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MANAGEMENT OF MELON APHID ON MUSKMELON AND WATERMELON WITH INSECTICIDES SPECIFIC FOR HOMOPTERA

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Abstract. **Insecticides that control specific groups of insects are often less harmful to beneficial insects than broad spectrum chemicals. In two spring growing seasons, several Homoptera-specific insecticides were evaluated for control of melon aphid (*Aphis gossypii* Glover) on watermelon, *Citrullus lanatus* (Thunb.) Matsum & Nakai and muskmelon, *Cucumis melo* var. *reticulatus* L. In 1995, pymetrozine, an experimental material, was highly effective for control of aphids on watermelon. In 1996, aphid populations reached an average of 400 aphids per leaf by the second week of sampling and caused severe damage to untreated muskmelon plants, while fewer than five aphids per leaf were found on those treated with endosulfan (a broad spectrum standard), pymetrozine, or imidacloprid. Pirimicarb-treated plants had an average of 200 aphids per leaf. Another new systemic aphicide, RH-7988, was significantly more effective than pirimicarb but not as effective as other insecticides. Predators and parasites reduced populations in the check plots by the fourth week of sampling, but plants did not recover from the early damage. Most of the materials tested have potential for use in integrated pest management programs for cucurbits.**

Aphis gossypii Glover, commonly known as cotton aphid or melon aphid, was reported causing damage to watermelon and cucumber vines in Sarasota and Bonifay, Florida as early as 1888 (Goff and Tissot, 1932). It can cause serious damage to watermelon (Johnson and Webb, 1992) early in the growing season when plants are small and natural enemies of the aphid are not abundant. Leaves colonized by aphids become curled and distorted.

Aphid resistance to several classes of insecticides has been reported in the South (Alabama, Texas, Mississippi) on cotton (Kerns and Gaylor, 1992; O'Brien et al., 1992). Reduced use of broad spectrum insecticides and judicial use of insecticides that are more specific to aphids and less harmful to beneficial insects could be the basis of an IPM program that would preserve natural enemies and slow the development of insecticide resistance.

Recently, new compounds have been developed that are specific to homopterous insects such as aphids and whiteflies. The objective of this study was to evaluate these new chemicals for use in a pest management program for cucurbits.

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Materials and Methods

1995 trial. In 1995, watermelon ('Minilee') was direct-seeded into raised beds of Alachua fine sand on 30 Mar. at the Central Florida Research and Education Center in Leesburg. A randomized complete block design with four replications was used. Each plot consisted of four 35-ft rows, 7 ft apart. Plants were spaced 2.5 ft apart in the row. Plots were separated by 15 ft of bare soil. Water was supplied as needed, by overhead irrigation, to supplement rainfall. Plots were irrigated, if needed, two to three days before insecticides were applied. Fertilization and other cultural practices were done according to University of Florida guidelines for growing watermelon. Fungicides were applied weekly for control of fungal diseases, usually two days after insecticide treatments. Mancozeb (1.5 lb [a.i.]/acre) was applied on 12 May and chlorothalonil (1.5 lb [a.i.]/acre) on 19 and 26 May, and 2, 9, and 16 June.

Treatments included: low (0.04 lb [a.i.]/acre) and high rates (0.09 lb [a.i.]/acre) of pymetrozine (CGA-215944 50 WP, Ciba, Greensboro, NC), a new chemical not yet labeled for aphid control, endosulfan (Thiodan 3 EC, FMC Corp., Philadelphia, PA) at 1.0 lb [a.i.]/acre, and an untreated check. All materials were applied with a two-row tractor-mounted boom sprayer with 18 Albuz (lilac) ceramic hollow cone nozzles, spaced 8 inches apart, delivering 133 gal/acre at 200 psi. The high rate of pymetrozine was applied once on 24 May, the only time a threshold of five aphids per leaf was exceeded. The low rate was applied on 24 May and 7 June. Endosulfan was applied on 1, 7, 13, and 20 June.

Twenty leaves were collected per plot each week for five weeks, beginning on 29 May and ending on 26 June. Aphids were counted on the entire leaf in the laboratory. Preliminary samples indicated that aphids were fairly evenly dispersed along the length of the runners. Samples were taken five days after treatment, and aphids were counted immediately so that the information could be used to make a decision to spray or not two days later.

1996 trial. In 1996, the same experimental design was used but muskmelon ('Athena') was planted instead of watermelon. Muskmelon was direct-seeded on 29 Mar. Plot dimensions were identical to the previous year's except that rows were 6 ft apart. Fertilization and other cultural practices (including irrigation) were performed according to University of Florida guidelines for growing muskmelon. Fungicides were applied weekly. Mancozeb (1.5 lb [a.i.]/acre) was applied on 24 May and 21 June, and chlorothalonil (1.5 lb [a.i.]/acre) on 31 May, and 14, and 21 June. *Bacillus thuringiensis* var. *kurstaki* (Dipel 2X, Abbott Laboratories, North Chicago, IL) was applied to plants in all plots on 24 May for control of pickleworm, *Diaphania nitidalis* (Stoll).

