# SEED ORCHARD PEST MANAGEMENT STRATEGIES

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Abstract.--Pests in seed orchards have traditionally been controlled by total coverage of the seed crop with pesticides. A concept central to pest management, however, is to accept pest populations and pest-caused losses within calculated limits. Although insecticides are the only materials presently available to control pests in seed orchards, the orchard manager should determine when these controls are necessary, set control priorities, and evaluate their effectiveness in managing insect populations. Product inventory should be an integral part of seed orchard management. Without such an inventory, the size of the crop and annual losses cannot be determined. When insecticides are used more concern should be shown for minimizing the amounts applied. Selective tree treatment based on crop size should be considered as a viable alternative to total orchard treatment.

The concept of pest management dictates toleration of minor damage by pests (Metcalf and Luckmann 1975). In other words, not all pest damage is intolerable in a forest or a seed orchard. Rabb (1972) defines pest management as "...the intelligent selection and use of pest-control actions that will ensure favorable economic, ecological, and sociological consequences."

A key term in this definition is the word, "favorable." So often we see the goal of seed orchard protection as insuring maximum production of viable seed. Surely this goal is within the stated objectives of any seed orchard manager. However, in pursuit of this goal we sometimes fail to recognize that there are other factors to consider. If pesticides are excluded, present knowledge suggests the orchard will sustain enormous seed losses. But if pesticide is relied on too heavily, the ecological and economic consequences may be unacceptable. Therefore, pest management must be considered as a balanced approach to product protection. In a business sense it is a balancing of credits and debits to produce a favorable return on investment.

My report is restricted to insects that reduce viable seed production in the seed orchard. However, many of the ideas presented can be applied to other seed orchard pests like diseases, birds, or rodents.

At the conclusion of the 12th Southern Forest Tree Improvement Conference in Baton Rouge, La., in 1973, an ad hoc committee reported the results of a questionnaire survey in which seed orchard managers were asked about existing or anticipated problems and the urgency of their solution (Dinus et al. 1973). This report stressed that the "most pressing concern in southern forest tree improvement is clearly the severe, continuing reduction in cone and seed crops caused by insects." Since that time, substantial progress has been made toward solving this problem.

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Perhaps the most important initiative was the formation of the Southern Seed Orchard Pest Committee (SSOPC) to coordinate insecticide testing, evaluate control effectiveness, and follow through to insecticide registration by the Environmental Protection Agency. This Committee's work resulted in two important accomplishments. First, in 1974 the Committee succeeded in getting registration for Guthion® (azinphosmethyl) extended from control of coneworms (*Dioryctria* spp.) in slash pine seed orchards only to control of coneworms in all southern pine seed orchards. However, this insecticide has a relatively high mammalian toxicity and must be sprayed four or more times during the growing season to be effective. Both of these characteristics are undesirable. Therefore, as a second goal, the Committee set out to find an effective substitute for Guthion®.

A two-year regional cooperative study extending from Pennsylvania to Texas culminated in the fall of 1976 with the registration of granular Furadan® (carbofuran) by EPA for control of seedbugs (*Leptoglossus corculus, Tetyra bipunctata*), coneworms, coneborers (*Eucosma* spp.), and cone beetles (*Conophthorus* spp.) in southern pine seed orchards. A great number of seed orchard managers have begun using this material in their insect control programs during the 1977 season.

Currently, the two insecticides, Guthion and Furadan®, are the only compounds registered for protecting cone crops in southern seed orchards from insects. Unfortunately, we have no other proven control methods. Therefore, when considering pest management of seed orchard insects we have few alternatives. The manager can, however, determine when these controls are necessary, set control priorities, and evaluate effectiveness in managing pest populations. The remainder of this paper will be devoted to these points.

## Product Inventory

It is not only important to know what pests are causing losses and when; it is equally important to know the volume of the crop needing protection.

