SEED ORCHARD SURVEY (SOS): FINAL REPORT AND SUMMARY OF HIGHLIGHTS

Earl W. Belcher and Gary L. DeBarr

Abstract.--Analysis of three years of field and laboratory data on cones and seeds of 219 slash and 297 loblolly clones from 29 slash and 26 loblolly seed orchards in 10 southern states have been completed.

Cone production averaged 170 cones per tree at 11 years of age for loblolly and 156 cones per tree at 13 years of age for slash pine. Of the cones produced, 11% of the loblolly and 12.8% of the slash had visible damage by insects. A radiographic evaluation showed 9.9% of the loblolly and 15.0% of the slash pine seed were damaged by insects and 18.0% of the loblolly and 14.7% of the slash pine seed were empty.

The efficiency of these trees to produce viable seed was 32.8% for the loblolly and 23.8% for the slash pine. These figures are very conservative because they do not include preharvest cone and conelet losses.

INTRODUCTION

The Seed Orchard Survey was begun in 1971 as a cooperative project between interested orchard owners and the U.S. Forest Service. It was derived from a proposal by the Southern Forest Tree Improvement Committee?/ to identify problems, to indicate research needs and to indicate immediate applicable orchard management procedures to improve seed quality and yield.

Establishment of clones in an orchard design creates a specialized environment somewhat different from which the ortets originated. The variation present over a wide range of seed orchard environments was largely spectulative before the southwide seed orchard survey. With the survey now complete, an analysis of the data offers some insights into influences on seed orchard yields.

ANALYSIS PROCEDURE

Only data of clones submitted all three years in the survey (1971-1973) were subjected to a computer analysis. The analysis included 219 slash and 297 loblolly clones from 29 slash and 26 loblolly seed orchards in 10 southern states. A total of 1244 slash and 1649 loblolly pine tree collections were included in the analysis.

1/ Director, Eastern Tree Seed Laboratory, Macon, Georgia and Research Entomologist, SEFES, U.S.F.S., Athens, Georgia respectively. The Eastern Tree Seed Laboratory is operated in cooperation with the Georgia Forestry Commission, Georgia Forest Research Council, Southern Forest Experiment Station, U.S.F.S. and SA, S&PF, U.S.F.S.

[2]/ ad hoc subcommittee on seed quality and yield: R.G. Hitt (chairman), LeRoy Jones, Carlyle Franklin, John Kraus, and Ron Schmidtling, U.S.F.S.; Ray Goddard, Univ. of Florida, J.B. Jett, N.C. State Univ., and Claude O'Gwyn, International Paper Company.

Input from field and laboratory data included tree age, total cones harvested per tree, number of visible insect damaged cones per tree, estimated cones per bushel, number of cones in a 10 cone sample that opened or only half opened, total number of seed per 10 cone sample, radiographic analysis of the seed, germination d4ta and information as to whether insect control measures had been applied.1[1] Seed per cone, viable seed yield per tree, potential seed yield per tree and the efficiency of each tree were calculated.

A large amount of information was generated by the SOS survey. This paper highlights data by species (Table 1) and by states (Table 3) for all measured and computed variables (Table 2). The data is summarized and discussed for (1) field observations, (2) laboratory findings and (3) pro-
ction potentials.

DISCUSSION OF FINDINGS

Field Observations

Loblolly pine ranged from 5 to 918 cones per tree with a mean of 170 cones at an average age of 11 years (Table 2). Slash pine produced an average of 156 cones per tree at an average age of 13 years with a low of 14 and a high of 1011 cones per tree. Cone yield varied more between years than within years but relative to other trees a high cone producer remained a high cone producer and a low cone producer remained a low cone producer. Although this survey covers only three years of production from young orchards, this data indicates that more consideration may need to be given to clonal fecundity if the future demands for seed are to be met.

After collection, cones were visually inspected for insect damage. Over the three year period, 11.0% of the loblolly and 12.8% of the slash pine cones were reported as attacked by insects (Table 1). Averages for individual clones ranged from 0 to 67% for loblolly and from 0 to 57% for slash pine clones.

