Evaluation of Aerial Applications of Acephate and Other Insecticides for Control of Cone and Seed Insects in Southern Pine Seed Orchards[1, 2]

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ABSTRACT Acephate was evaluated for control of cone and seed insects in southern pine seed orchards from 1980 to 1985. Insecticides compared with acephate during this study were azinphosmethyl, fenvalerate, malathion, and the bacterium *Bacillus thuringiensis*. Insecticides were applied aerially, by hydraulic sprayers, and by airblast sprayers. Experiments were conducted in loblolly pine seed orchards in Florida and North Carolina and in two slash pine seed orchards in Florida. Control of coneworms, *Dioryctria* spp., slash pine flower thrips, *Gnophothrips fuscus* (Morgan), and two seed bugs, the leaffooted pine seed bug, *Leptoglossus corculus* (Say), and the shieldbacked pine seed bug, *Tetyra bipunctata* (Herrich-Schäffer)
was evaluated. Frost damage and a serious infection of southern cone rust, *Cronartium strobilinum* (Arth.) Hedgc. and Hahn, caused significant flower and conelet losses and may have obscured differences between treatment effects during some years. All of the insecticide treatments were equally effective in controlling coneworms. The percentages of trees infested with pine tortoise scale, *Toumeyella parvicornis* (Cockerell), and the striped pine scale, *T. pini* (King), and the numbers of scale insects per branch after five applications of insecticide, differed significantly for acephate and fenvalerate treatments.

KEY WORDS Acephate, fenvalerate, azinphosmethyl, malathion, *Bacillus thuringinensis,* cone and seed insects, *Cronartium strobilinum,* scale insects, loblolly pine, slash pine, seed orchards.

Aerial applications of acephate effectively control forest defoliators such as the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), (Neisses et al. 1976), the western spruce budworm, *Choristoneura occidentalis* Freeman (Markin 1977), the gypsy moth, *Lymantria dispar* (L.) (Willcox and Coffey 1977)

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[2] This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended. CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife – if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers. The use of of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any produce or service to the exclusion of others that may be suitable.

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and the larch casebearer, *Coleophora laricella* (Hübner) (Hard et al. 1979). Acephate, applied by hydraulic sprayer, also was found to reduce insect-caused mortality of female strobili of slash pine by up to 34% and to increase seed yields and seed quality (Fatzinger et al. 1984). Because acephate effectively controls many insects, and reportedly represents little hazard to humans and the environment, it was evaluated for control of insects in southern pine seed orchards. In this paper we evaluate aerial applications of acephate and compare the efficacy of acephate, azinphosmethyl, *Bacillus thuringiensis*, fenvalerate, and malathion for control of cone and seed insects in two slash pine, *Pinus elliottii* Engelm. var. *elliottii,* and two loblolly pine, *P. taeda* L., seed orchards.

Application of fenvalerate in southern pine seed orchards is suspected to be closely associated with subsequent outbreaks of scale insects, including the pine tortoise scale, *Toumeyella parvicornis* (Cockerell) and the striped pine scale, *T. pini* (King) (Clarke et al. 1988). The effects of aerial, airblast-sprayer, and hydraulic-sprayer applications of acephate and fenvalerate on post-spray population densities of scale insects were evaluated.

Methods and Materials

Three experiments were conducted from 1980 to 1985. In the first experiment, we compared aerial and hydraulic-sprayer applications of acephate for control of seed insects in a slash pine orchard. The second experiment was conducted in the same orchard and evaluated possible interactions between methods of applying acephate or fenvalerate and post-spray population densities of scale insects within treated plots. The objective of the third experiment was to obtain additional efficacy data for aerial applications of acephate to slash and loblolly pines, and to evaluate *B. thuringiensis* as a control agent for coneworms, *Dioryctria* spp. Azinphosmethyl, which is effective in controlling cone and seed insects and which is widely used in southern pine seed orchards, was used as a standard in experiments 2 and 3.

