EVALUATION OF SEED PRODUCTION BY CONE ANALYSIS

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ABSTRACT

A recently developed procedure, cone analysis, provides seed orchard managers an opportunity to estimate their orchard's potential seed production. The stage of development at which seed losses occur and the cause can also be identified. The procedural techniques are discussed. The analysis has been implemented as a testing service at the Eastern Tree Seed Laboratory, Macon, Ga. A summary of the results from the first year of this service program is presented.

INTRODUCTION

High seed yield from the seed orchard is an integral part in the success of a tree improvement program. However, in the South, as pine seed orchards began to produce larger cone crops, the yield of sound seed began to diminish. This same situation might also develop in the Northeast as orchards begin to mature. Therefore, orchard managers need a procedure to identify and quantify seed production losses in conifers. Cone analysis (Bramlett, 1974) is such a procedure. It provides information which is needed to evaluate and modify orchard management procedures so that seed yield can be maximized. The Eastern Tree Seed Laboratory in Macon, Georgia, now offers this analysis as a service. This paper describes the analysis technique and presents data from the first year of the program.

METHODS

Data Collection

Nineteen cooperators submitted a total of 1,246 cones of loblolly and slash pine for analysis in individual bags bearing identification of the sampling unit. Sampling in 1975 was either by bulk lot or by clone and ramet. Data was collected on each individual cone.

The cones were dried in a kiln at 40°C for 24 hours. All loose seeds and aborted ovules were then extracted. Each cone was then given an overnight water soak to close the scales and soften the cone for dissection.

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The core of the cone was removed by a series of drill bits (1/4, 5/16, 3/8, 7/16, 1/2) in a variable speed electric drill. This allowed the scales and all remaining seeds as well as aborted ovules to be freely removed and the analyses begun. The potential of the cone to produce seed (seed potential) was known to be equal to twice the number of fertile scales. The fertile scales were identified, during dissection, by their wider base and by the depression left by developing ovules.

Two separate fractions of fully developed seed were obtained: (1) that extracted from the dried cones and (2) the seed removed by dissection. Both were cleaned, counted and x-rayed. The first fraction was germinated. By use of x-radiography the fully developed seed were classified into: (A) sound, apparently viable seed, (B) insect damaged seed and (C) empty seed.

Ovule abortion is that portion of the potential seed production not accounted for by the fully developed seed. Ovules aborting during the second year of development (second year aborted ovules) were separated from fully developed seed by their smaller size and collapsed condition. The number of ovules aborting during the first year of development (first year aborted ovules) were determined by subtracting the sum of fully developed seed and second year aborted ovules from seed potential. The average per cone for the 1975 data is given in figure 1.

Data Calculations and Interpretation

Analysis of the data can provide a clear quantitative picture of where seed losses occur. The first step in the analysis is to calculate seed efficiency. Seed efficiency is equal to the number of undamaged filled seed obtained, divided by the number of potential seed.

Low seed efficiency will usually result from three causes: poor pollination, genetic lethals or insect damage. Insects are largely responsible for first year aborted ovules (DeBarr and Ebel, 1974), second year aborted ovules (Krugman and Koerber, 1969; DeBarr, 1967; Bramlett and Moyer, 1973) and for empty seed (DeBarr and Ebel, 1974; Bramlett and Moyer, 1973). Poor pollination is also a well established cause of first year ovule abortion (AcWilliam, 1959; Brown, 1971; Sarvas, 1962; Bramlett, 1974), while genetic lethal factors (Sarvas, 1962; Bramlett and Popham, 1971) are known causes of second year ovule abortion and empty seed. Deter--mining the relative importance of insect and non-insect factors to seed losses is easily accomplished by caging cones to prevent insect feeding. The losses in caged cones provide the amount of the total loss that is due to non-insect factors.