No provisions were made in SOS to identify specific insect pests; however, it is likely that most of the cones were infested by coneworms, *Dioryctria* spp. Seed yields from *Dioryctria* infested cones are almost nil (Sartor and Neel 1971) so cones reported as infested in SOS may be considered a total loss. Pre-harvest losses caused by insects occur over a two-year period for each cone crop and harvest counts of cone crops could underestimate the impact of insects by 50% or more (DeBarr 1974, DeBarr and Barber 1975). Therefore, the SOS estimates of cones lost to insects should be viewed as conservative.

Cooperators were also asked to indicate if the SOS ramets had been protected with insecticides. Over the three-year sampling period, more than 80% of the loblolly pine clones and 60% of the slash pine clones reportedly received at least one insecticide application per year. It appears, however, that, on the average, these treatments had little or no effect upon the percentage of insect-damaged cones occurring over the three-year period for

---

1/ Specific details on data measurements were previously reported by Belcher and Hitt, 1973.

either pine species. A wide diversity of insecticidal control measures were reportedly used, some of which offered little promise for Dioryctria control.

Cones with no visible insect damage were used to estimate the number of cones per bushel. This data was subject to considerable error since containers were not standardized between orchards and estimates were made to the nearest 1/4 bushel. Regional variations were noted (Table 3) but the low precision of the measurements limit the reliability of the data.

Laboratory Findings

For the three-year period of the SOS, an average of 8 slash pine and 8.6 loblolly pine cones per 10-cone sample opened, yielding 68 and 77 seed per cone respectively (Table 1). A radiographic analysis of the seed showed that 18.0% of the loblolly and 14.7% of the slash pine seed were empty. The cause of the empty seed was not determined.

Based on reported methods (DeBarr, 1970), identifiable seed insect damage was also noted. Radiographs revealed that 9.9% of the loblolly pine and 15.0% of the slash pine seed harvested had been destroyed by insects. The individual clone averages ranged from 0.3 to 37% for loblolly pine and from 0 to 61.3% for slash pine.

These estimates of seed losses caused by seedbugs are very conservative. Research studies have shown that radiographic examination of mature seed samples detects only late second-year damage (DeBarr and Ebel 1973, 1974). Conelet as well as first- and second-year ovule abortion were not identified by SOS, but were reflected only by decreased yields. In addition, some of the empty seed previously mentioned had probably also been destroyed by seedbugs.

The loblolly and slash pine clones which reportedly had been protected with insecticides yielded more seed per cone (Table 4) and had lower percentages of seedbug-damaged and empty seed than the unprotected cones.

Viability as measured by germination is an important aspect of production. The actual (or overall) germination was very low for both species. Loblolly averaged 68.9% and slash 62.5% with a range of 19.7% to 93.2% for loblolly and 22.6% to 90.2% for slash pine seed. However, empty seeds possess no capacity to germinate and thereby distort the true picture of viability. When germination is based on only the filled seed, loblolly averaged 91.6% and slash 81.7%. The filled seed which did not germinate might be attributed to abnormal development and seedbug damage which amounted to 10.4% for loblolly and 16.5% for slash.

The amount of fungal growth in the germination dishes were observed to be in proportion to the amount of seedbug damage and as a general observation almost any amount of seedbug damage is detrimental to seed viability (Rowan and DeBarr, 1974).

Production Potentials

The actual viable seed yield per tree for this survey was 10.0 M for loblolly and 8.0 M for slash as computed by the formula: Yield per tree = (seed/cone)(number sound cones/tree)(actual germination). Averages for individual clones ranged from 0.2 to 70.8 for loblolly and 0.2 to 61.1 for slash pine.

The number of ovules which are potentially capable of producing seed has been reported (Bramlett, 1974) as 170 for slash pine and 155 for loblolly pine. The potential seed yield per tree was obtained from the product of the appropriate seed potential and the total number of cones harvested per tree. The potential viable seed yield was 26.4 M for loblolly and 26.5 M for slash pine.

The efficiency of these trees to produce viable seed was expressed as the ratio of the actual yield to that of the potential yield. This was 32.8% for loblolly and 23.8% for slash pine. Although these figures may seem low they do not tell the whole story. Production efficiency, as defined in this paper, was based on the harvested cone crop and did not account for preharvest cone and conelet losses.