Spray plots, established for experiments involving aerial or airblast-sprayer applications of insecticides, contained replicate ramets (sample trees) of the same clones represented in other plots in the same experiment. Additional ramets of these clones, located outside the spray plots, were utilized as sample trees for hydraulic-sprayer applications and as untreated (check) trees.

Damage Evaluation. Treatment efficacy was evaluated by comparing differences in rates of insect attack on female strobili of sample trees. Sequential observations were made on samples of female strobili using methods similar to those reported by Fatzinger et al. (1988) to enumerate and identify treatment differences in strobilus mortality factors. A randomly distributed 10% sample of the flower clusters in the crown of each sample tree was selected for observation during experiment 1. In experiments 2 and 3, 20 randomly distributed and selected clusters per tree were examined. Each sample cluster was identified by a numbered tag attached to the branch immediately below the cluster. Clusters of first-year strobili (female flowers) were tagged when they became visible on sample trees (initial flower year) and provided baseline data on the numbers and conditions of strobili present on sample trees prior to the first insecticide application. Second-year strobili (conelets) present on sample trees at the time of flowering also were tagged to facilitate observation of insect-related mortality on the two crops of strobili present throughout the year. During the second year of each experiment, only the new flowers had to be tagged for inclusion in the sample. Use of this system resulted in strobilus mortality and survival records over one complete cycle of strobilus development (flowers to mature cones), and two partial cycles of strobilus development (flowers to late first-year conelets, and early second-year conelets to mature cones).

Experiment 1 (Acephate: Aerial and Hydraulic-Sprayer Applications). Aerial and hydraulic-sprayer applications of acephate were compared for control of insects in a slash pine seed orchard during 1980 and 1981. The orchard was located in Hamilton County near White Springs, FL and contained 12-year-old trees which averaged 7.6 m [25 ft] in height and were spaced at intervals of 9.1 x 9.1 m [30 x 30 ft]. Three 4.05-ha [10-ac] plots were established for aerial applications. Each of these plots contained two to four randomly selected ramets from each of six clones. Additional ramets of the same six clones were located 84 m [275 feet] from the aerial spray plots. Acephate was applied to some of these trees by hydraulic sprayer, while the other trees served as unsprayed checks.

Acephate was applied aerially to separate plots at the rates of 3.36, 1.68, and 0.84 kg ai/ha [3.00, 1.50, and 0.75 lb ai/ac] in 187.1 l of water per hectare (l/ha) [20 gallons per acre (gal/ac)]. Applications were made from a fixed-wing aircraft equipped with 62 "Spray Systems®" D-12 nozzles with No. 56 swirl plates. Spray boom pressure was 3.52 kg per square cm [50 psi] and calibration swath width was 9.1 m [30 ft]. Applications were made ca. 3.1 m [10 ft] above the tree crowns at an air speed of 160 kph [100 mph].

Hydraulic-sprayer applications of a 0.5% ai solution were made with a Friend® sprayer operated at 28.12 kg per square cm [400 psi] from a mobile platform 2.43 m [8 ft] tall. The entire tree crown was sprayed until the foliage was thoroughly wet (sprayed to the point of drip-off).

Experimental plots were sprayed three times a year to coincide with periods of major damage by the slash pine flower thrips (SPFT), *Gnophothrips fuscus* (Morgan), and coneworms. The first application of acephate in 1980, however, had to be postponed one week beyond the optimum time for control of SPFT due to rain. Acephate treatments were applied on January 22, February 28, and May 21 in 1980, and on February 5, March 5, and May 19 in 1981. The first two sprays were applied each year for control of SPFT on first-year flowers, and the third sprays were applied for control of coneworms on second-year cones. During 1981, a prolonged period of cold weather delayed the first application of acephate until February. Strobili on 111 sample trees were examined at intervals of about 1 month from flower initiation through June, and again at cone harvest in September.

