THE VALUE OF INSECT CONTROL IN SEED ORCHARDS: SOME ECONOMIC AND BIOLOGICAL CONSIDERATIONS

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There are more than 6000 acres of clonal pine seed orchards in the southern United States, with additional acreage being established each year. The projected capital value, at age 1S, of the orchards already established, is estimated at over 30 million dollars. For the orchardist managing these valuable pieces of forest real estate a critical facet of his job is the protection of the orchard and its annual crop of superior seed from devastating insect attacks. To meet this responsibility the seed orchardist has to decide whether or not to use insect control measures, and asks himself the question, "What will insect control buy for me in my orchard?"

Protection of the large, per-acre, capital investment in the orchard, and its annual seed crop justify the use of insect control methods far too costly to employ under normal conditions of forest management. Thus, insecticides are applied in seed orchards to protect new grafts, as well as to reduce cone and seed insect populations, and in turn, increase seed yields. Because they were cheap, readily available, and had excellent residual properties, the organochlorine insecticides were first used in seed orchards; DDT to control tip moth, *Rhyacionia* spp., BHC for the coneworms, *Dioryctria* spp., and heptachlor against the flower thrips, *Gnophothrips fuscus* (Morgan). More recently dimethoate and phorate have been used for tip moth, azinphosmethyl (Guthion®), for coneworms and seedworms, Laspeyresia spp. (DeBarr and Merkel 1971) and malathion for thrips (DeBarr and Matthews 1971). These "non-persistent" organophosphate insecticides are more rapidly metabolized, and thus have shorter effective biological half-lives. They are also more expensive.

Seed orchards vary as to tree species, age, productivity, location, size, prevalent species of destructive insects, and diversity of management practices employed. But, how much can be spent to control insects in an orchard, and still make the operation economically justifiable? It should be obvious that the complexity of the problem precludes any hard-fast rules. To answer the question of what we are "buying" through the control of seed orchard insects, in terms of protection of the capital investment in the orchard, or increased productivity, a number of factors must be considered.

PROTECTING THE SEED ORCHARD FROM INSECTS

Excluding the costs incurred in searching for and selecting superior parent trees, the initial investment in growing root stock, grafting, and planting a new seed orchard, ranges from $1.00 to $3.00 per tree. Operation and management costs during the unproductive establishment period along

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with a reasonable rate of return on the investment, results in a high capital value, per acre of seed orchard, by the time the orchard reaches the age of initial commercial production. Davis (1967), working with data from a 100-acre and 40-acre loblolly pine seed orchard, predicted that if they reached commercial production at 15 years of age, their capital value would be $4728 and $7636 per acre, respectively. Thus, at age 15, each tree in the seed orchard represents an investment of $100 to $150.

Insects cause varied types of injury to all the tree species currently included in the South's tree improvement programs. For example, Smith (1954) reported that a small bark beetle, *Pityophthorus pulicarius* (Zimm.) attacked the scions of slash pine grafts. This beetle is a potentially serious pest in the South, and has killed as high as 25 percent of the grafts in a newly established orchard. Dioryctria spp. are important insects devastating southern pine cone crops, but they also are responsible for other types of damage. In newly-planted seed orchards, *D. amatella* pitch masses are found near the graft union (Fatzinger & DeBarr, 1968). In older orchards, the larvae also bore into the crotches between limbs and the main stem, or enter through mechanical wounds in the bark such as those caused by tree shakers. This feeding can cause the branches to break off, and in some cases the entire upper-tree crown is destroyed. These are but two examples of insects that have already become important seed orchard pests because they indirectly affect seed production by distorting, or killing the seed-producing tree. It does not require any extensive calculations to determine the economics of protecting 15-year-old trees worth from $100 to $150 each.

Many other insects are occasionally encountered in seed orchards. Aphids and scale insects, for instance, are often found sucking the juices from the buds, branches, and needles of fast-growing seed orchard trees. Their feeding activity undoubtedly weakens the tree, but the effect upon the ultimate goal of maximum seed production is unknown. Investments in control for such less threatening insects is currently questionable.

PROTECTING THE SEED CROP FROM INSECTS

The high value of individual trees within a seed orchard makes it easy to justify the use of almost any conventional control method to protect them from insects. But, the problem of how much can be spent to protect the annual seed crop from insects is not as easily resolved. Controls must be examined in terms of their potential to increase seed yields. However, for most research results on cone and seed insect control, the degree of control obtained is expressed in terms of decreased insect infestation, i.e. the percentage the infestation is reduced as a result of the control. There are two primary reasons we examine infestation levels, rather than seed yields. First, data on the degree of insect infestation are often much more easily obtained than data on seed yields. Secondly, most research studies are conducted to demonstrate that a particular control method or chemical has the potential to prevent insect infestations, rather than to determine if the method or insecticide is economical.

According to the economic principle of Marginal Cost and Marginal Revenue, expenditures are economically sound, as long as the marginal revenue for each unit of output is of equal or greater value than the cost incurred in its production. This production cost should also include a return on the investment in the control, at the firm's guiding rate of return. Essentially, this means that in a seed orchard an insect control program is economical, as long as the costs, including interest on the investment, are less than or equal to the value of the increased seed yields.

