florida, aimed at determining the extent of selfing in slash pine seed orchards through the use of gene-marker clones. Our entomological study was superimposed upon this study. To segregate insect-caused seed losses from pollination problems, small screen wire cages were used to protect cones.

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Using techniques described by Bramlett (1974), we also determined the maximum seed production potential for cones of the gene-marker clones. Then seed losses from self, polymix, and wind pollination were categorized and expressed in terms of seed potential. Finally, seed efficiencies were calculated from the yields of filled seed and the seed potential per cone.

MATERIALS AND METHODS

The ramets were located in six slash pine seed orchards owned by Brunswick Pulp and Paper Company, Florida Division of Forestry, ITT-Rayonier, Inc., University of Florida, and USDA Forest Service.[2/] Twenty-four clusters of female strobili were bagged for control pollinations on each of 8 gene-marker clones--16 for selfing and 8 for controlled crosses. An additional 8 unbagged wind-pollinated clusters were also designated. At the time of bag removal, one-half the clusters in each pollen treatment were caged. Thus, caged totals included selfed flowers on 8 shoots, poly-crossed flowers on 4 shoots, and wind-pollinated flowers on 4 shoots for each clone.

Protecting the strobili clusters from seedbugs during the months from pollination to harvest required the use of two types of small screen wire cages (DeBarr and Ebel 1974). Cages used to protect conelets were installed during the months of March and April 1973. In August of 1973, these cages were replaced with a second type that protected the strobili until harvest in September of 1974.

At collection, cones were placed in individual kraft paper bags. The sample cones were dissected and the cone scales identified as fertile or infertile (Bramlett 1974). Based on radiographic examination (DeBarr 1970), all ovules and seeds on fertile scales were classified as (1) first-year aborted ovules, (2) second-year aborted ovules, (3) empty seed, (4) filled seed, (5) seedbug-damaged seed, or (6) *Laspeyresia*-killed seed. Seed potential (2X the number of fertile scales) and seed efficiency (the number of filled seed divided by seed potential) were also calculated (Bramlett 1974).

RESULTS AND DISCUSSION

Ovule abortion.--First-year ovule abortion was the most frequent cause of loss (fig. 1). There are two known causes of first-year ovule abortion--lack of viable pollen and seedbugs. Unpollinated ovules abort several months after receptivity, but the seed wing continues to develop (Sarvas 1962). The presence of viable pollen, even if it is self pollen, assures continued ovule development. Only 23 ovules/cone in the wind-pollinated protected cones aborted during the first year, compared to 98/cone for selfs and 127/cone for the polymix strobili. Since insects were excluded from these cones, the most probable causes of ovule abortion relate to the supply or viability of the pollen or to the mechanisms of pollination. For example, any of the following conditions could produce the same effect: (1) pollen application did not coincide with the peak period of strobili receptivity, (2) inadequate supply

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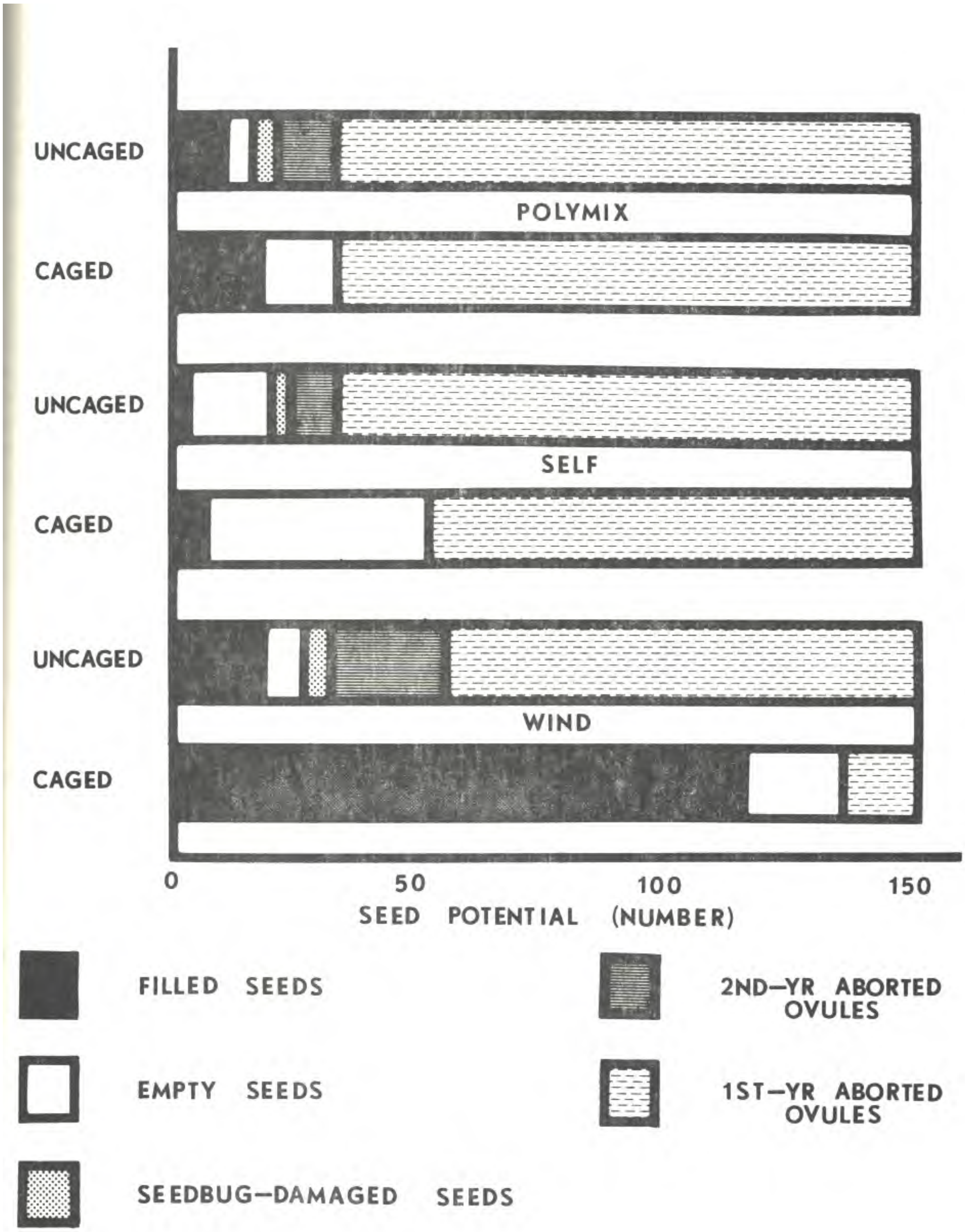