In September 1980 and 1981, all mature sample cones in tagged clusters were collected. Seed was extracted by hand and radiographed. The number of seed per cone was determined and seed damage was attributed to insects such as the leaffooted pine seed bug, *Leptoglossus corculus* (Say); the shieldbacked pine seed bug, *Tetyra bipunctata* (Herrich-Schäffer); seedworms, *Cydia* spp.; and other factors. Germination tests were conducted to determine seed viability.

Experiment 2 (Acephate versus Fenvalerate: Aerial, Airblast-, and Hydraulic-Sprayer Applications). The efficacy of acephate and fenvalerate for control of cone and seed insects was compared during 1983. The effects of acephate and fenvalerate on subsequent scale insect infestations were compared also. Applications of each insecticide were made on April 5, May 3, June 2, July 5, and August 9. Aerial, airblast, and hydraulic sprayers were used on different plots.

Experiment 2 was conducted in the same slash pine seed orchard where experiment 1 had been conducted. The orchard had received 5 monthly aerial applications of fenvalerate from March through July of the previous year, and relatively large populations of scale insects were observed on orchard trees during the fall of 1982. Prior to initiation of experiment 2, the entire orchard received aerial applications of malathion for control of SPFT and of ferbam for control of southern cone rust. Malathion was applied at a rate of 3.36 kg ai/ha [3.0 lb ai/ac] and ferbam at a rate of 0.56 kg ai/ha [0.5 lb ai/ac]. Applications of malathion mixed with ferbam were made on January 25 and February 9, and one application of ferbam alone was made on February 1. Four plots ranging in size from 4.05 to 12.14 ha [10 to 30 ac] depending on the locations of ramets within the clones sampled, each containing two to five ramets of the same six clones, were established to evaluate: 1) aerial applications of acephate (3.36 kg ai/ha [3.0 lb ai/ac]) and fenvalerate (0.84 kg ai/ha [0.75 lb ai/ac]), and 2) airblast-sprayer applications of these insecticides at the same per-hectare rates. From two to five ramets of the same clones, located at least 15.8 m [60 ft] from the spray plots, received individual hydraulic-sprayer applications of fenvalerate and acephate at the same per-hectare rates of application or were untreated (check) trees. The total number of sample trees was 116. A spreader-sticker (Chemnut® 80-20, 1.25 ml/l [16 oz/100 gal]) and a drift retardant (Orthotrol®, 0.39 ml/l [5 oz/100 gal]) were included in all insecticide solutions. The same techniques and equipment employed in experiment 1 were employed in experiment 2, but the application rate was changed from 187.1 to 93.6 l/ha [20 to 10 gal/ac]. The airblast sprayer was a tractor-mounted Hardi Combi II®, which was equipped with No. 18 nozzles with white swirl plates in the upper spout and one No. 18 nozzle plus three No. 4 nozzles with gray swirl plates in the lower spout. Tractor speed was maintained at 1.9 kph [1.2 mph] to apply 378.5 l/ha [100 gal/ac] of spray solution. The same hydraulic sprayer employed in experiment 1 was used to apply an average of 22.7 l [6 gal]/tree of spray solution.

Sample strobili were examined for insect attack during March and August. The relative densities of mature female scale insects, *Toumeyella* spp., on sample trees were estimated by two techniques. During late August we counted the numbers of sample trees infested by one or more scale insects. We also estimated the population densities of scale insects by counting their numbers on five 50-cm-long branch tips in the southeast crown quadrants (two branch tips in the upper crown, two in the mid-crown, and one in the lower crown).

Experiment 3 (Acephate, Azinphosmethyl, B. thuringiensis, and Malathion: Aerial Applications). Various combinations of acephate, azinphosmethyl, malathion, and *B. thuringiensis* were compared for efficacy in controlling insects in 3 tests conducted in different seed orchards from 1983 to 1985 (Table 1). Except as otherwise noted, the same techniques and equipment employed in experiment 1 were used during experiment 3.

Table 1. Aerial insecticide tests conducted in three pine seed orchards during experiment 3 (April 1983—September 1985).