By far, the greatest cause of seed loss identified by the SOS survey was insects. When the data was summarized and analyzed by insect control treatments vs no control, the protected clones averaged about 20% higher in production efficiencies for both species. With the registration and use of more effective insecticides it is reasonable to expect an improvement in present seed production efficiencies.

REFERENCES CITED

Belcher, Earl W. and Robert G. Hitt. 1973. Observations on two-year results of the seed orchard survey (SOS). Proc. 12th So. For. Tree Imp. Conf. Baton Rouge, La., pg. 55-63.

Bramlett, David. 1974. Seed potential and seed efficiency. In Proc. of a Colloquium: Seed Yields from Southern Pine Seed Orchards. Ed. John Kraus. Ga. For. Res. Council, Macon, Georgia, pg. 1-7.

DeBarr, Gary L. 1970. Characteristics and radiographic detection of seedbug damage to slash pine seed. Fla. Entomol. 53: 109-117.

DeBarr, Gary L. 1974. Harvest counts underestimate the impact of Dioryctria on second-year slash pine cone crops. USDA For. Serv. Res. Note SE-203, 3 p. Southeast. For. Exp. Stn., Asheville, N.C.

DeBarr, Gary L., and Bernard H. Ebel. 1973. How seedbugs reduce the quantity and quality of pine seed yields. Proc. 12th South. Conf. on Forest Tree Improv., Baton Rouge, La., 1973: 97-103.

DeBarr, Gary L. and Bernard H. Ebel. 1974. Conelet abortion and seed damage of shortleaf and loblolly pines by a seedbug, Leptoglossus corculus. For. Sci. 20: 165-170.

DeBarr, Gary L. and Larry R. Barber. 1975. Mortality factors reducing the 1967-1969 slash pine seed crop in Baker Co., Florida--life table approach. USDA For. Serv. Res. Note (In Press). Southeast. For. Exp. Stn., Asheville, N.C.

Rowan, S. J. and G. L. DeBarr. 1974. Moldy seed and poor germination linked to seedbug damage in slash pine. Tree Planters' Notes 25(1): 25-27.

Sartor, C. F., and W. W. Neel. 1971. Impact of Dioryctria amatella on seed yields of maturing slash and loblolly pine cones in Mississippi seed orchards J. Econ. Entomol. 64: 28-30.

Table 1.--Three-year species means and statistics of the measured and computed SOS variables.

	Loblolly_Eine_			Slash_Piue		
Variablen	N	MEAN	C.V.%	N	MEAN	C.V.%
AGE	1610	10.9	23.6	1245	13.1	16.1
CONE-YLD	1528	170.1	137.7	1241	155.8	102.6
PER-INF	1505	11.0	125.9	1238	12.8	121.3
CONES-BU	1114	261.1	38.8	1033	166.1	34.3
SEED-CON	1624	77.1	44.2	1185	68.1	50.6
PER-BUG	1506	9.9	107.1	1058	15.0	91.8
PER-MAL	1506	0.5	537.6	1058	1.5	268.8
PER-EMPT	1506	18.0	81.2	1058	14.7	84.2
PER-SD	1506	71.6	28.4	1058	68.7	29.4
ACT-GER	1595	68.9	29.2	1139	62.5	32.6
FULL-GER	1600	91.6	13.0	1142	81.7	18.7
YLD-TREE	1451	10.0	172.6	1132	8.0	149.5
POT-YLD	1528	26.4	137.7	1241	26.5	102.6
PROD-EFF	1451	32.8	58.4	1132	23.8	68.0

1/ Defined in Table 2.

Table 2.--Definition of variables used in reporting of the Seed Orchard Survey.

