CHALLENGES FOR INSECT PEST MANAGEMENT IN FOREST TREE SEED ORCHARDS

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Abstract.--There are large applied forest tree improvement programs for Douglas-fir in the Pacific Northwest and loblolly pine in the South. There are also similar programs for tree species of lesser commercial importance. Intensively managed seed orchards, which produce tons of genetically improved seed used to reforest millions of acres of commercial forest land, are key elements of these programs. Insect pests are a very serious problem in seed orchards. In the 1970's and 1980's researchers developed insect control methods that were quickly implemented by pest management specialists and orchard managers. As a result, seed yields exceed expectations. The 1990's bring new challenges for seed orchard pest management. New challenges include (1) insuring that insecticides are available for use in seed orchards, (2) reducing insecticide loads in orchards, (3) improving efficiency of control tactics, (4) addressing changing orchard management goals, (5) considering insect pests in orchard site selection, (6) gaining a better understanding of interactions among arthropod species in the seed orchard canopy, and (7) developing noninsecticidal tactics and strategies for controlling insects. Ways of addressing these challenges are discussed.

Keywords: Coneworms, seed bugs, insecticides, cone and seed insects.

INTRODUCTION

Seed orchards are an important part of the applied tree improvement programs in North America (Zobel and Talbert 1984) and are key elements for the success of these programs. While less than 20,000 acres of orchards exists in North America, these areas represent a major forestry investment. Individual orchards are small, ranging in size from 5 to 500 acres. Management is for the single purpose of supplying the tons of genetically improved seeds needed to grow seedlings for the reforestation of millions of acres of commercial forest lands. An array of insect pests threatens seed crops (Ebel et al. 1976, Hedlin et al. 1980, Turgeon and deGroot 1992). Each tree species has its own unique complex of cone and seed insect pests.

As first-generation seed orchards came into production during the 1970's the demands for genetically improved seed were high. Once the impact of cone and seed insect pests was clearly recognized, entomologists developed insect control methods and orchard managers quickly put them into practice (DeBarr 1990). These methods were highly effective and yields exceeded expectations of tree improvement specialists and geneticists.

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Wakeley (1954) noted that in harvests from natural stands of southern pines, "each species averages about 1 lb. per bushel of cones in good years, about 0.5 lb. per bushel in years of moderate crops and 0.2 lb. per bushel or less in very poor crop years". Twenty years later, a loblolly pine seed orchard in the North Carolina State University-Industry Cooperative yielded 2.36 lb. per bushel (Anon. 1985). The report stated that "effective orchard management practices have allowed cooperative members to reach production efficiencies once thought impossible".

The theme of our 1993 Southern Forest Tree Improvement Conference (SFTIC) is "Forest Genetics in a Changing World". The 1990's bring a new series of challenges for seed orchard pest management. I discuss some of these challenges and ways to meet them in this paper.

INSURE INSECTICIDE AVAILABILITY FOR SEED ORCHARDS

Insecticides are the most widely used method for controlling cone and seed insects in forest tree seed orchards. They will continue to be important for seed orchard pest management, as long as they remain available to us. Insecticides most effective for cone and seed insect controls have long residual or systemic activity. They are readily available, easy to use, cost-effective and provide broad-spectrum control of many different cone and seed insect pests. Both managers and the general public are also aware of their potential disadvantages. To ensure that insecticides are available for our use, tree improvement specialists and forest entomologists must work together to keep our current registrations and register any new insecticides that are potentially useful for controlling orchard pests.

Retain Current Registrations

Few insecticides are registered for use in southern pine seed orchards (Table 1). Most of the registrations are at least 10 years old (van Buijtenen 1981). The Environmental Protection Agency (EPA) granted the last Federal registration in 1987 and canceled the use of Furadan® in seed orchards in October 1992. Other registrations are being reviewed by the EPA and some of these insecticides may not be re-registered by the chemical companies. Recently, the SFTIC organized a subcommittee called the Seed Orchard Pest Management Committee (SOPMC) to address this problem. Working together, this group of tree improvement specialists and forest entomologists made several important accomplishments. One is the reclassification by EPA of seed orchards from forestry sites to non-food crop, terrestrial sites. This action should make it somewhat easier to keep insecticides available for use in seed orchards.