Test	Insecticides*	Dates applied 1983	1984	1985
FL-LOBLOLLY	acephate		April 21	
	azinphosmethyl		May 18	
			June 20	
NC-LOBLOLLY	acephate	April 18	April 26	
	azinphosmethyl	May 25	June 5	
		June 29	July 12	
		Aug. 9	Sep. 18	
FL-SLASH	acephate		Feb. 23	Jan. 14
	malathion		March 15	Feb. 26
	azinphosmethyl		April 24	April 16
	Bacillus thuringiensis		May 18	May 21
			June 18	June 11
			July 20	July 16

* Acephate, azinphosmethyl, and malathion were applied at the rates of 3.4 kg ai/ha [3.0 lb ai/ac] and *B. thuringiensis* was applied at 39.5 BIU/ha [16.0 BIU/ac].

Test 1: FL-LOBLOLLY. Acephate and azinphosmethyl were applied at a rate of 3.36 kg ai/ha [3.0 lb ai/ac] in 93.6 l/ha [10 gal/ac] to loblolly pine plots near Newberry, FL. The applications were made on April 21, May 18, and June 20, 1984 from a fixed-wing aircraft flying at 177 kph [110 mph]. Treatments were randomly assigned to treatment plots and each insecticide was applied to 3 plots containing 3 ramets of 3 clones for a total of 27 ramets per insecticide. An equal number of ramets were utilized as untreated (check) trees. Insect damage to the first- and second-year sample strobili was observed in April, June, July, and September.

Test 2: NC-LOBLOLLY. Acephate and azinphosmethyl insecticides were applied at a rate of 3.36 kg ai/ha [3.0 lb ai/ac] in 93.6 l/ha [10 gal/ac] of water to loblolly pine plots near Washington, NC. Aerial applications were made on April 18, May 25, June 29, and August 9, 1983; and on April 26, June 5, July 12, and September 18, 1984. The aircraft employed was a helicopter with Simplex® spray-system boom, calibrated at a 18.3 m [60 ft] swath width, 350 VMD, and flying at 80 kph [50 mph]. Insect damage on first-and second-year strobili was observed on 2 sample ramets of each of 6 clones per spray plot, including one check plot, in April, June, and September of 1983 and 1984.

Test 3: FL-SLASH. Acephate, azinphosmethyl, and malathion (3.36 kg ai/ha [3.0 lb ai/ac]) in 93.6 l/ha [10 gal/ac] of water were applied to slash pine plots near Munson, FL from a fixed wing aircraft flying at 177 kph [110 mph]. Six insecticide applications were made at monthly intervals from February to July in 1984 and January to July in 1985. Malathion was used as a substitute for azinphosmethyl from January to March for control of SPFT. Each insecticide was applied to one of two plots containing 2 sample ramets from each of 7 clones. A similar plot was established for untreated (check) trees. Based on the preliminary success of McLeod and Yearian (1981) an additional plot was added to the study during February 1985 to evaluate *B. thuringiensis* (Thuricide® 32 LV, aqueous, HD-1 strain, 32 BIU/gal) for control of coneworms. Germination tests were conducted on samples of 100 seed extracted from 6 cones per sample tree during 1984 (initiated as flowers during 1983). Radiographic analyses were conducted to determine seed quality and causes of nonviability of seed extracted from 6 sample cones collected from each sample ramet during 1985. (These cones were initiated as flowers during 1984.)

Analysis of Data. An analysis of variance was used to test for significant differences between treatment means for percentages of strobili destroyed by insects or other factors; percentages of seeds that were classified as full, empty, insect damaged, or malformed; and for percentages of seed that germinated. The arc sin $\sqrt{x}$ transformation was applied to the percentage data prior to data analysis, but only the percentages are listed in the tables and results. Duncan's multiple range test (Duncan 1955) was used to compare treatment means.