Because of the diversity among seed orchards and specific insect problems, as well as variation in management practices and objectives, a control method that is economical in one orchard may be too expensive to justify in another orchard. There are at least four important factors that an orchardist might want to consider before deciding whether or not controlling cone and seed insects will "buy" anything in his particular orchard.

Value of the seed

First, the orchardist must know the value of the crop he is trying to protect. It is difficult to place a value on seed produced in clonal seed orchards since the final assessment of the genetic improvement realized from selecting and breeding trees with superior qualities is yet to come. Barber (1963) used initial measurements of progeny from clonal orchard parents to arrive at a S to 10 percent or more increase in growth and yield over current yields. Marler (1963), considering the factors of better adaptation of seed to the site, better disease resistance, and improved wood quality, as well as increased growth in straighter more vigorously growing trees, stated that it is entirely realistic to expect at least a 5-percent overall improvement from current seed orchard programs. Perry and Wang (1958) worked out the expected increase in profits from growing trees of various assumed degrees of genetic superiority in a pulpwood rotation. Based upon calculations in their example, a two percent genetic improvement would permit an expenditure of $18.90 extra per pound of seed over and above the cost of wild-type seed,.and still allow a 5-percent interest profit annually. A five percent genetic improvement would allow an expenditure of approximately $40 per pound. Davis (1967) used data from two loblolly pine seed orchards to determine the investment costs of improved seed, or what he refers to as "the difference in price between what the forest manager would have to pay for improved seed and what he would have to pay for ordinary seed." He stated that a gross cost of $15 per pound of improved orchard seed was the best single estimate that could be made on the limited base of his study.

Estimate of the expected yield

Secondly, the orchardist must make a reasonable estimate of the expected yield in his orchard. Cone crops will probably increase in size until an orchard reaches the age of maximum productivity and then they will fluctuate from year to year. In addition, certain clones within an orchard will be more prolific cone producers than others.

Estimate of the expected seed losses to insects without control

Third, the orchardist must have an idea of the seed losses he can expect, if he does nothing at all to control cone and seed insects in his orchard. He can rely upon loss data from the previous years cone crop. Another way to obtain the data is to leave some trees in the orchard untreated, to serve as checks. If the latter method is used, it should be kept in mind that for an accurate evaluation the check trees must be isolated from the effects of existing control measures. Also remember that certain clones appear to be more susceptible or resistant to cone and seed insects.

How good is the control method

Finally, the orchardist must be aware of the degree of insect control he can expect from any particular control method. No control method currently available will consistently provide complete elimination of the damage caused by any particular cone and seed insect. There are, however, several control methods which when properly applied, will reduce insect damage by 95 percent or better.

Information on each of the four factors discussed is necessary to make a knowledgeable decision as to "what cone and seed insect control is buying, or can buy, in terms of increased seed yields." Two examples will illustrate one way to approach the problem of evaluating the economic of cone and seed insect control.

The first example is based upon data published by Merkel and Yandle (1965). Their study was conducted to determine the effectiveness of three treatments for controlling coneworms, *Dioryctria* spp., and the slash pine seedworm, *Laspeyresia* anananjada Miller, infesting second-year, slash pine cones. Briefly, the sprayed trees received three applications of one of the following treatments: (1) 0.5-percent BHC (hydraulic sprayer); (2) 2.5-percent BHC (mist blower); and (3) 1.0-percent Guthion® (mist blower). An average of 8.5 gallons of insecticide-water emulsion was applied per tree with the hydraulic sprayer, compared to 1.0 gallon per tree with the mist blower. The cost of the insecticide alone for 3 hydraulic spray applications was $2.40 per tree compared to $1.44 per tree for 3 mist blower applications. On unsprayed trees second-year cone attacks by *Dioryctria* spp. averaged 30 percent, while an additional 30 percent were infested by Laspeyresia. Control of ***Dioryctria*** and **Laspeyresia** **resulted** in a seed-yield increase of from 0.5 to 1.2 lbs. per tree (Table 1). Assuming a value of $15.00 per pound, the additional seed yield per tree, obtained as a result of insect control, was worth from $7.50 to $18.00, depending upon the treatment. Labor costs, equipment investments, and a return on the investment at the firms guiding interest rate would **have to** be taken into account to decide if control was economically sound.

Table 1.--Slash pine seed yields from various treatments to control seedworms and coneworms 1/

Treatment	Average seed yield/ cone	Average yield of seed/ tree 2/	Increased seed yield/tree over checks		Value of seed/ tree 3/	Value of the increased seed yield/tree
	Number	Lb.	Lb.	(Percent)	Dollars	Dollars
0.5% BHC-hydraulic sprayer	118	2.1	1.2	(133)	31.50	18.00
2.5% BHC-mist blower	87	1.6	0.7	(78)	24.00	10.50
1.0% Guthion-mist blower	78	1.4	0.5	(56)	21.00	7.50
Check-no spray	53	0.9	--	--	13.50	--

1/ Based upon data from Merkel and Yandle (1965).