Table 1. Federal registrations of insecticides for cone and seed insect control in seed **orchards.**

Trade name	Common name	Class*	Year registered
Cygon	dimethoate	OP	1962
Guthion	azinphosmethyl	**OP**	1974
Furadan**	carbofuran	**CB**	1976
Ambush	permethrin	PY	1980
Pounce	permethrin	PY	1980
Pydrin	fenvalerate	PY	1980
ASANA* **	esfenvalerate	PY	1987
Foray	Bt	MC	1991
Capture	bifenthrin	PY	199?

*OP = organophosphate, CB = carbamate, PY = pyrethroid and MC = microbial insecticide.
**Canceled by EPA Oct., 1990. ***Isomer of Pydrin.

Register New Insecticides

Only a few new insecticides have become available in recent years and chemical companies no longer eagerly pursue registrations for forestry uses. These markets are small and there is increasing public concern with the use of insecticides on forest lands. Efficacy data for early registrations of insecticides for cone and seed insect control in seed orchards were based upon field tests using individual trees. However, the current method of choice for applying insecticides in seed orchards is with aircraft. Region-wide efficacy tests of aerial applications of new insecticides are costly and difficult to carry out. Recently, the SOPMC committee conducted a Southwide efficacy test of the pyrethroid insecticide, Capture. Some of the problems were the uncertainty as to which formulation the manufacturer wanted to test and register for seed orchard use, a year delay because of an Experimental Use Permit and limited replication due to the small number of orchards suitable for the test. In addition, all the time and resources for planning and conducting the test were contributed by members of the SOPMC and the participating orchard managers. Finally, standardized procedures had to be developed and orchard personnel from each site had to be trained to ensure consistency in the applications. Because of the efforts by the SOPMC, it is now permissible to use Capture in seed orchards, under 24-C registrations, in most of the southern states (Lowe et al. 1993). If registered by the EPA, Capture will be the first new Federal registration of an insecticide for seed orchard use in almost a decade.

MINIMIZE INSECTICIDE LOADS IN SEED ORCHARDS

Continuing to reduce the amount of insecticide applied in seed orchards will help to keep insecticides available for our use. Additional benefits include lower costs, increased

safety, reduced environmental risks and delayed development of pest resistance. Two ways to reduce insecticide loads in seed orchards are to use less per application and make fewer applications.

Reduce Insecticide Rates per Acre

Using less insecticide per acre diminishes both costs and potential environmental problems. The rates we use today, are much lower than those once applied for cone and seed insect control in seed orchards (Table 2). This is the result of two important changes in pest management that occurred in the early 1980's.

Table 2. Insecticide amounts per acre for single applications with several control methods.

Insecticide	Control method	lb.active ingredient/acre*
Furadan	Soil systemic	12**
Guthion	Hydraulic sprayer	8
Guthion	Mistblower	5
Guthion	Aircraft	3
Ambush/Pounce	Aircraft	0.75
ASANA	Aircraft	0.19
Capture	Aircraft	0.1

*assuming the maximum registered rate. **assuming 48 trees 10" dbh/acre.

First, the pyrethroid insecticides, Ambush® and Pounce®, were registered for seed orchards. These pyrethroid insecticides are more effective, on an active ingredient per acre basis, than is the older organophosphate insecticide, Guthion®, or the carbamate insecticide, Furadan®. ASANA® is a refined isomer of Pydrin®. Capture® is a second-generation pyrethroid, which is effective at even lower rates than Ambush®, Pounce® and ASANA®. We must continue to look for new insecticides that work at even lower rates.

Second, the use of aircraft has made it possible to get the insecticide to cones in the tops of the trees more efficiently than with ground sprayers (Barry et al.1984). Using aircraft often attracts more public attention, but it is a much better choice than ground applications. Besides lower rates per acre, other advantages include better spray coverage, reduced worker exposure, better timed applications and lower costs because of improved efficacy. It is particularly important that we retain the option of using aircraft to apply chemical and microbial insecticides in seed orchards. In the future, aircraft may also be needed to apply chemicals that modify insect behavior.

Reduce Application Frequency

Fewer applications per year mean less pesticide load in seed orchards. It was not uncommon to spray orchards as often as 6 times each year, when genetically improved seed was scarce. Since the importance of each pest often varies with the orchard site, orchard managers have learned how frequently they must spray to protect seed crops in their particular orchard. With cone crop monitoring, surveys using pheromone traps and their own individual experience, the number of applications per year is more likely to be 2 to 4.