Results

Experiment 1. During 1980, an abnormal prolonged period of freezing weather occurred after flowering and destroyed many flowers throughout the orchard. Flower mortality due to thrips, freezing weather, and strobilus abortion from unknown causes totaled about 30% by early March. By mid-April, about 24% of the residual first-year strobili had become infected with southern cone rust, *Cronartium strobilinum* (Arth.) Hedgc. & Hahn. The infected conelets rapidly hypertrophied and became infested with larvae of the south coastal coneworm, *Dioryctria ebeli* Mutuura & Munroe. Outbreaks of this coneworm typically parallel those of the southern cone rust and a large population of the south coastal coneworm developed in the rust infected conelets (by early May most of the rust-infected conelets were inhabited by 4 to 13 larvae each). When the first-year conelets infected with rust died and fell from the trees in early June, the large population of coneworms destroyed about 35% of the second-year cones present on the same trees. The susceptibility of ramets to infection by southern cone rust varied from clone to clone and was related to the efficacy of acephate treatments. In general, treatment differences in insect control were obscured by this interaction.

Experiment 2. Total strobilus mortality caused by insects during the 7-month study period in 1983 was less than 5% throughout the orchard. Only aerial applications of fenvalerate and hydraulic sprayer applications of acephate were associated with significant ($P < 0.05$) reductions in damage done to strobili by all insects (including coneworms, loopers, and unidentified insects). All of the insecticide treatments were equally effective in controlling coneworms, and the percentages of strobili damaged by coneworms were significantly greater for untreated trees than for insecticide-treated trees (Table 2).

When acephate and fenvalerate were applied aerially, the percentage of scale-infested trees was significantly lower in the acephate plots than in the fenvalerate plots and did not differ significantly from the percentage of scale-infested trees in the check plots (Fig. 1A). Scales present on unsprayed trees

Table 2. Insect damage on trees sprayed with fenvalerate (0.84 kg ai/ha [0.75 lb ai/ac] or acephate (3.36 kg ai/ha [3.00 lb ai/ac] using aerial, airblast-, and hydraulic-spray equipment in a slash pine seed orchard near White Springs, FL (Experiment 2, January to September 1983).

	Percentage of female strobili damaged by insects*	
Treatment	All insects	Coneworms
Untreated	4.8 a	4.1 a
Aerial (Acephate)	3.0 ab	1.7 b
Aerial (Fenvalerate)	0.5 c	0.4 b
Airblast (Acephate)	2.1 bc	1.3 b
Airblast (Fenvalerate)	1.2 bc	0.4 b
Hydraulic (Acephate)	0 c	0 b
Hydraulic (Fenvalerate)	1.8 bc	0.2 b

* Means within a column and followed by the same letter are not significantly different at the $P < 0.05$ level.

during 1983 were probably a residual population from those observed after the 1982 operational sprays of fenvalerate. Neither fenvalerate nor acephate appeared to control these residual scale insects. The mean numbers of scale insects collected from a sample of five branch tips per tree differed significantly by insecticide (Fig. 1B). Trees treated with fenvalerate consistently had more scales per branch tip than did the untreated trees or trees treated with acephate. Differences between means for the acephate-treated trees and the untreated trees were not significant.

Experiment 3: Test FL-LOBLOLLY. Insect damage in the Florida loblolly pine seed orchard remained low through 1984. Significantly ($P \leq 0.01$) greater percentages of first- and second-year strobili were destroyed by coneworms on untreated trees than on trees treated with either acephate or azinphosmethyl (Table 3). The percentage of cones attacked by coneworms did not differ significantly by insecticide. Damage of the type caused by thrips was observed on about 4.7% of the first-year flowers, but damage levels did not differ significantly by treatment. Seed quality and germination for the insecticide treatments were not significantly different from seed quality and germination for the checks (Table 3).

Experiment 3: Test NC-LOBLOLLY. In the loblolly pine seed orchard in North Carolina, differences between treatment means for the percentages of healthy strobili on insecticide treated and untreated trees were not significant (Table 4). Coneworms attacked fewer strobili on acephate-treated trees than on untreated trees, but the mean differences were not statistically significant.