When I look at the pest monitoring programs presently being conducted in seed orchards, I am reminded of the story about a tool manufacturing company. To control the stealing of tools by employees, the company placed a guard at the gate to search everyone's lunch box as he left at the end of the work day. Each day one particular employee showed up at the gate pushing a wheelbarrow covered with a white cloth. Dutifully each day, the guard checked the man's lunch box and looked under the white cloth covering the wheelbarrow for stolen tools. This continued for weeks and months and yielded no stolen tools. However, the company continued to experience significant losses. It was not until some enterprising young executive decided to institute a product inventory control system that the company found out that their major losses stemmed from one of their employees stealing wheelbarrows.

A lesson to be learned from this story is that to justify controlling pests in seed orchards, we must know the quantity of the product to be protected, when losses are sustained, and finally the causes of these losses. In short, some form of product inventory or accountability must be developed to extend throughout the term of seed development (from flower bud formation to seed harvest). Such a product inventory or accountability system can be achieved with life tables.

A number of workers have completed life tables for seed crops of pines. Such tables have been produced for slash pine in Florida (DeBarr and Barber 1975), and for shortleaf (Ebel and Yates 1974) and loblolly pines (Yates and Ebel, In Press) in the Georgia Piedmont. In these studies, the sequence of insect-caused damage and mortality was recorded for 2 or more years.

Figure 1 shows a life table developed for shortleaf pine. The lines on the graph show numbers of surviving conelets and cones over the 2-year cone development period. During life table development, each mortality factor and its importance in limiting the potential seed crop can be isolated. The relative importance of each destructive agent and its attack period can be determined. With this information, the manager can determine when controls are best applied.

Because of their small size, newly emerging female flowers are the most difficult seed producing structure to inventory; they appear during the late winter or early spring. Despite the difficulties, these structures must be counted because their numbers form the baseline for the continuing inventory. Periodic flower, conelet, and cone inventories on the same trees should be conducted throughout the 2-year period of seed development. Then the harvested cones should be analyzed as described by Bramlett et al. (In Press). With this data, product life tables can be developed to indicate the size of initial crop, when losses occur, and the agent(s) responsible for these losses.

There seem to be two obstacles to the widespread use of such a product inventory control system. One is the reluctance of managers to sacrifice the product of selected check trees from which insect controls are withheld, and the second is the apparent unwillingness of managers to spend the time to make initial and subsequent counts. These concerns may seem reasonable, but a continuing product inventory is needed to rationally plan for pest control. Without such a "Judas plot" and periodic inventories, your pest control practices may be protecting a crop of unknown size from imaginary dangers. Until such an inventory system is instituted, you cannot establish the relative importance of various attacking agents. More importantly, you cannot set meaningful priorities on control procedures and determine their effectiveness.

In the seed orchard we are concerned with protecting the developing seed crop for roughly 2½ years. During this developmental period, the crop is subjected to an array of pests (Ebel et al. 1975), primarily insects, which may attack a specific fruiting structure such as flowers, conelets, and cones for varying periods of time. For instance, the Nantucket pine tip moth, *Rhyacionia frustrana* (Comstock), damages or kills female buds and flowers of shortleaf and loblolly pines during April through June of the first growing season (Fig. 2). In contrast, the blister coneworm, *Dioryctria clarioralis* (Walker), which attacks all species of southern pines, attacks shoots, buds, conelets, and cones throughout the entire two growing seasons (Feb.-Nov.) (Fig. 3).

Effective control of each of these insect pests provides a different return on the control investment. In this example, control of the Nantucket pine tip moth could be expected to increase yield of harvested cones by about 15 percent (dotted line) (Fig. 2), and treatment would be required for only 2½ months during the first season. The increased yield due to effective blister coneworm control would be only about 5 percent and would require a 4½ month

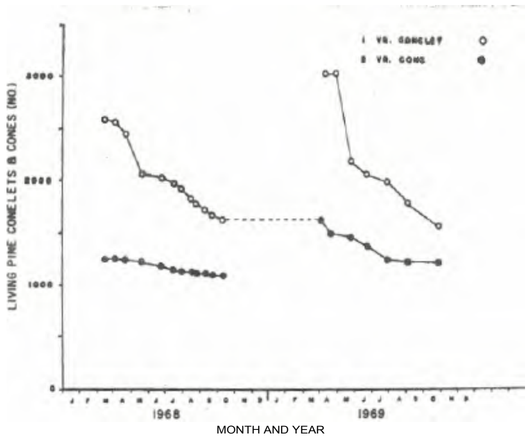


Figure 1.--Life table of shortleaf pine seed producing structures. Circles indicate dates that data was taken. First-year conelets are open circles; second-year cones are black dots.

