Table 3. Effects of ethoprop nematicide on nematode population, growth, and yield of 'Dasher II' cucumbers double-cropped with tomatoes.

		Plant					
Nematicide	Nematodes (no./500 cm³)	Fresh wt (oz)	Dry wt (oz)	Stem length (inch)	Flowers (no.)	Yield (bu/acre) Prem.	Yield (bu/acre) Mark.
Treated	625	17.1	1.8	66.8	25.2	508.8	913.1
Untreated	1860	10.4	1.1	51.1	14.4	215.9	441.5
Signif.	NS[z]	**	**	**	**	**	**

[z]T test was significant at the 1% level (**) or not significant (NS).

reducing nematode population and increasing cucumber yields. It also indicates that pre-plant treatment of cucumber plots with ethoprop was effective in producing vigorous plants and increasing yield.

The application of the ethoprop did not result in lower nematode populations in the cucumbers at harvest. However, application of ethoprop did significantly improve the plant growth and development of parameters measured and resulted in higher yields. It was apparent that ethoprop did not lower final nematode populations, but it was possible that use of the nematicide resulted in lower numbers of *M. incognita* juveniles infecting roots during the seedling and young plant stage and improved plant establishment and growth. Similarly, the use of transplants where roots had already developed prior to exposure to nematodes may have allowed plants to withstand nematode infection during the early season to a greater degree than direct-seeded plants.

It appears from these preliminary studies that cultural practices such as double-cropping cucumbers with nematode-resistant tomatoes and using transplants instead of direct seeding can be viable alternatives to pesticide treatment to reduce losses from root-knot nematodes.

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MANAGEMENT OF INSECT PESTS OF SQUASH

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Additional index words. sweetpotato whitefly, *Bemisia tabaci*, pickleworm, *Diaphania nitidalis*, melonworm, *Diaphania hyalinata*, *Aphis gossypii*.

Abstract. **Aphids (*Aphis gossypii* Glover), sweetpotato whitefly [*Bemisia tabaci* (Gennadius)], pickleworm [*Diaphania nitidalis* (Stoll)], and melonworm [*Diaphania hyalinata* (L.)] can cause serious damage to squash (*Cucurbita pepo* L.) and other cucurbits in Florida. In 1991 and 1992, various control measures were evaluated for management of these insect pests. Standard chemical insecticides, detergent, *Bacillus thuringiensis*, and mineral oil were tested either alone or in combination. In 1991, a combination of detergent and *Bacillus thuringiensis* was more effective than endosulfan for control of pickleworms and melonworms. Detergent did not effectively control aphids or whiteflies. Mineral oil in combination with a pyrethroid was highly effective against the entire pest complex in 1992 and also controlled powdery mildew.**

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Yellow summer squash and zucchini (*Cucurbita pepo* L.), winter squashes (*C. pepo* and *C. moschata* L.), and cucumbers (*Cucumis sativis* L.) are a significant part of Florida vegetable production, with a total value of $128.7 million in 1991-92 (Anonymous, 1993). Development of a sound insect pest management program for these crops could result in less insecticide use and possibly lower production costs. Since

Schuster (1981) reported results of chemical control of pickleworm on cucumber, little information has been published on the effects of conventional or biorational methods of managing insect pests of cucurbits in Florida.

Squash and cucumber are susceptible to the same insect pest complex, namely aphids (primarily *Aphis gossypii* Glover), sweetpotato whitefly [*Bemisia tabaci* (Gennadius)], pickleworm [*Diaphania nitidalis* (Stoll)], and melonworm [*Diaphania hyalinata* (L.)]. Sweetpotato whitefly has only been a problem in Florida for the past five years, and is responsible for silverleaf of squash (Maynard and Cantliffe, 1989; Yokomi et al., 1990; Schuster et al., 1991). Because it was important to know the effect of different insecticides on the entire pest complex, the effects of various treatments on all of the above insects on summer squash were evaluated. Some treatments were specific for pickleworm and melonworm and could be useful if biological and cultural control methods were available for managing whiteflies.