Figure 1.--Quantity and quality of seed harvested in 1974 from poly-cross-, self-, and wind-pollinated slash pine cones, with (caged) and without (uncaged) screening to exclude insects.

of pollen, (3) poor pollen distribution in the bag, or (4) nonviable pollen. *In-vitro* pollen germination was considered to be satisfactory (20 to 40 percent), but such germination may not always be a reliable measure of pollen vigor.

Seedbugs also destroyed first-year ovules (fig. 1). For all three pollination types, uncaged cones contained more aborted first-year ovules than caged cones. Eighty-six percent of the ovules in the caged wind-pollinated strobili were still healthy at the beginning of the second growing season, compared to only 64 percent in the uncaged wind-pollinated strobili.

Ovule abortion also occurred early in the second year of seed development. These ovules, destroyed before the formation of a mature seedcoat, appeared in mature cones as collapsed, resinous, or flattened seed. Caging tests have proven that abortion of second-year ovules in slash pine, Virginia pine, *P. virginiana* Mill., (Bramlett and Moyer 1973) and loblolly pine, *P. taeda* L., (DeBarr 1974) is caused exclusively by insects. In the present study, caged cones averaged less than 1 second-year aborted ovule per cone regardless of the pollen treatment, compared to 8, 12 and 23 second-year aborted ovules in the uncaged self-, polymix-, and wind-pollinated cones, respectively.

Seed quality.--In all but the caged wind-pollinated cones, more than two thirds of the seed potential was lost to ovule abortion by the time of fertilization early in the second season of strobili growth. Normally, fertilized ovules develop a stony seedcoat and become filled seeds. Under self pollination, there is a high probability of a recessive combination of embryonic lethals. If this occurs, the integuments continue to develop, while the embryo and female gametophyte degenerate, forming an empty seed. Eighty-six percent of the seeds from the self-pollinated cones protected with cages were empty, compared to only 14 percent of the wind-pollinated seeds from protected cones. For all three pollen types, protected cones yielded a higher percentage of filled seeds than unprotected cones.

From 5 to 11 percent of the seeds from the uncaged cones of the three pollen types were classed as seedbug damaged on the radiographs. In contrast, an average of less than 1 seed per caged cone was classed as seedbug damaged.

Strobili survival.--Conelet and cone abortion were not measured directly in our study but the numbers of conelets pollinated and the numbers of cones harvested were counted. Caging increased overall survival by almost one-third (table 1). Snyder and Squillace (1966) reported a long-term average of 40 percent of the cross-pollinated slash pine flowers surviving to maturity. Our uncaged value of 47 percent is within the range of their observations.

Table 1.--Percentage of flowers maturing into cones--slash pine, 1974

Protection	Pollen: Wind	Self	Polymix	Overall Average
Caged	76	63	55	68
Uncaged	56	33	45	47

Seed efficiency.--Bramlett (1974) found that the average seed potential for sample cones from a slash pine seed orchard was approximately 170 seeds per cone. The seed potential for our 8 gene-marker clones averaged 152 seeds per cone. Seed efficiency was least for self-pollinated strobili and greatest for the wind-pollinated strobili. Caging greatly increased the seed efficiencies for all three pollen types. An efficiency of 72 percent was obtained for the wind-pollinated caged cones.

CONCLUSIONS

Most seed loss occurred as aborted ovules before seedcoat formation. Both insect damage and pollination problems contributed to the high seed losses. Our yields from caged wind-pollinated cones demonstrate that it is possible to obtain a seed efficiency of 72 percent seed potential when insect damage is prevented. If pollination problems can be overcome, then insect protection would assure similar seed efficiencies for cross-pollinated cones. Perhaps geneticists and tree physiologists should reexamine techniques used in control pollinations.

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