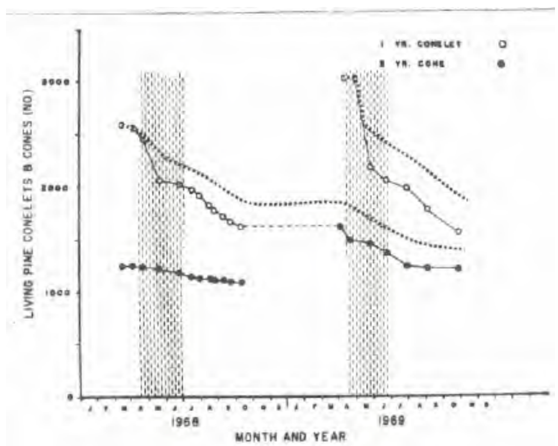


Figure 2.--Life table of shortleaf pine seed producing structures showing attack period of the Nantucket pine tip moth (shaded area). The dotted line indicates the expected increased yield of harvested cones if the Nantucket pine tip moth were controlled.

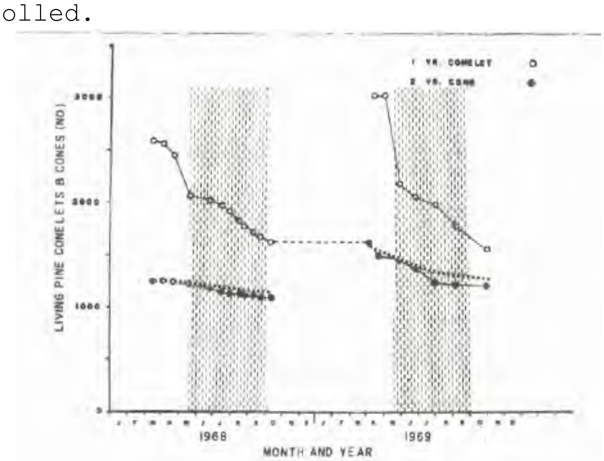


Figure i.---Lice table of shortleat pine seed producing structures showing attack period of the blister coneworm (shaded area). The dotted line indicates the expected increased yield of harvested cones if the blister coneworm were controlled.

commitment for two seasons (dotted line) (Fig. 3). It is obvious which insect is the more important to control. These examples are for only 2 of the 22 known insect species or species complexes that the manager is confronted with in southern pine seed orchards.

Cost-Benefit Ratio of Product Protection

Since the registration of Furadan® for seed orchard use by the Environmental Protection Agency, a number of companies have decided to apply this granular insecticide once a year. While this treatment is highly effective, our present methods of application are both wasteful and environmentally unsound.

When insecticide formulations are sprayed, the operator usually can direct measured amounts of spray to cover tree crowns of various sizes. He can also terminate the spray discharge where missing trees create open areas in the seed orchard. Even with these capabilities, insecticide spray methods are not particularly noted for their efficiency. Most present mechanized methods of applying granular Furadan® in seed orchards have neither of these capabilities.

Figure 4 represents a series of trees ranging from 2 to 8 inches in diameter which might be found growing in a seed orchard. In applying granular Furadan®, the registration specifies 4-8 ounces of material per inch of tree diameter. Using an 8 oz. rate, an 8-inch tree should receive 64 ounces; a 6-inch tree, 48 ounces; and a 2-inch tree, 16 ounces of Furadan®. However, since most present mechanical systems do not allow the application rate to be varied while they are in operation, some managers would set the application rate for the 8-inch trees or at 64 ounces per tree. After all, the largest trees are usually the biggest cone producers and the treatment rate must be established accordingly. That means that one-half of the trees receive more insecticide than called for in the EPA approved registration (the 6-inch tree receives 10.6 ounces/inch of diameter and the 2-inch tree receives 32 ounces/inch of diameter). This is not only wasteful but down right illegal!