Treatments included pymetrozine at 0.04 lb [a.i.]/acre, with and without an organosilicant wetting and spreading agent (Kinetic, Helena Chemical, Memphis, TN), pymetrozine at 0.07 lb [a.i.]/acre, endosulfan at 1.0 lb [a.i.]/acre, imidacloprid (Provado 1.6 F, Bayer Corp., Kansas City, MO) at 0.04 lb [a.i.]/acre plus Kinetic; pirimicarb (Pirimor 50 WP, ZENECA Ag Products, Wilmington, DE) at 0.25 lb [a.i.]/acre; RH 7988 50 WP (Rohm and Haas Co., Philadel-

Table 1. Number of aphids per watermelon leaf (n=80), 1995.

Treatment	Rate: lb [a.i.]/acre	Sample date 29 May	5 June	12 June	19 June	26 June
Pymetrozine	0.04	1.4±0.2 c[z]	2.2±0.4 c	0.8±0.3 b	1.6±0.8 a	3.0±1.1 a
Pymetrozine	0.09	4.1±1.0 b	14.0±5.0 b	0.1±0.1 c	0.1±0.1 bc	0.3±0.2 bc
Check	NA	104.2±9.5 a	109.1±16.3 a	3.4±1.4 a	0.7±0.3 b	0.6±0.2 b
Endosulfan	1.00	NA	0.2±0.1 c	0.1±0.1 c	0.0±0.0 c	0.0±0.0 c

[z]Mean separation in columns by Waller-Duncan k-ratio t-test, k = 100 (ca. 5% level).

phia, PA) at 0.18 lb [a.i.]/acre plus Kinetic, and an untreated check. All materials were applied as in 1995. Kinetic was used at a concentration of 0.094% v:v (12 oz/100 gal.). Treatments were applied on 9, 16, and 30 May. It was recommended for some chemicals that two treatments be made a week apart, with longer intervals afterward, so all were applied this way. The aphid population declined dramatically after the end of May so no further applications were made.

To ensure that there were sufficient aphids for the test, each plant in each plot was infested with melon aphids from a laboratory colony (started from aphids collected from the field the previous year). This was done twice, on 26 April and on 3 May. By the date of the first insecticide application, almost all plants had some aphids.

Twenty leaves per plot were collected each week for five weeks, beginning on 15 May and ending on 12 June. Aphids and aphid mummies were counted on the entire leaf in the laboratory. Leaves with extremely high numbers of aphids were shaken in alcohol and aphids counted over a grid. Samples were collected at least five days after treatment. Abundance of predators and parasites was assessed by examining 10 leaves per plot and scoring the leaf for the presence or absence of natural enemies.

Three of the treatments and the check were harvested, beginning on 14 June and continuing until 3 July. Melons were counted and weighed.

Data analysis. In both years, a square root transformation was used to stabilize variance of aphid counts for analysis. An arsine square root transformation was used for proportions (percent parasitism and percent of leaves with predators). Parasitism was analyzed by plot rather than individual leaves. An analysis of variance and a mean separation test (Waller-Duncan k-ratio t-test) were used to determine significant differences among treatments. Analysis of yield data was done with total number of melons per plot and total weight per plot for both dates combined. SAS for Windows, version 6.08 (1989, SAS Institute, Cary, NC) was used for all analyses. All tables were constructed with non-transformed data.

Results and Discussion

1995. Aphid populations were moderately high when spraying began (Table 1). A natural population had developed on nearby muskmelon planted several weeks earlier. The first application of pymetrozine dramatically reduced the number of aphids per leaf, with the high rate of aphicide initially giving significantly better control. Populations remained high on plants in the untreated check on 5 June, and the threshold was exceeded for the low rate of pymetrozine. Between 5 and 12 June, the aphid population declined rapidly. I believe that this was mainly due to parasitism, but lady beetles and other predators were also abundant. Aphid counts on all treated plants were significantly lower than on untreated plants on 12 June. The additional application of the low rate of pymetrozine reduced the number of aphids to the same level as that in the endosulfan-treated plots. Aphid populations on leaves treated once with the high rate of pymetrozine were slightly higher, but still well below the threshold. On the last two dates, the number of aphids on untreated leaves decreased even further, so that populations on pymetrozine-treated leaves were not significantly lower. The high rate of pymetrozine, which had only been applied once, was still giving excellent control one month later. Fewer aphids, however, were found on leaves treated with the low rate, which had been applied on 24 May and 7 June.

Both rates of pymetrozine gave excellent control of melon aphid with long residual effects. The timing of the second application of the low rate coincided with the collapse of the

Table 2. Effect of insecticides on melon aphid on muskmelon.