DEVELOP STRATEGIES FOR CHANGING ORCHARD MANAGEMENT GOALS

Low Intensive Management in Older Orchards

As new generation orchards become productive, pest management activities are often stopped in older orchards. However, some managers continue to harvest seed from the best clones in their old orchards. Without insect control yields will be poor. Spraying the entire orchard is not a cost-effective alternative. In this situation, individual tree protection appears to offer some advantages. The idea of controlling insects on individual trees in seed orchards is an old one (DeBarr 1971), but it never gained acceptance because the demands for seed were high. Any of the insecticides currently registered for use in mistblowers or hydraulic sprayers will protect individual trees. Systemic insecticides implanted into the trunks of pines is an effective way to control cone and seed insects (Merkel and DeBarr 1971). However, there are no systemic insecticides registered for use as implants in southern pine seed orchard trees.

High Intensity Management in Young Advanced Generation Orchards

Seed from advanced generation orchards are always scarce. Insect control in these orchards is essential and managers are unwilling to tolerate losses. Since yields from first generation orchards exceeded expectations, geneticists are establishing smaller orchards for advanced generations. Continued high yields, will depend upon pest management that is as good as or better than that for first-generation orchards.

ORCHARD SITE AND INSECT PEST MANAGEMENT

Geneticists consider many factors in selecting a site for a new seed orchard. Usually, not much thought is given to the effect of the location on future insect pest management. Selecting the wrong site can result in constant problems with insect pests, as well as limit the options for pest management. Guidelines for evaluating an orchard site for pest management problems would be a valuable aid.

Minimize potential for orchard infestation and reinfestation

Advanced generation orchards established next to older orchards, with large cone-bearing trees, will quickly become infested by cone and seed insects. They are also highly susceptible to reinfestation. Once harvesting has stopped in older orchards there is seldom any insect control. Abundant cones in these sanctuaries allow insect numbers to increase. Managers should destroy these orchards, if they cannot afford to control the pests. Invasion of a new orchard can also occur when cone-bearing trees are present in adjacent natural stands, plantations, abandoned fields, fence rows or parks and residential areas. Locations such as these should be avoided. If more than one tree species is planted at the same orchard site, problems are created if they share the same insect pests. For example, when a loblolly pine orchard is next to a slash pine orchard, seed bugs may concentrate on the loblolly pines, after the slash pine cones are harvested.

Avoid Environmentally Sensitive Sites

Problems associated with pest management practices, especially the use of insecticides, are often not considered when choosing an orchard site. Health, safety and environmental problems due to insecticide drift or runoff, whether real or perceived, can rule out the use of insecticides. There have been many cases where insecticides could not be used or had to be used with extreme caution because orchards were located too close to springs, wells, streams, rivers, lakes, homes, farms, or urban areas.

IMPROVE PEST MANAGEMENT TACTICS

With few exceptions, orchard managers apply insecticides on a preventive basis to control cone and seed insect pests. Two ways to make insect pest management more efficient are to develop methods for predicting the need for control and to time controls.

Develop Techniques to Predict the Need for Control

It is very difficult to predict losses caused by insects. Few successful examples exist for agriculture, fewer still for forestry, and practically none for seed orchards. One exception is the egg sampling technique for the Douglas fir cone midge (Miller 1986). Insect populations are affected by many biological and environmental factors and their interactions. Practical techniques for predicting losses must be reliable, inexpensive and easy to use. Cone and seed insects are particularly difficult to sample because low numbers cause substantial damage and they spend long periods of the time in life stages that are small and well hidden. These low numbers have a highly variable distribution within the orchard and the large spatial area of the tree crowns. To be most useful, prediction methods should be available for all the key pests for each host species. Otherwise, orchard managers will opt for using preventive sprays.

Develop Techniques for Timing Controls

There are a number of ways to time controls to coincide with periods of maximum vulnerability in the life cycle of an insect pest. A readily identifiable event in the phenological development of the host can be used. Degree-day models are based on the fact that insect growth is largely controlled by temperature. Temperature development relationships have been determined for the southern coneworm (Hanula et al. 1987). Studies of the temperate development relationships for the leaffooted pine seed bug and the shieldbacked pine seed bug are currently underway in our laboratory. The challenge is to demonstrate the practical value of degree-day models for pest management.