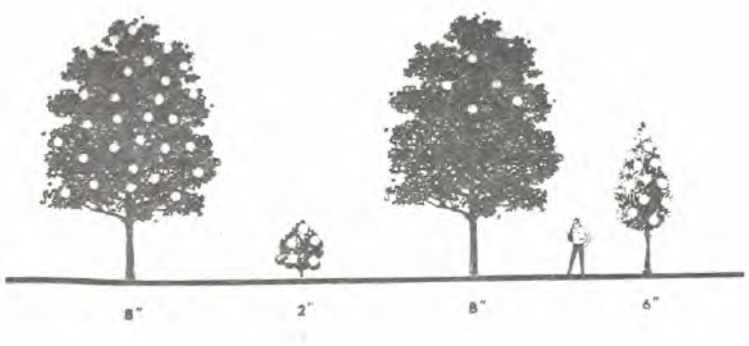


Figure 4,•-Simulation of four seed orchard trees of varying diameters and cone crops.

Figure 5 shows a hypothetical seed orchard with trees 2, 6, and 8 inches in diameter. Missing trees are indicated by circles with a crossbar. Here again, let us assume we have decided upon a rate of 8 ounces per inch of tree diameter. Treatment of this complete plot would require 72 pounds of insecticide using a mechanized applicator. If, however, flow cutoffs were installed on the applicator, we could reduce this quantity to 60 pounds of insecticide, a 17 percent reduction (Fig. 6). A further refinement incorporating both flow cutoff and flow rate control would result in delivery of only 37 pounds of insecticide, a 49 percent reduction (Fig. 7). This last treatment would not oily give adequate control based on research but would be in keeping with label registration requirements.

Selective Product Protection

Treatment based on tree size alone can be quite wasteful. As pointed out by DeBarr in 1971, it costs as much to protect a tree with half a bushel of cones as it does to protect one of equal size with four bushels. Therefore, it is important to consider the cost-benefit ratio of product protection. Figure 4 shows four trees with varying diameters and cone crops. It should be obvious that on the basis of product protection treatment priorities would be: (1) the 8-inch tree on the left with 28 cones, (2) the 6-inch tree with 11 cones, (3) the 2-inch tree with 5 cones, and (4) the 8-inch tree with only 5 cones.

Alan Lakein is a time planning and life goals consultant. In his book, "How to Get Control of Your Time and Your Life," he tells people to think more about what they do (Lakein 1973). He bills himself not as an efficiency expert but rather an effectiveness expert. Effectiveness, he says, is achieved by selecting the best task to do from all the possibilities available and then doing it the best way.

In all planning, we make lists, mental or written, and set priorities on the tasks to be accomplished based on what is important to us now. Mr. Lakein believes that if all the items on your list are arranged in order of value, 80 percent of the value would come from only 20 percent of the items. He calls this the 80/20 rule.

I would like to enlarge upon this rule by relating this principle to seed orchard pest management.

At the 1976 meeting of the Southern Seed Orchard Pest Committee in Atlanta, Ga., Gary DeBarr suggested that if managers concentrated their control programs on the clones that are good cone producers and on the trees that are most susceptible to insect attack, it might be possible to protect 90 percent of the seed crop by treating only 10 percent of the trees. [2] I have called this idea the "D 90/10 rule"--"D" for DeBarr.

[2] Minutes of the Southern Seed Orchard Pest Committee Meeting, Atlanta, Ga., November ¯3, 1976.