2/ Based upon an average of 250 cones/tree and assuming an average of 14,000 slash pine seed/lb.

3/ Assuming a value of $15.00/lb. of seed.

A second example also involves the control of *Dioryctria* and Laspeyresia. It is based upon data from a recent study involving trunk implants of the systemic insecticide, Bidrin®' (Merkel DeBarr -- In Press). Briefly, 70-foot-tall slash pines in a seed production area, were implanted with 5 grams of Bidrin® technical liquid per inch of diameter at d.b.h. A single implantation of the systemic was made during May of 1967. Thirty percent of the cones on the untreated trees were infested with one or more seedworm larvae, and yielded an average of 74.6 seed/cone (Table 2). The Bidrin® treatment resulted in a 84-percent reduction in the number of seedworm infested cones, and a 15-percent increase in seed yield per tree. Dioryctria infested only 10-percent of the unprotected cone crop. The Bidrin® treatment reduced Dioryctria infestation to less than 2 percent. The net gain is seed yield per tree, as a result of controlling both Laspeyresia and *Dioryctria, was* 27 percent (Table 2). Assuming the seed was superior seed from a seed orchard and worth $15.00 per lb., the value of the increased seed yield would amount to $4.50 per tree. The cost of the single implant was $1.70 per tree including materials and labor.

Table 2.--Slash pine seed yields from Bidrin® implant treatments to control seedworms and coneworms, Olustee, Fla. 1967

Treatment	Average seed yield/ cone	Average yield of seed/ tree 1/	Increase seed yield/tree over checks		Value of seed/ tree 2/	Value of the increased seed yield/ tree
	Number	Lb.	Lb.	(Percent)	Dollars	Dollars
		Laspeyresia Damage Only 3/				
Bidrin® implant (5 gm./in. dia.)	83.1	1.5	0.2	(15)	22.50	3.00
Check - never treated	74.6	1.3	--	--	19.50	--
		Dioryctria and *Laspeyresia* Damage				
Bidrin® implant (5 gm./in. dia.)	81.3	1.4	0.3	(27)	21.00	4.50
Check - never treated	64.0	1.1	--	--	16.50	--

1/ Based upon an average of 250 cones/tree and assuming an average of 14,000 slash pine seed/lb.

2/ Assuming a value of $15.00/lb. of seed.

3/ Based upon a sample of 50 cones not damaged by *Dioryctria* spp./tree.

The value of the additional seed obtained as a result of controlling Laspeyresia and Dioryctria more than offset the cost of the control efforts. For several reasons I think that these examples of "what cone and seed insect control is worth" are both realistic and conservative. First, the assumed value of $15.00 per lb. of genetically superior seed is low. As genetic gains increase by repeated clone selection superior tree seed may prove to be worth considerably more. Second, in the Bidrin® implant example, the Dioryctria infested only 10 percent of the total second-year cone crop which I consider an unusually light infestation. In orchards where Dioryctria damage accounts for losses of greater magnitude, control efforts are even more important, and more economical. Third, although not taken into account in my examples, controls which protect second-year cones also afford simultaneous protection of the first-year conelet crop from Dioryctria attacks. Finally, in the two examples, Dioryctria and Laspeyresia were the primary insects for which control was applied. However, some methods may also give some control of other cone and seed insects, such as the seed bugs Leptoglossus corculus (Say) and Tetyra bipunctata (H. E S.) (DeBarr, 1967) which can destroy as high as 20 percent of the seed crop in slash pine orchards.

SOME FINAL CONSIDERATIONS

The same sort of thinking would be required to evaluate the economics of non-insecticidal methods of cone and seed insect control. However, insecticides will probably continue to play an important role in seed orchard management for some time to come. Therefore, it seems worthwhile to point out several ways to make cone and seed insect control with insecticides more efficient and more economical.

First, insecticides should be used only when insects are causing seed losses of economic proportions. Insecticides applied to endemic populations provide little additional seed. But, repeated applications are expensive, can cause unnecessary pollution problems, and may contribute to a build-up of insect resistance.

Secondly, when spraying a seed orchard, it costs just as much to protect a tree with half a bushel of cones, as it does one the same size with 4 bushels. The same is true for implanted systemics. Thus, the orchardist might consider protecting only the clones of high productivity, rather than every tree in the orchard. In this way most of the seed will be protected at a much lower cost.

Finally, clones vary in their inherent resistance to cone and seed insects. This was first shown for Dioryctria spp. (Merkel a *at.* 1965) and Laspeyresia spp. (Merkel 1967) on slash pine, and later for the seedbugs and flower thrips (DeBarr et *at.* 1971), as well. The orchardist might consider spraying only the most susceptible clones, or perhaps even rogueing them where spacing permits; the entomologist should look for the factors responsible for susceptibility, and the genetist should consider the merits of breeding resistance to cone and seed insects.

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