SELECTION POTENTIAL FOR CONEWORM AND SEED BUG
RESISTANCE IN LOBLOLLY PINE
SEED ORCHARDS

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Abstract.--Current seed orchard practices rely heavily on pesticide control of cone and seed insects. Advanced generation orchards will have a greater need for control as seed becomes more valuable. However, as environmental concerns about pesticide use change political pressure may force changes in management practices. Increasing costs of pesticides and the need for new formulations may make the use of inherent resistance breeding seem more plausible. Intensive breeding programs utilizing decreased generation lengths can be adapted to allow for the inclusion of several resistant parents. Levels of resistance within the orchards can be increased slowly, a little each generation, and coupled with selective spraying regimens without great disruption of current management schemes. Advanced generation selections made without regard to infestation potential, perhaps because pesticide use has virtually eliminated the problem in the 1st generation orchard, may result in a 2nd or 3rd generation orchard with an infestation potential that has increased beyond the control capabilities of available pesticides.

Additional keywords: Pesticide, Dioryctria, breeding

Coneworms (Dioryctria spp.) and seed bugs have been recognized as ;erious threats to seed orchard production (Ebel et al. 1981) with damage estimates as high as 90% in some untreated southern pine orchards.)ioryctria amatella, D. disclusa, D. merkeli, Leptoglossus corculus and 'etyra bipunctata are the main problem pests for southern pines. Coneworms

lay be extensive some seed may be salvageable from infested cones. Together hey constitute a management problem that is currently dealt with by spray applications of insecticides such as fenvalerate. The commercial value of seed orchard seed, particularly those from advanced generation orchards,

Even in orchards with great amounts of damage, the pattern of _nfestation is not consistent among all trees. Some trees are virtually eliminated as seed producers while others receive no appreciable damage.)ifferentiation of heavily infested and lightly infested trees has been found :o be associated with clonal affiliation in some orchards, Askew et. al :1985). They found that among 22 loblolly pine (Firms taeda) seed orchards -anging in age from 9 to 13 years, 13 had significant clonal variation in :oneworm damage. We have found 8 of these same 22 orchards with significant

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levels of clonal variation in seed bug damage. If lower infestation levels are due to a resistance mechanism as suggested by Merkel et al. (1966) then the variation among clones suggests that breeding for resistance may enhance current chemical control measures. This paper will discuss some alternatives to current pesticide application techniques and their implications for the breeding program.

SELECTION

Selection for coneworm and seed bug resistance may be effective if the controlling mechanism is genetic in nature. However, selection for this type of resistance is much different than selection for other types of pest resistance that are associated with product degradation in the outplanted progeny. Such selection places emphasis on a non-commercial product in the sense of fiber, lumber, etc. Improvement in seed production will not necessarily improve the potential genetic gain obtainable in the orchard, but will provide a greater resource for planting improved trees. Consideration of the increase in base population size necessary for incorporation of an additional independent criterion is of primary importance. The additional criterion will not be burdensome if the resistance level is positively correlated with the major commercial traits being evaluated. However, the number of trees to be screened may be increased by several fold, perhaps to an impractical level if a strong negative correlation is found. Askew et al. (1985) found little or no correlation of seed bug or coneworm infestation levels with height growth or diameter growth performance values. They found that the probability of a tree selected on its commercial value having less than 5% coneworm infestation was approximately 0.35. Hence, if no conscious selection was practiced for resistance, 35 out of every 100 select trees would be expected to be 95% resistant. Only 40% of the clones examined had less than 5% of their seed damaged by seed bugs. However, if coneworm damage and seed bug damage are viewed as independent events. Then only 14% of the trees selected for commercial traits could be expected to suffer less than 5% damage from both coneworms and seedbugs without effective pesticide applications.

In general, it seems to be an undesirable proposition to include resistance as a selection criterion for every first generation selection. Commercial value of the wood product far outweighs the potential problem of seed and cone predation. Even if the resistance criterion was mandatory it would be difficult to evaluate the potential for infestation of trees growing in the wild. The opportunity for infestation may not exist at the time of evaluation or may not he a problem in that particular geographic region. Low levels of cone production in forest stands may be prohibitive to the formation of large insect populations and hence infestation levels may be low even on highly susceptible trees. Indirect selection is also a problem because at present there is no morphological trait that is known to be highly correlated with the trees' infestation potentials. A breeder would be limited to selecting trees on the basis of commercial value and then estimating the number of resistant trees that will be included by chance. Thus, it would be difficult to assess the potential for cone and seed insect problems until the orchard was established and their trees began to produce substantial cone crops.