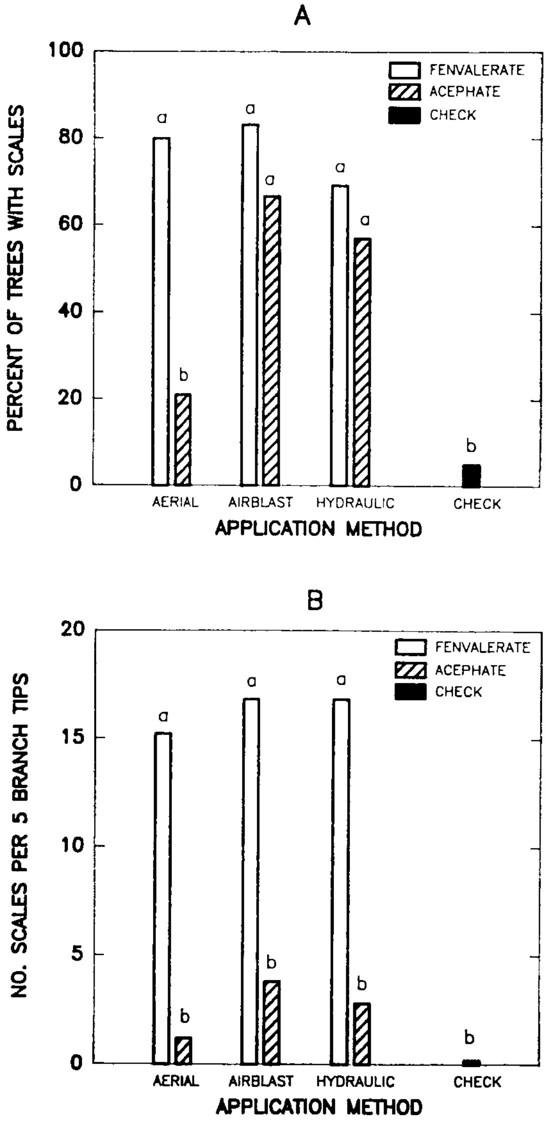

Fig. 1. Comparison of the effects of five monthly applications of two insecticides (acephate, fenvalerate) on subsequent population levels of scale insects in a slash pine seed orchard near White Springs, FL (Experiment 2, January - September 1983); A) percentage of trees infested by scale insects, B) mean number of scale insects per sample of five branch tips. Treatment means represented by bars with the same letter are not significantly different ($P > 0.05$; Duncan's [1955] multiple range test).

Table 3. Damaged and healthy female strobili following three applications of acephate or azinphosmethyl insecticide (3.36 kg ai/ha [3.0 lb ai/ac] by fixed-wing aircraft in a loblolly pine seed orchard near Newberry, FL (Experiment 3: Test FL-LOBLOLLY, January to September 1984).

	Percentage of initial strobili*		
Item	Acephate	Azinphosmethyl	Untreated
	Flower Year 1983 (2nd-yr Strobili)		
Coneworms	2.2	1.0	6.3*
Unknown	13.7	13.1	10.4
Healthy	81.7	79.5	80.1
Other	2.4	6.4	3.2
	Flower Year 1984 (1st-yr Strobili)		
Thrips-like†	3.4	6.6	4.2
Coneworm	2	.4	3.5*
Unknown	19.7	12.7	17.6
Healthy	72.7	75.2	74.0
Other	4.0	5.1	0.7
	Flower Year 1983 Strobili (Percentage of Total Seed‡)		
Sound	70.2	70.3	60.4
Empty	29.1	29.5	29.6
Seed bug	.4	.2	.6
Fungus	.3	<.1	.4
Germinated	58.4	55.2	51.8

* Means followed by an asterisk are significantly different ($P \leq 0.01$) from other means without an asterisk in the same row.