Materials and Methods

Evaluations were conducted during the fall growing season in 1991 and 1992 at the Central Florida Research and Education Center in Leesburg, FL. In both years, squash was planted 2.5 ft apart in beds of Apopka fine sand. Each plot consisted of four 25-ft rows, spaced 6 ft apart. Plots were separated by 15-ft. alleys. Each treatment was replicated four times in a randomized complete block design.

Zucchini squash, ('Senator') was planted in 1991, on 4 Sept. The following treatments were tested for insect control: endosulfan (Thiodan 3 EC, 1.0 lb(ai)/acre); bifenthrin (Capture 2 EC, 0.1 lb(ai)/acre); bifenthrin alternated with endosulfan (same rates as when used separately); and *Bacillus thuringiensis* var *kurstaki* (Dipel 2X, 1.0 lb(ai)/acre), mixed with a 0.25% solution of detergent (Ivory Liquid). Treatments were applied on 18 and 26 Sept., and 2 and 9 Oct. with a 12-ft tractor-mounted boom sprayer with 18 Albuz (brown) ceramic hollow cone nozzles, 8 inches apart, delivering 145 gal/acre at 200 psi. All plots were treated weekly with chlorothalonil at a rate of 1.5 lb (ai)/acre, beginning on 13 Sept. On 14 Oct., five plants from the middle two rows in each plot were examined for whitefly adults, aphids, pickleworm and melonworm larvae, and pickleworm damage to fruit and blossoms. Two leaves from the lower third of three plants per plot were collected and examined in the laboratory to estimate the number of immature whiteflies present. Eggs and nymphs were counted on two leaf disks, 0.8 inches in diameter, cut from one half of each collected leaf. The center rows were harvested for 2 weeks after which all fruit was severely damaged by mosaic viruses.

In 1992, a yellow straightneck squash, 'Multipik', was planted on 7 Sept. Ten insecticide treatments were applied on 5, 12, 20, and 26 Oct. and on 2 Nov. The two-row spray boom from the previous year was modified so that there were seven ceramic hollow cone nozzles (Albuz lilac) per row (five over the row and one drop nozzle on each side) which delivered 110 gal/acre at 200 psi. Treatments which included a mineral oil formulation (JMS Stylet Oil) were applied at 400 psi. Oil was applied twice weekly from 21 Sept. until 9 Nov., including the dates above when it was mixed with either *Bacillus thuringiensis* or bifenthrin. All plots were treated weekly with mancozeb (Manzate 200 DF) at a rate of 1.5 lb (ai)/acre to control fungal diseases. Chlorothalonil could not be used because it was not compatible with oil.

Insects were counted in the same manner as in 1991 but on two dates, 22 Oct. and 12 Nov. Immature whiteflies were counted on three leaf disks per leaf on 29 Oct.

Analysis of variance and Fisher's protected LSD (P = 0.05) were used to detect differences between treatments for insect counts and yield. Insect counts were analyzed after square root transformation. Non-transformed means are presented in figures and tables.

Results and Discussion

1991. All treatments, except *Bacillus thuringiensis* and detergent, controlled aphids. There were fewer aphids on plants treated with detergent and *Bacillus thuringiensis* than on untreated plants (113 versus 135 per plant, P = 0.05). Pickleworm and melonworm were significantly reduced by all treatments. For control of melonworm, *Bacillus thuringiensis* was no different from bifenthrin and more effective than endosulfan (0.2 versus 1.4 per plant, P = 0.05), and no different from endosulfan for pickleworm control (0.5 damaged blossoms per plant versus 0.07) (Fig. 1). All materials, including detergent, were equally effective at reducing the number of adult whiteflies. There were approximately twice as many adult whiteflies counted on untreated plants as on treated plants (Fig. 1). Endosulfan alone and alternated with bifenthrin was most effective in reducing the number of immature whiteflies (1.1 eggs and nymphs per square inch versus 2.6 on untreated plants, difference significant at P = 0.05) (Fig. 1). There were no differences in the number of immature whiteflies and eggs on plants from the untreated check, or from plants treated with *Bacillus thuringiensis* and detergent, or bifenthrin alone.