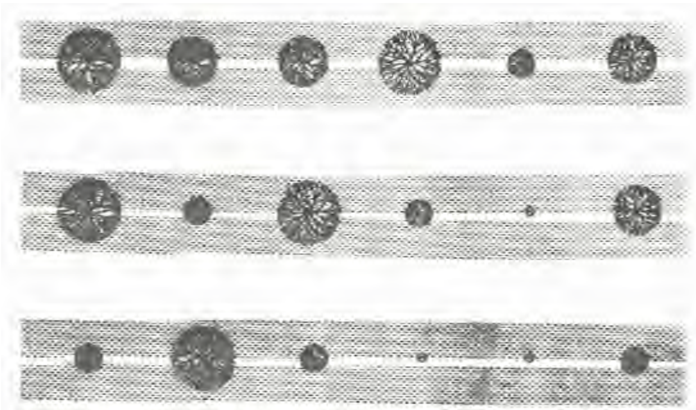

Figure 5.--Simulation of 18 seed orchard trees of varying diameters (2", 4", 6"). Open circle with crossbar indicates a tree location where tree is missing. Shading along tree rows shows distribution of granular insecticide by mechanical application.

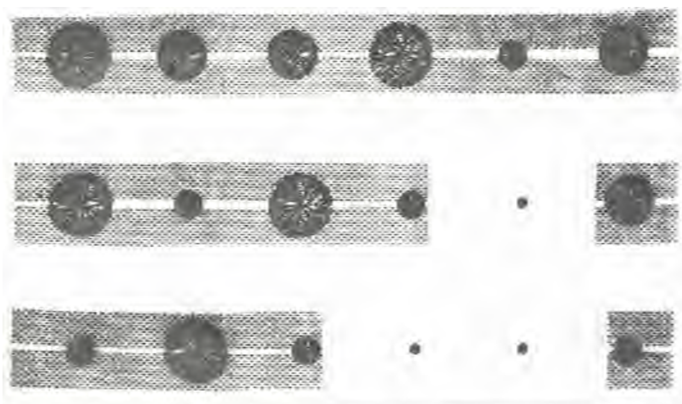

Figure 6.--Simulated seed orchard showing distribution (shaded area) of granular insecticide delivered by mechanical applicator with flow cutoff control.

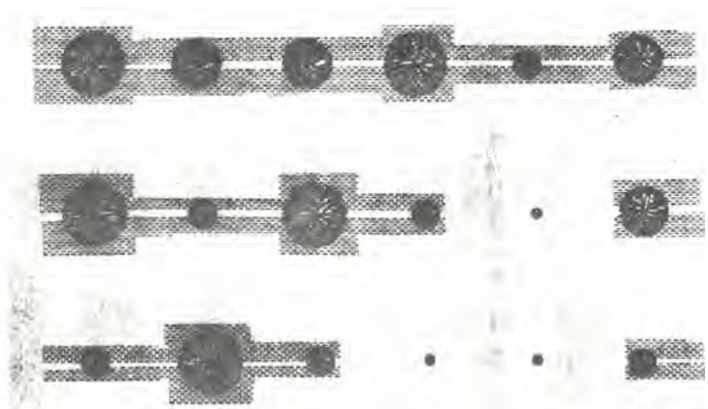

Figure 7.--Simulated seed orchard showing distribution (shaded area) of granular insecticide delivered by mechanical applicator with both flow cutoff and flow rate control.

In 1976 a fertilizer experiment was installed in a 12-acre block of shortleaf pine seed orchard trees at the Beech Creek Seed Orchard at Murphy, North Carolina.[3] This block contains 22 rows with 53 tree locations in each row. Total tree locations are 1166. Fifty clones are systematically replicated throughout this seed orchard. The cones on each tree were completely inventoried.

The seed orchard is pictorially reproduced in Figure 8. Trees are spaced at 15-foot intervals and rows are 30 feet apart. Each living tree is represented by a dark circle, and locations where a tree is missing are blank. Trees are in their 10th growing season.

In this discussion, it is assumed that Furadan® 10% granules will be applied at the registered rate of 8 ounces per inch of tree diameter. However, nearly all the same principles I present will apply to the use of any other registered chemical controls.

Treatment of this entire seed orchard block with granular Furadan® using a mechanized applicator will require about 3500 pounds of insecticide. That is: maximum tree diameter of 6 inches x 8 ozs. x 1166 tree locations = 3498 lbs. Since there is no cutoff on the delivery system of most existing mechanized applicators, all 1166 tree locations would be treated; since the study block contains only 875 living trees (trees are at 75 percent of the tree locations), 25 percent of the insecticide will be wasted during application. The amount applied could be reduced from 3498 lbs. to 2625 lbs. by putting a cutoff on the delivery system.