INCREASE KNOWLEDGE OF SEED ORCHARD ECOLOGY

Research on cone and seed insects has focused on the major cone and seed insect pests. However, we know relatively little about interactions among insect and other arthropod species found in seed orchards, the role of natural enemies in regulating pests, or potential for problems with secondary-insect pests. Understanding these biological details is essential to the development of new control strategies. Such knowledge can be the key to successful insect control and can prevent unforeseen problems. Two examples illustrate these points.

Observations of the webbing coneworm led to the discovery that young larvae feed in the catkins of loblolly pines before attacking second-year cones. We discovered that they were highly vulnerable to sprays applied within 7 days after peak pollen flight, just before they attack cones. Webbing coneworm control using this "7-day window of opportunity" is very reliable.

Outbreaks of secondary insect pests occurred when pyrethoid insecticides were first introduced for cone and seed insect control in southern pine seed orchards in the early 1980's. Pydrin caused the most severe problems. These outbreaks occur because Pydrin residues stay on pine foliage longer than for other insecticides (Nord and DeBarr 1992). This residual activity provides excellent control of cone and seed insects. It also kills the natural enemies of scale insects (Clarke et al. 1988), but not the scale insects. In contrast, Capture was almost as toxic to the scale insects, as Guthion (Clarke et al. 1992).

DEVELOP NEW CONTROL STRATEGIES AND TACTICS

Seed orchards offer one of the most ideal situations in forestry to implement new approaches to insect pest management. Crop values are high and orchard sizes provide clearly defined areas for treatment. Skilled managers and rapid communication through the tree improvement cooperatives and the SFITC, make technology transfer easy. Some new approaches that are potentially useful for cone and seed insect control include cultural control, pathogenic microbials, behavioral chemicals and biocontrol. As the following examples show, each approach has its strong and weak points.

Cold water sprayed on Douglas fir orchards prevents gall midge attacks by delaying female strobili development (Miller 1983). Limitations include the high costs for irrigation equipment and lack of control during years with cool temperatures. However, if dimethoate, the insecticide commonly used to control the midge is unavailable, this tactic might be more acceptable. Prescribed fire kills overwintering cone beetles in eastern white pine seed orchards. Since EPA rescinded the registration of Furadan in 1990, fire is the only alternative available for cone beetle control and it has been used in several seed orchards. Major limitations are adequate fuel, relatively few days with optimum condition for burning and concern over the effects of repeated fires on tree health..

The microbial insecticide, *Bacillus thuringensis* (Bt) will control some of the coneworm species, however, Bt only affects certain insect groups and it will not kill seed bugs. There are many species of parasites and predators of cone and seed insect pests (Yates 1989), but we know little about their contribution to control in seed orchards. It seems likely that natural enemy populations are severely affected by the routine use of insecticides in seed orchards. Augmentation of natural enemies through rearing and release seems impractical, but less frequent use of more selective insecticides will conserve these potentially useful insects in seed orchards. The use of synthetic pheromones, attractants and inhibitors to modify insect behavior through such techniques as trap-out or male confusion offers promise, but much additional basic and applied research will be necessary to develop techniques that provide reliable cone and seed insect control. These chemicals are also subject to the same complexities of registration, as are traditional chemical insecticides.

Methods such as these, are likely to be less reliable and more expensive than chemical insecticides. Therefore, even if these approaches prove useful, they may not be widely used, as long as chemical insecticides are available. To compete with insecticides, new tactics and strategies must be cheaper, more effective, offer environmental advantages or be easier or safer to use than the currently registered insecticides.

CONCLUSIONS

There have been many challenges for insect pest management in forest tree seed orchards during the past 25 years. The formidable challenges we face today are even more complex than those that confronted us before. Research will lead to the discovery of new and better pest ways for dealing with cone and seed insect pests. However, there is a wide gap between the promise of research and practical pest management techniques. Continued cooperation by tree improvement specialists and forest entomologists is necessary to bridge this gap and ensure that orchard managers have the tools they need to produce the large quantities of seed for forestry in .the South.

LITERATURE CI **1 ED**

Anon. 1985. Twenty-ninth Annual Report: N. C. State Univ.-Industry Coop. Tree Improv. Prog., Coll. of For. Resoures, N. C. State Univ., Raleigh, N.C. 24 pp.