Yields were much higher from plants treated with bifenthrin, either alone or alternated with endosulfan (Fig. 2) than from plants in untreated plots or from plants in plots treated with *Bacillus thuringiensis* and detergent. Pickleworm damage appeared to have the most effect on yield. There was no significant difference in yield between *Bacillus thuringiensis*-treated plants and endosulfan-treated plants or between *Bacillus thuringiensis*-treated plants and untreated plants.

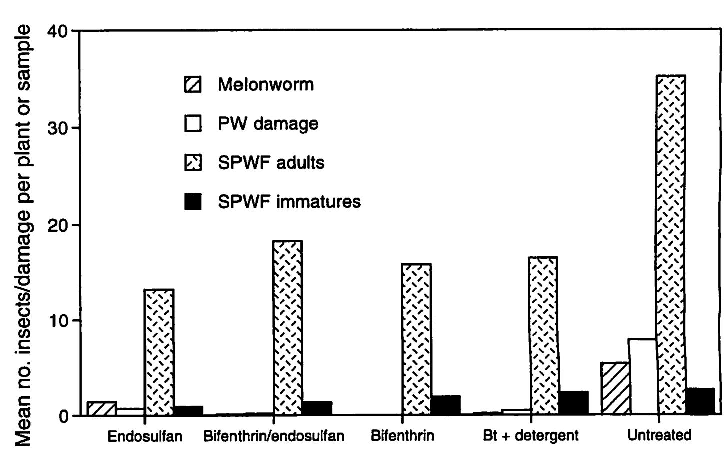

Fig. 1. Melonworms, blossoms damaged by pickleworms (PW), and sweetpotato whitefly adults (SPWF) per plant (n = 5), and number of whitefly nymphs and eggs per square inch of leaf on zucchini squash, 1991.

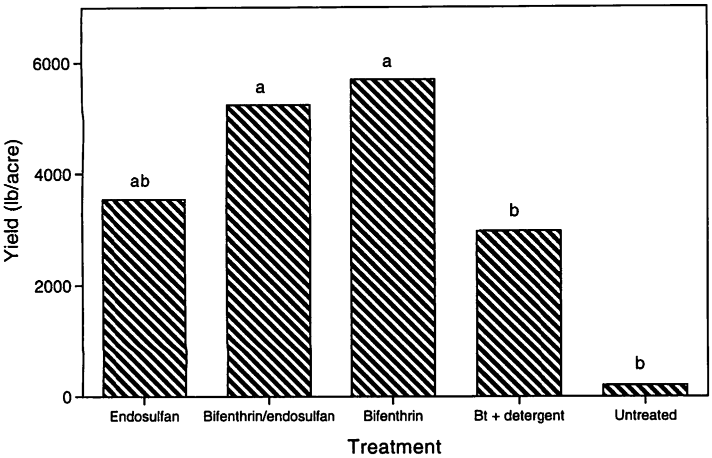

Fig. 2. Yield (lb/acre) of zucchini squash, 1991. Columns with the same letter are not significantly different, Fisher's protected LSD, $P = 0.05$).

1992. In the second year, more treatments were included and *Bacillus thuringiensis* was used alone as well as in combination with oil (Table 1). A lower rate of bifenthrin was added and bifenthrin was used in a tank mix with endosulfan in addition to being used alternately as in 1991. Fenpropathrin (Tame 2.4 EC) was included, and acephate (Orthene 75 WP), mainly for whitefly control.

Aphids were not controlled by oil and *Bacillus thuringiensis* but were controlled by all other treatments used. Treatments that included bifenthrin were most effective (Table 1). Pickleworm and melonworm populations were so low that the data (not shown) could not be analyzed in a meaningful way. Whitefly populations were very low on 22 Oct. but had almost doubled on untreated plants by 12 Nov. All treatments except *Bacillus thuringiensis* (which is only effective against lepidopterous pests) were effective for reducing both adult and immature whitefly populations. The low rate of bifenthrin was much more effective when used in combination with oil than when used alone (Table 1). Although oil was not effective against aphids, it was highly effective against whiteflies. It is possible that oil may interfere with host acceptance by whiteflies and not by aphids. Oil does reduce the spread of aphid-borne viruses in squash, however (Zitter and Ozaki, 1978).