AGE	Average age of trees during the 3-year study duration.
CONE-YLD	Total cones harvested per tree.
'ER-INF	Percent of total cones which were insect (Dioryctria) damaged as determined by visual inspection.
,ONES-BU	Cones per bushel estimated to nearest 1/4 bushel.
SEED-CON	Mean number of seed extracted per cone.
PER-BUG	Percent age of seed sample damaged by seedbugs as evaluated on radiographs.
'ER-MAL	Percent age of seed sample which appeared abnormally developed or malformed on radiographs.
PER-EMPT	Percent age of seed sample which appeared empty on radiograph and could not be attributed to seedbug damage.
PER-SD	Percent age of seed sample which appeared full and nondamaged on radiograph.
ACT-GERM	Actual germination. Germination of lot as it is.
FULL-GERM	Full seed germination. Germination of only filled seeds.
YLD-TREE	Viable seed harvested per tree (in thousands).
'OT-YLD	Potential yield of viable seed per tree (in thousands) based on published mean seed potential per cone and number of cones harvested.
PROD-EFF	Ratio of actual to potential seed yield per tree.
N	Number of ramets involved in determination of mean.
3.V.%	Coefficient of variation.

Table 3.--Three year means of measured and computed SOS variables by state in which orchards are located.

STATE	N	AGE	CONE-YLD	PER-INF	CONES-	SEED-CON	PER-BUG	PER-MAL	PER-EMPT	PER-SD	ACT-GERM	FULL-GERM
						Loblolly Pine						
AL	76	9.4	104.3	9.0	195.7	60.5	3.2	0.9	19.6	76.3	73.8	93.8
FL	15	12.6	666.4	3.6	298.3	100.3	9.2	0.4	18.6	71.8	67.6	92.1
GA	154	9.1	196.5	17.8	329.9	51.4	13.6	2.6	24.8	59.0	58.8	91.0
LA	156	11.1	113.5	10.9	265.9	79.4	9.7	0.4	14.4	75.4	70.5	90.1
MI	150	11.4	113.1	11.8	246.6	86.7	6.7	0.2	12.3	80.8	78.3	94.4
NC	419	12.4	166.3	11.4	242.2	92.1	7.5	0.3	14.3	77.9	75.1	93.6
SC	517	10.3	188.4	8.7	258.8	74.6	11.9	0.2	19.6	68.2	66.3	90.8
TE	42					50.2	8.9	0.6	24.8	65.7	65.2	93.2
TX	50	14.9	296.1	14.3	353.2	48.6	21.8	0.0	43.7	34.5	36.1	84.0
VA	57	10.6	15.9	29.1		80.5	10.8	2.1	14.7	72.5	65.0	85.0
						Slash Pine						
AL	56	13.3	112.6	12.0	151.5	79.0	17.9	0.2	10.5	71.4	59.1	69.0
FL	500	13.5	154.8	11.9	177.0	68.4	17.1	1.8	13.3	67.7	61.5	81.5
GA	435	13.2	146.6	13.6	152.8	64.8	13.2	1.5	13.5	71.9	65.0	82.9
LA	54	9.7	155.0	3.9	180.7	61.1	10.8	1.0	30.9	57.3	51.6	78.6
MI	59	13.7	171.7	33.7	156.5	83.4	10.4	2.8	8.5	78.3	70.3	82.8
NC	60	12.8	155.9	14.1	165.9	80.7	9.5	0.4	17.6	72.5	70.3	91.4
SC	44	12.6	277.9	3.0	202.0	66.0	17.5	0.7	24.8	57.1	57.1	83.8
TX	37	12.7	173.8	5.3	152.8	52.5	22.9	1.1	21.5	54.5	51.6	75.1

Table 4.--Comparison of data from clones protected with insecticides and unprotected clones--SOS 1971-1973.

Insecticide protection	Number of clones	% Insect-damaged cones	% Seedbug-damaged seed	% Empty seed	Number of seed/cone
LOBLOLLY PINE					
Yes[1/]	[illegible]	11.2	8.8	16.9	78.2
No	30	10.0	14.0	25.4	69.3
Unknown[2/]	[illegible]	10.1	15.4	18.8	75.5
SLASH PINE					
Ye[1/]	128	11.2	14.1	13.4	73.7
No	75	14.8	16.4	16.5	60.1
Unknown-	16	14.6	16.7	18.4	62.7

1! Insecticide applied at least once each year.

2! Not reported by Cooperator; may or may not have been protected.