A more significant savings in insecticide could be made if the application technique could be regulated to account for differences in tree diameters as well as missing trees. The total tree diameter of the 875 trees in the seed orchard block is 3,290 inches (average tree diameter = 3.76"). Therefore, adequate protection of all trees would require only 1645 pounds of insecticide, and the savings would be 53 percent (1645 lbs. versus 3498 lbs.). Only by individual tree treatment is such a savings presently possible.

Up to this point we have considered treatment of all trees in the seed orchard. Now let's see what happens if we treat only the trees on which 90 percent of the cones are present.

When the 50 clones in the orchard are ranked according to numbers of cones present, it can be shown that 90 percent of the seed crop is being produced by only 20 percent of the clones (10 top producing clones). On the basis of total tree diameter--934 inches--treatment of the top 10 producing clones would require only 467 pounds of Furadan. The savings would be 86.7 percent over treatment of the entire seed orchard.

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[3] Experimental area established by Dr. Jack T. May, School of Forest Resources, Univ. of Ga., Athens, Ga.

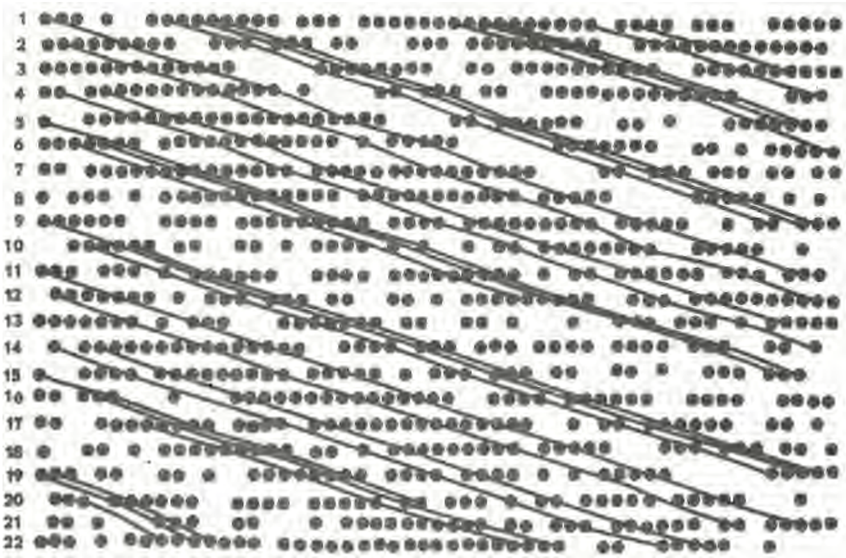


Figure 8.--Circles represent living trees in a 12-acre research block of short-leaf pine at Beech Creek Seed Orchard, Murphy, N. C. Row numbers are indicated at the left. Lines bisecting circles identify trees which belong to the 10 highest producing clones. Protection of these 122 trees would protect 90% of the cone crop.


Figure 9.--White dots superimposed on dark circles indicate the location of top producing trees (145 trees) which support 90% of the cone crop.

If the "D 90/10 rule" is applied to individual trees, we find that 90 percent of the cones in the seed orchard are being produced by only 145 trees. Locations of these trees are indicated, by white dots superimposed on dark circles (Fig. 9). These trees occupy only 12.4 percent of the tree locations in the study area. This is a fairly close approximation of the proposed rule.

How much of a savings of insecticide is made by treating just these 145 trees? Total diameter of these trees is 680 inches, which represents only 20 percent of the total seed orchard tree diameter. Treatment would therefore require 340 pounds of insecticide for protection (680 inches x 8 ounces). Recall that treatment of the complete seed orchard to protect 100 percent of the seed crop using a mechanized applicator required 3500 pounds of insecticide. Selecting the top producing trees, then, could achieve a 90.3 percent savings of insecticide (340 lbs. versus 3500 lbs.).