There were no significant differences in yield among treatments, presumably because there was so little insect damage. Infection of plants with aphid-vectored potyviruses reduced yields in all treatments in both years.

Of the materials tested, only endosulfan is currently recommended for use on squash. Some formulations of *Bacillus thuringiensis* include pickleworm and melonworm on their labels but few data on efficacy are available. In 1991, *Bacillus thuringiensis* was used only in combination with detergent, but, because there are no reports of detergents controlling lepidopterous pests, it seems likely that pickleworm and melonworm control was due solely to *Bacillus thuringiensis*. In 1992, populations of pickleworm and melonworm were so low that the effectiveness of *Bacillus thuringiensis* alone or in combination with oil could not be evaluated. Further work needs to be done.

Although *Bacillus thuringiensis* is not effective against aphids, both it and oil are compatible with parasites and predators of aphids. Even on our untreated plants, aphids did not reach high levels, in part due to natural control. Oil was effective against whiteflies, particularly reducing the number of nymphs on leaves. In addition to reducing the spread of aphid-vectored viruses in other studies (Zitter and Ozaki, 1978), oil also markedly reduced the level of powdery mildew in our trial in 1992. By the end of the season, all plants, except those treated with oil, were covered with this fungus.

Butler et al. (1993) also found that a mineral oil formulation reduced the number of whitefly nymphs on cucumber in Florida. Detergents reduced the number of adult whiteflies as in our study, but not the number of nymphs. In other tests, conducted in a greenhouse, detergents did cause significant mortality of immature whiteflies on zucchini squash (Butler et al., 1993).

Table 1. Effect of pesticides on insect pests of summer squash.

		Immature SPWF[z]		Mean no. insects or damage/plant[y]			
		Eggs	Nymphs	SPWF adults		Aphids	
Treatment	Rate lb (AI)/acre	29 Oct	29 Oct	22 Oct[x]	12 Nov[w]	22 Oct	12 Nov
Mineral oil + *Bacillus thuringiensis*	3 qt/100 gal[v] + 1.00	0.5cd	1.0bc	2.1c	4.7gh	111.8a	116.3a
Mineral oil + bifenthrin	3 qt/100 gal[v]	0.1d	0.1d	0.3f	2.3h	1.8e	0.7f
Bacillus thuringiensis	1.00	1.6a	3.3a	5.2ab	16.6abc	90.0b	117.3a
Bifenthrin	0.06	0.7bc	0.3cd	1.6c	13.6bcd	17.8c	17.9d
Bifenthrin	0.10	0.0d	0.4bcd	0.8def	10.7de	1.2e	3.2f
Bifenthrin, endosulfan[u]	0.08, 1.00	0.4cd	0.8bc	0.7ef	8.1ef	3.4cde	1.1f
Bifenthrin + endosulfan	0.08 + 0.50	0.2cd	0.9bc	0.6ef	10.4cde	2.2de	15.3de
Endosulfan	1.00	0.4cd	0.6bc	0.5ef	6.3fg	5.8cd	2.1ef
Endosulfan + acephate	1.00 + 0.50	0.5cd	0.6bc	1.0cde	7.7ef	5.4cd	2.7ef
Fenpropathrin	0.20	0.8bc	1.0b	1.5cd	21.4a	6.1cd	28.8c
Untreated		1.6a	2.9a	6.1a	15.7ab	100.8ab	127.0a

Column means followed by the same letter are not significantly different (K ratio=100, WD). Square root transformation of data was made before analysis. Untransformed means are presented.

[z]Per 1.5 inch^2, mean of 2 leaves/plant, n=12.

[y]n=20 on 22 Oct, n=15 on 12 Nov.

[x]2 days after treatment.

[w]10 days after treatment except for oil applied alone on 9 Nov.