Guidelines for evaluating cone analysis results have been prepared by DeBarr and Bramlett. These guidelines indicate that the first year

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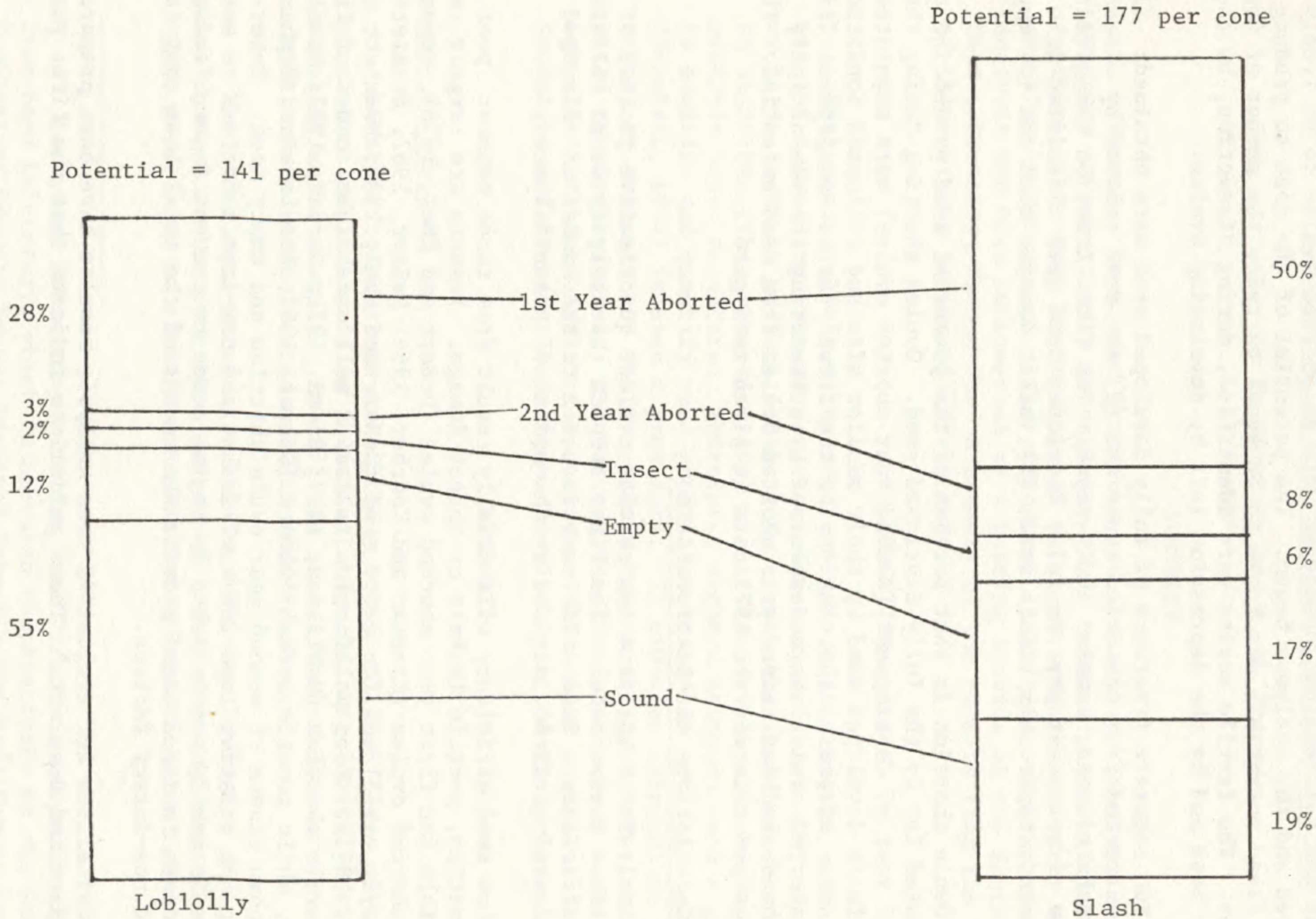

Figure 1. Summary of the cone analysis of 369 slash and 877 loblolly cones collected in the fall of 1975.

aborted ovules should not exceed 10 percent of the seed potential, second year abortions not more than 8 percent, and visible insect damage not more than 10 percent. A seed efficiency of 80 percent is a reasonable objective (Bramlett, 1974); however, 50 percent or less was more commonly observed.