The situation may be best illustrated by Figure 10. The vertical scale is in percent and the horizontal scale is in number of trees. The vertical line to the right delimits the total seed orchard tree population of 875 trees. Tree population percentage is shown by the heavy line extending upward from "0" at a 45 degree angle. The dot-dash line represents the percent accumulated cone production. Accumulated tree diameter is indicated by a slant-dash line. With this graph any standard of cone protection can be established for this seed orchard block and the number of trees we need to protect and the quantity of insecticide required to meet this standard determined. The shaded area added to the graph delimits these quantities for protection of 90 percent of the cone crop as proposed in the "D 90/10 rule."

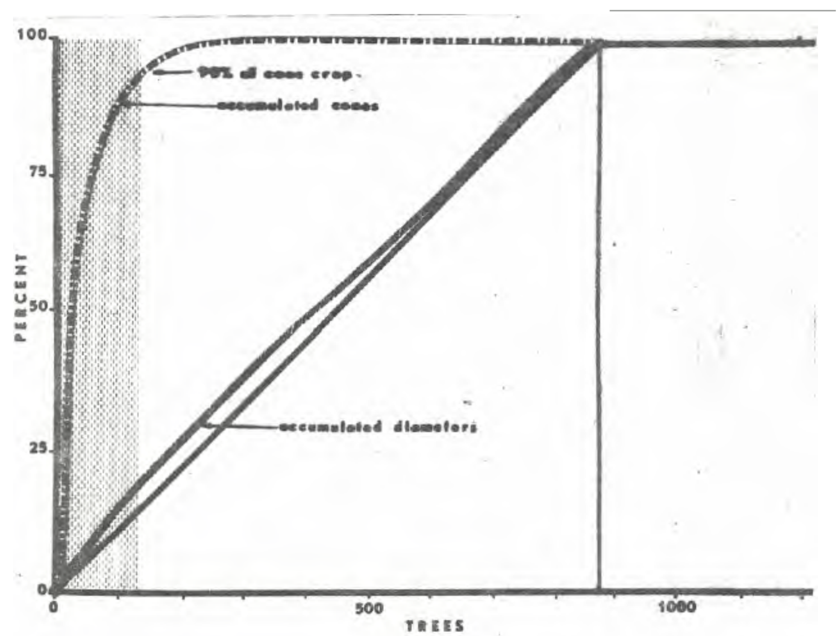


Figure 10.--Cone production (dot-dash line) and tree diameter (slant-dash line) profiles for research block at Beech Creek Seed Orchard, Murphy, N. C. Shaded area delimits number of trees and their total tree diameter which needs treatment to protect 90% of the total cone crop.

I do not mean to suggest either that the results in this particular seed orchard are necessarily typical or that the "D 90/10 rule" should in all cases be closely followed in seed orchards. Trees at the Beech Creek Seed Orchard are quite young, and production might be more evenly distributed among trees that are more mature. Furthermore, some clones may have characteristics that justify protection of small numbers of cones. What I am saying is that the orchard manager should consider how many cones he is protecting before he applies large amounts of insecticide.

For years we have argued, and rightly so, that a seed orchard is not a forest but a unique high value area that lends itself to the application of pest control techniques which are economically impractical in the forest. It is this rationalization that has encouraged the development and use of pesticides as the backbone of our seed orchard pest control programs. Certainly these chemicals will continue to figure prominently in the future, largely because pesticides presently provide the only acceptable solution to our seed orchard pest problems.

However, in view of an increasing national concern about the effects of pesticides on the ecosystem and human health, we need to be more judicious in the use of pesticides.

In summary, I would like to underscore the following points.

1. Seed orchard managers must have some form of product inventory and accountability. Life tables can meet this requirement. These will provide information on initial crop size, identity of pests causing losses, when these losses occur, and their magnitude. Until such information is known, credible pest management decisions are not possible.

2. Decisions to apply or continue pest control actions must be based upon crop size, expected pest-caused losses, and an assessment of the effectiveness of control procedures. Establishment and maintenance of check or "Judas plots" within the seed orchard is the only likely way this baseline information can be obtained.

3. Selective product protection, either on a clone or individual tree basis, should be considered. This system of deciding which trees to treat will give the best return for the money and have the least unfavorable environmental effects.

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