Barry, J. W., L. R. Barber, P. A. Kenny, and N. Overgaard. 1984. Feasibility of aerial spraying of southern pine seed orchards. South. J. For.8: 127-131.

Clarke, S. R., G. L. DeBarr and C. W. Berisford. 1088. Differential susceptibility of *Toumeyella pini* (King) (Homoptera: Coccidae) to pyrethroid and organophosphate insecticides: a factor in outbreak in southern pine seed orchards. J.Econ. Entomol. 81: 1443-1445.

Clarke, S. R., J. F. Negron and G. L. DeBarr. 1992. Effects of four pyrethroids on scale insect (Homoptera) populations and their natural enemies in loblolly and shortleaf pine seed orchards. J. Econ. Entomol. 85: 1246-1252.

DeBarr, G. L. 1971. The value of insect control in seed orchards: some economic and biological considerations. pp. 178-185 *in:* Proc. 11th Southern For. Tree Imp.Conf., Atlanta, Ga.

DeBarr, G. L. 1990. Research on cone and seed insects in North America: Past, present and future. pp. 1-23 In: R. J. West, Ed. Proc. Cone and Seed Pest Workshop, St. John's Newfoundland. For. Can., Inform. Rept. N-X-274, 128 pp.

Ebel, B. H., T. H. Flavell, L. E. Drake, H. 0. Yates III and G. L. DeBarr. 1976. Seed and cone insects of southern pines. U.S. Dept. Agric. For. Serv. Gen. Tech. Rep. SE-8, Southeast. For. Exp. Stn., Asheville, N.C. & Southeast. Area, State & Priv. For., Atlanta, Ga. 40 pp.

Hanula, J. L, G. L. DeBarr, and C. W. Berisford. 1987. Threshold temperature and degree-day estimates for developing immature southern pine coneworms (Lepidoptera:Pyralidae), at constant and fluctuating temperatures. J. Econ. Entomol.. 80: 62-64.

Hedin, A. F., H. 0. Yates III, D. C. Tovar, B. H. Ebel, T. W. Koerber, and E. P. Merkel. 1980. Cone and seed insects of North American conifers. Can. For. Serv., U. S. Dep. Agric. For. Serv.. and Secr. Agric. Recur. Hidraul, Mexico. 122 pp.

Lowe, W. J., L. R. Barber, R. S. Cameron,. G. L. DeBarr, G. R. Hodge, J. B. Jett, J. L. McConnell, A. Mangini, J. Nord and J. W. Taylor. 1993. A southwide test of bifenthrin (Capture) for cone and seed insect control in seed orchards. J. Appl. For. **(IN PRESS).**

Merkel, **E. P.** and G. L. DeBarr. 1971. Trunk implantations of dicrotophos for cone-insect control in slash pine seed production stands. J. Econ. Entomol. 64: 1295-1298.

Miller, G. E. 1983. Evaluation of the effectiveness of cold-water misting of trees in seed orchards for control of Douglas-fir gall midge (Diptera:Cecidomyiidae). J. Econ. Entomol. 76: 916-919.

Miller, G. E. 1986. Damage prediction for *Contarinia oregonensis* Foote(Diptera:Cecidomyiidae). Can. Ent. 118:1297-1306.

Nord, J. C. and G. L. DeBarr. 1992. Persistence of insecticides in a loblolly pine seed orchard for control of the leaffooted pine seed bug, *Leptoglossus corculus* (Say) (Hempiptera: Coreidae). Can. Ento. 124: 617-629.

Turgeon, J. J. and P. deGroot. 1992. Management of insect pests of cones in seed orchards in eastern Canada. For. Can., For. Pest Mgt. Inst., Sault Ste. Marie, Ont. 98 pp.

van Buijtenen, J. P. 1981. Insecticides for seed orchards--a case study in applied research. South. J. Appl. For. 5: 33-37.

Wakeley, P. C. 1954. Planting the southern pines. USDA For. Serv., Agric. Monograph 18, 223 pp.

Yates, H. 0. III. 1989. Natural enemies of cone and seed insects of world conifers. pp. 82-90. *in* Miller, G. E. (Ed.) Proc. of IUFRO Cone and Seed Working Party Conf.. Victoria, B. C., Canada, June 27-30, 1988.

Zobel, B. J. and J. T. Talbert. 1984. Applied forest tree improvement. Joh Wiley and Sons, N. Y. 505 pp..