The effectiveness of extraction procedures (extraction efficiency) was also estimated. Extraction efficiency is the number of sound seed extracted by kiln drying, divided by the total number of sound seed produced by the cone.

Finally the full seed germination, obtained from the germination test, tells how many of the sound seed have the capacity to produce a seedling.

The product of seed efficiency, extraction efficiency, and full seed germination gives the proportion of the seed potential that is capable of producing seedlings (figure 2). This term we call seedling efficiency.

SUMMARY OF 1975 DATA

Production of sound seed was much higher for loblolly pine *(Pinus taeda* L.) than for slash pine *(Pinus elliottii* Engelm.). Visible insect damage was 6 percent for slash and only 2 percent for loblolly. Considering the higher visible insect damage on slash pine seed, along with the research findings that most seed losses come from insect feeding, it appears that insect problems might be twice as severe in slash orchards as they are in loblolly orchards.

The percent germination of filled loblolly pine seed (table 1) was in the high 90's, indicating that seed orchard seed is as good as or better than, wild collections if properly cleaned. Loblolly full seed germination averaged 97 percent while slash averaged 83 percent on the samples analyzed.

The data in table 1 also suggests the importance of collecting mature cones. As an example, orchard 9 had an average seed efficiency 19 percent greater than the average seed efficiency for orchard 2. However, the seedling efficiencies were almost equal because of the poorer extraction efficiency of orchard 9. The problem probably was caused by cone immaturity. It is well known that cone maturation varies among individual trees (Dorman and Squillace, 1974); therefore, several cone collections may be beneficial.

Seed potentials in loblolly pine appear to show geographic variation. Twenty clones from three orchards in Oklahoma and Arkansas had an average seed potential of 131 while sixteen clones from six orchards in North Carolina and South Carolina had an average of 156.

Seed potential was a far less variable trait than seed efficiency. Coefficients of variation for seed potential consistantly fell between 10 percent and 15 percent, while those for seed efficiency were in the range of 30 to 60 percent or higher. The findings of Bramlett[2] agree with these results. Estimations of seed potential could therefore be done with greater accuracy and with smaller samples of cones.

Table 1. *Loblolly Orchard Efficiency Statements.*

ORCHARD	2	4A	4B	9	12	57	MEAN
STATE	NC	NC	NC	SC	SC	SC	--
NO. CLONES	3	3	7	4	bulk	2	--
NO. SEED	38	66	59	57	56	51	54
PERCENT EXTRACTION	98	78	87	72	94	84	86
PERCENT FULL SEED GERMINATION	99	92	95	98	98	98	97
SEEDLING	37	50	52	40	54	46	46

$$\frac{\text{TOTAL SOUND SEED}}{\text{SEED POTENTIAL}} \times \frac{\text{EXTRACTED SOUND SEED}}{\text{TOTAL SOUND SEED}} \times \frac{\text{NUMBER OF SEEDLINGS}}{\text{EXTRACTED SOUND SEED}} = \frac{\text{NUMBER OF SEEDLINGS}}{\text{SEED POTENTIAL}}$$

Figure 2. Formula for computing seedling efficiency.

The proper sample size to estimate seed efficiency has not yet been precisely defined, but our data shows that a sample of two cones per clone is not adequate. Two bulk lots submitted for testing were composed of two cones from each of 15 or 16 clones. Variation within clones in these bulk lots was often quite large and would provide poor estimates. In samples of 20 to 25 cones, however, observed variations were small enough to provide estimates that probably were accurate within 10 to 15 percent. More conclusive statements concerning sample size will certainly be possible as research progresses. However, for the present, a sample of 20 to 25 cones per clone appears to be sufficient to begin identifying the major problems.

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