† First-year female strobili (flowers) exhibited small beads of resin similar to those that indicate SPFT damage on slash pine.

‡ Means did not differ significantly ($P > 0.05$) by treatment.

Trees treated with azinphosmethyl, however, had significantly fewer coneworm attacks than did the untreated trees. Seed quality did not differ significantly by insecticide treatment (Table 4), but the untreated trees had significantly more malformed seed.

Experiment 3: FL-SLASH. Levels of insect damage were relatively high in the untreated block of the Florida slash pine seed orchard throughout 1984 and 1985 (Table 5). In 1984, coneworms attacked significantly ($P < 0.01$) smaller percentages of second-year strobili on acephate-treated trees than on untreated trees (Table 5). There was no significant difference between frequencies of coneworm attacks on untreated trees and on trees treated with azinphosmethyl, but the absence of difference may have resulted from an accidental decrease in the rate of application of azinphosmethyl from 3.36 kg to 1.12 kg ai/ha [3.0 to 1.0 lb ai/ac] during July.

Neither acephate nor azinphosmethyl appeared to control coneworms effectively during 1985 on strobili initiated in 1984 and 1985. Trees treated with either azinphosmethyl or acephate, however, had significantly greater percentages of healthy strobili at cone harvest during September 1985 than did untreated trees, possibly because losses from unknown causes were reduced in treated trees. Control of SPFT was not adequately measured during 1984. The sample trees were tagged after most of the SPFT damage occurred and presumably after many of the SPFT-attacked strobili had fallen from the trees. During 1985, damage by SPFT was reduced significantly on trees treated with acephate, but not on those treated with malathion or *B. thuringiensis*. In 1985, treatments with *B. thuringiensis* resulted in significantly greater control of coneworms on second-year strobili than did any other treatments. No significant differences in survival of first-year strobili were detected.

There were no significant treatment differences in seed quality in 1984 (Table 5).

Summary and Conclusions

A prolonged period of freezing weather killed many first-year strobili during 1980, and an outbreak of southern cone rust destroyed many others. This unexpected mortality obscured the effects of the insecticide treatments conducted for experiment 1 and statistically significant differences could not be identified.

Total insect-caused mortality of strobili in the same slash pine orchard was less than 5% during the 1983 experiment designed to compare the efficacy of acephate and fenvalerate for control of cone and seed insects. All of the insecticide treatments were equally effective for control of coneworms on second-year cones, and the percentages of strobili damaged by coneworms were significantly smaller for insecticide-treated trees than for untreated trees.

The percentage of trees infested with scale insects was significantly smaller for trees treated with acephate than for those treated with fenvalerate, and fenvalerate-treated trees had more scales per tree than did the untreated or acephate-treated trees. Acephate and azinphosmethyl treatments generally were equally effective in preventing coneworm attacks on female strobili, and the use of either insecticide usually resulted in significantly fewer coneworm-damaged strobili at cone harvest. Damage by SPFT also was reduced signifi-

Table 4. Damaged and healthy female strobili following four annual applications of acephate or azinphosmethyl (3.36 kg ai/ha [3.0 lb ai/ac] by rotary-wing aircraft in a loblolly pine seed orchard near Washington, NC (Experiment 3: Test NC-LOBLOLLY, January 1983 to September 1984).

Years spray applied	Data collection period	Item	Percentage of initial strobili*		
			Acephate	Azinphosmethyl	Untreated
			Flower Year 1983 (1st-Yr Strobili), 8 Insecticide Applications		
1983-	Jan. 83-	Loopers	0	0	0
1984	Sept. 84	Coneworms	2.6 ab	1.0 b	4.7 a
		Midges.	.4	.3	.5
		Unknown	35.9	29.2	35.8
		Healthy	61.1	69.4	59.0
			Flower Year 1984 (1st-Yr Strobili), 4 Insecticide Applications		
1984	Jan.-Sept.	Loopers	8.9	6.4	9.1
	1984	Coneworms	0	0	0
		Midges	0	0	0
		Unknown	15.5	14.1	14.4
		Healthy	75.6	79.5	76.5
			Flower Year 1983 Strobili (Percentage of Total Seed) 8 Insecticide Applications		
1983	Jan. 83	Sound	87.8	88.0	85.1
1984	Sept. 84	Empty	11.0	11.2	13.1
		Seed Bug	.8	.3	.7
		Malformed	.5a	.4a	1.0b

* Treatment means within a row and followed by the same letter or no letter are not significantly different ($P \leq 0.05$).