In light of the problems of developing methods of selecting base trees for resistance it seems feasible to use selection for resistance when the orchard receives its first roguing. If cone and seed insects are a major problem despite spraying, then a substantial gain in seed production and perhaps a reduction in insecticide costs can be obtained by tailoring the roguing criteria to include insect problems as well as commercial genetic value. There are several implications of selecting against insect damage at the time of roguing. First, you must determine what level of infestation is tolerated for your orchard. You may have to rogue 65% of your trees if a level of 5% infestation is the maximum you wish to allow. As you reduce the stringency of your criterion the number of trees that will meet your needs will increase. In any case it will be necessary to begin with a larger base orchard in order to assure an orchard of sufficient size after roguing.

Rather than placing a strict resistance criterion on every selection it may be possible to develop selection indices that incorporate both commercial traits and insect resistance with each being weighted relative to its importance. Another possibility would be to use several "completely" resistant trees as parents for second generation orchard trees. This would allow resistance to be bred into the commercially superior base population. As the breeding program advance, resistance would be accumulated as a companion trait. Introduction of resistance in this manner would allow for basic selection on commercial value for the majority of the trees but would rely on a highly heritable resistance trait in the few trees to be used as donors.

SELECTIVE SPRAYING

If breeding for resistance is undesirable, a well structured spraying program may be a viable alternative. Current orchard spraying regimens usually involve a series of whole-orchard sprayings. Heavily infested trees receive the same treatment as lightly infested or noninfested trees. DeBarr et al. (1972) suggested spraying heavily infested clones on an individualized basis. Noninfested and lightly infested trees could be ignored or receive an abridged treatment. This idea bears some merit but several assumptions must be met if it is to be successful. First, the breeder must be able to accurately identify the heavily infested trees at a sufficiently early stage in order to prevent damage. Secondly, the insect population must be choosing the trees that they heavily infest because they are more susceptible than the others. If the selection is by chance, or because they are attracted to these trees rather than being repelled from others the insect population may merely shift its host base and the problem will still exist. If these criteria are met, the selective spraying technique may provide the breeder with a more economical and more effective treatment program.

Combining the selective spraying ideas with inbred resistance would be the next logical step. During the early years of the breeding program resistance levels would be low and spraying would be necessary to minimize the losses. As the level of resistance is increased with advancing generations, the spraying requirements should decline and may eventually be unnecessary.

Long generation lengths may make this combined approach technically viable but practically inoperative. However, advanced generation breeding techniques which reduce generation length may soon put forest tree improvement efforts on a par with agronomic crop improvement programs. The main point is: tree improvement programs are already in place for many corporations and public agencies and a minimal effort would be required to introduce some highly specific genetic material to attain a gain in pest resistance. Reliance on pesticides causes a continued need for new pesticides as they lose their effectiveness. Utilizing a natural resistance mechanism may provide the orchard manager with an opportunity to produce more seed for less money.

FUTURE PROBLEMS

A potential problem needs to be considered if cone and seed insect resistance is strongly heritable. Breeding and production programs that are currently experiencing complete control of cone and seed pests by pesticide application may not see the justification for increasing the selection criteria burden. However, infestation potentials may increase with advancing generations as genes from highly susceptible clones are unknowingly combined to produce a new parent generation. Potential infestation levels could accidentally increase to the point being uncontrollable by pesticides alone. Corrective measures during 4th or 5th generations would be extremely costly in money and time.

It is important to remember that tree improvement programs in the South are in their infancy. One or two generations of breeding and selection are not satisfactory for determining future successes and patterns. Information that is currently superfluous may he crucial in several generations. Lessons learned by crop breeders need to be remembered by tree breeders. Our failure to prepare for future problems cannot be readily corrected. Our problems may develop slower than those in agriculture but, in all liklihood, they will develop.

NEEDS

Much of this proposed breeding strategy is based on a small data base and personal observations. Many factors still need to be examined in detail. Heritability of insect resistance needs to be examined. If the trait is highly heritable and is an additive effect then the prospects for its incorporation into the commercial orchards gene pool are good. If dominance factors are the controlling mechanisms the prospects are poor. Linkage may also be a factor that needs to be carefully evaluated. If the resistance mechanism is tightly linked to undesirable characteristics, a more exhaustive search of the base population may be necessary to find qualified trees. The material necessary for evaluating the heritability of resistance already exists in progeny test plantings and second generation orchards. Several years of cone collections using statistically rigorous sampling schemes should provide breeders with the necessary information for evaluating the potential of this technique.

Spraying studies need to be conducted in existing orchards to evaluate the population dynamics of the undesirable insect species. Correct timing of pesticide applications will be crucial to the success of a "custom made" breeding and spraying program. Annual changes in infestation levels will need to be studied before generalized spraying recommendations can be prepared. Confirmation that uninfested trees remain uninfested when the insect population is excluded from their prime hosts will require careful observation and cone analyses.

Finally, a method of evaluating the potential for infestation of trees in previously unaffected regions or orchards will need to be established. Identification of defense mechanisms and the identification of morphological markers or biochemical markers that can be easily and positively identified in the field or laboratory are of prime importance.

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