[v]Concentration of oil, applied at 155 gal/acre.

[u]Applied in alternate weeks, beginning with bifenthrin.

Although most insecticides tested were highly effective against insect pests of squash, long-term sustainable management of pests and preservation of natural enemies requires the identification of less toxic control methods. The use of mineral oil formulations and *Bacillus thuringiensis* appears to be compatible with biological control and should be tested further for use in cucurbit pest management.

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CHEMICAL CONTROL OF THE TWOSPOTTED SPIDER MITE, *TETRANYCHUS URTICAE* KOCH (ACARI:TETRANYCHIDAE), IN STRAWBERRIES

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Additional index words. *miticides, pameras, flower thrips.*

Abstract. **Two experiments were conducted on plots of strawberry (*Fragaria* × *ananassa* Duch. cv. Sweet Charlie) in Dover, Florida, to compare new and long-used pesticides as control agents of the twospotted spider mite (*Tetranychus urticae* Koch). A single application of bifenthrin and the combination of hexakis with pyrethrum plus rotenone and other cube resins resulted in reductions in spider mite densities. Abamectin and propargite resulted in reductions after 2 or 3 weekly applications. Hexakis alone reduced spider mite densities after 2 weekly applications, but did not do so after 3 applications. Dicofol, alanycarb, and methomyl were ineffective in reducing spider mites, but alanycarb and methomyl greatly reduced pameras (*Pachybrachius bilobatus* (Say)) and flower thrips (*Frankliniella bispinosa* Morgan).**

Florida strawberries were produced on 1903 ha that yielded fruit valued at $94.7 million during the 1991-92 crop season (Fla. Agric. Statistics Service, 1993). The twospotted spider mite feeds and lives on leaves and is the major arthropod concern on all strawberries produced in Florida (Howard et al., 1985). Reductions in fruit yield may occur from the mite's morphological or physiological effects on leaves and thus mite populations may require management (Oatman et al., 1981; Sances et al., 1979a, 1979b; Sances et al., 1981).

The new insecticides and miticides, abamectin, bifenthrin and alanycarb, were compared to the long-used compounds, propargite, hexakis, dicofol, methomyl, and pyrethrum with rotenone and other cube (pronounced "koo-bay," *Lonchocarpus* spp.) resins for their effects on the twospotted spider mite in strawberries. In addition, observations were recorded on effects of alanycarb and methomyl on the incidental species, pameras and flower thrips. Results of those investigations are reported herein.

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Materials and Methods

Two experimental areas were prepared similarly in spring 1993. Rooted 'Sweet Charlie' strawberry plants were set in mid-Oct. 1992 in Dover, Florida, on raised beds of Scranton fine sand (3% organic matter). The soil was adjusted with dolomite to a pH of 6.5, provided 225 N, 32 P, and 187 K kg/ha fertilizer, and fumigated with 98% methyl bromide and 2% chloropicrin at 450 kg/ha. Beds 60 cm wide were spaced on 1.2 m centers and covered with 1.25 mil black polyethylene mulch. Constant daytime overhead irrigation was provided during the first 2 weeks after transplanting. Thereafter, plants were irrigated based on need.

Plots were 2 rows, each with 10 plants spaced at 30 cm intervals. A 2.5 m or greater unplanted buffer separated plots in all directions. All plants were treated with captan (1.7 kg/ha) twice weekly during fruiting; methomyl (Experiment 1 only) was applied at 1.0 kg/ha 5 times at weekly intervals beginning 10 Jan. to reduce biological control agents and enhance spider mite population development.

Experiment 1. Miticidal treatments (Table 1) were applied as mite densities increased in Mar. (Poe, 1972). Sprays were applied at 947 liters/ha (of mulched bed) via a hand-held sprayer, outfitted with a hollow cone nozzle and pressurized by CO_2 to ca. 4.2 kg/cm^2. Designs for experiments were randomized complete blocks with 4 replications.

Four treatments were applied at 7 day intervals beginning on 11 Mar. after mite population densities had begun to increase. Ten terminal leaflets were sampled periodi-