Table 5. Damaged and healthy female strobili following two annual applications of malathion (3.36 kg ai/ha [3.0 lb ai/ac] for control of thrips and four annual applications of azinphosmethyl (3.36 kg ai/ha [3 lb ai/ac], acephate (3.36 kg ai/ha [3.0 lb ai/ac], or *Bacillus thuringiensis* (39.5 BIU/ha [16 BIU/ac]) by fixed-wing aircraft in a slash pine seed orchard near Munson, FL (Experiment 3: Test FL-SLASH, January 1984 to September 1985).

Data collection period	Item	Percentage of initial strobili*				
		Acephate	Azinphos-methyl†	Mala-thion‡	*B. thur-ingiensis*§	Untreated
			Flower Year 1983 (2nd-Yr Strobili) 6 Insecticide Applications			
Feb.-Sept. 1984	Coneworms	9.3 b	33.6 a	-	-	37.5 a
			Flower Year 1984 (1st- and 2nd-Yr Strobili) 12 Insecticide Applications			
Feb. 1984-Sept. 1985	Thrips	6.8 ab	-	4.8 b	0 c	9.2 a
	Coneworms	30.9 a	31.7 a	-	22.1 b	35.8 a
	Other Insects	.1 a	0	-	0 a	.1 a
	Unknown	31.6 a	30.2 a	-	28.9 a	35.5 a
	Healthy	28.0 b	25.3 a	-	48.9 c	11.4 a
	Other¶	2.6	8.0		.1	8.0
			Flower Year 1985 (1st-Yr Strobili) 6 Insecticide Applications			
Feb. - Sept. 1985	Thrips	5.6 b	-	17.8 a	18.3 a	26.1 a
	Coneworms	2.3 a	2.7 a	-	1.6 a	3.6 a
	Other Insects	.1 a	.1 a	-	.2	7a
	Unknown	31.3 ab	23.5 ab	-	19.6 b	32.6 a
	Healthy	29.2 b	36.9 b	-	33.8 b	20.0 a
	Other¶	31.5	19.0		26.5	17.0
			Flower Year 1984 Strobili (Percentage of Total Seed£) 12 Applications of Insecticide			
Sept. 1985	Sound	75.3	73.6	-	77.7	69.2
	Empty	17.4	16.4	-	13.2	16.1
	Seed Bug	6.6	9.3	-	8.7	16.6
	Seedworm	0	<.1	-	0	<.1
	Unknown	.7	.6	-	.3	1.0
	Avg. No. Seed/Cone	114.9	122.5	-	105.7	107.9

* Means within a row and followed by the same letter are not significantly different at the P < 0.05 level.

† The July 1984 application of azinphosmethyl was applied at a rate of 1.12 kg ai/ha [1.0 lb ai/ac].

‡ Malathion was applied to the azinphosmethyl spray plot only during February and March of 1984 and January and February of 1985 for control of slash pine flower thrips.

§ Only 5 applications of *B. thuringiensis* were applied in 1985.

¶ Includes strobili mechanically damaged during sampling, strobili (young flowers) apparently killed by a late winter frost, and flowers on branches that died from pitch canker. The significance of differences within a row was not computed for this group of factors.

£ Means did not differ significantly (P > 0.05) by treatment.

cantly following aerial applications of acephate. Although tested only 1 year, *B. thuringiensis* showed promise for control of coneworms on second-year strobili of slash pine. Further testing of this bacterial insecticide is warranted.

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