Treatment	Rate: lb [a.i.]/acre	15 May Aphids[x] n=80	15 May Mummies n=80	23 May Aphids n=80	23 May Mummies n=80	29 May Aphids n=80	29 May Mummies n=80	5 June Aphids n=80	5 June Mummies n=80	12 June Aphids n=80	12 June Mummies n=80
Endosulfan	1.0	1.8 c[z]	0.1 c	1.8 d	0.0 c	4.1 d	0.0 c	0.1 d	0.0 d	0.9 d	0.0 c
Imidacloprid + Kinetic[y]	0.04	0.8 d	0.0 c	4.1 d	0.0 c	6.7 cd	0.0 c	0.9 c	0.0 d	3.1 c	0.0 c
Pirimicarb	0.25	151.3 a	1.7 a	211.6 b	2.2 b	25.4 b	2.5 c	4.9 a	2.5 b	10.1 a	1.3 b
Pymetrozine	0.04	2.1 d	0.1 c	4.3 d	0.0 c	8.4 c	0.0 c	0.7 c	0.0 d	1.4 cd	0.0 c
Pymetrozine + Kinetic	0.04	0.4 d	0.1 c	1.9 d	0.0 c	6.7 c	0.0 c	0.9 c	0.0 d	2.2 cd	0.0 c
Pymetrozine	0.07	1.4 d	0.0 c	1.5 d	0.0 c	4.1 d	0.0 c	1.1 c	0.0 d	2.3 cd	0.0 c
RH-7988 + Kinetic	0.18	33.3 c	0.2 c	64.4 c	1.9 b	28.9 b	2.7 b	1.9 b	0.9 c	7.4 b	1.1 b
Untreated	NA	96.5 b	0.7 b	398.5 a	9.3 a	59.7 a	7.7 a	3.1 a	4.7 a	9.5 a	4.6 a

[z]Mean separation in columns by Waller-Duncan k-ratio t-test, k = 100 (ca. 5% level).
[y]Organosilicant wetting and spreading agent, 0.094% v:v.
[x]Number of aphids per leaf.

Table 3. Percentage of muskmelon leaves with natural enemies (n=40), 1996.

Treatment	Rate: lb [a.i.]/acre	22 May	6 June
Endosulfan	1.00	12.5 c[z]	2.5 c[z]
Imidacloprid + Kinetic[y]	0.04	17.5 c	17.5 c
Pirimicarb	0.25	82.5 a	67.5 b
Pymetrozine	0.04	2.5 c	22.5 c
Pymetrozine + Kinetic	0.04	7.5 c	15 c
Pymetrozine	0.07	15 c	2.5 c
RH-7988 + Kinetic	0.18	60 b	57.5 b
Untreated	NA	85 a	92.5 a

[z]Mean separation in columns by Waller-Duncan k-ratio t-test, k = 100 (ca. 5% level).
[y]Organosilicant wetting and spreading agent, 0.094% v:v.

population and this may be part of the reason that the number of aphids in this treatment remained so low during the rest of the trial. The proximity of aphid-infested muskmelon that had been planted earlier than the watermelon may have provided a good source of parasites and predators as well as aphids.

1996. In 1996, there were pronounced differences among treatments on all dates (P=0.0001). In general, the pymetrozine treatments, imidacloprid, and endosulfan were most effective, followed by RH-7988 and pirimicarb (Table 2). The number of aphids on pirimicarb-treated plants was higher than on the untreated plants on the first sample date. On the last two dates, there was no difference between pirimicarb-treated plants and the untreated check plants. RH-7988 was generally more effective than pirimicarb but not as effective as the other treatments. Except on 29 May, which was two weeks after treatment, there were no differences among the pymetrozine treatments. On 29 May, plants treated with the higher rate of pymetrozine had fewer aphids, suggesting greater persistence of the chemical. Endosulfan was slightly more effective than pymetrozine on 5 June, and more effective than the lower rate on 29 May. Kinetic had no significant effect on the efficacy of pymetrozine on this crop although the activity of parasitic wasps appeared to be slightly reduced (Table 3).

The number of mummies (aphids parasitized by wasps swell and turn a bronze color as the parasite develops and pupates [Goff and Tissot, 1932]) (Table 2) and the percentage of leaves with natural enemies (parasitic Hymenoptera, syrphids, chrysopids, coccinellids) (Table 3) appeared to be roughly correlated with the number of aphids present. On 22 May, leaves from the untreated plants and plants treated with pirimicarb were significantly more likely to have predators and parasites present than those from other treatments. In all other treatments, except RH-7988, natural enemies of aphids were present on fewer than 20% of the leaves examined. Predators and parasites of aphids were present on 60% of leaves from plants treated with RH-7988. There were only slight differences on 6 June, with parasites and predators found most often on leaves from untreated plants. The percentage of aphids that were parasitized (Table 4) on the first sample date was relatively high in some of the plots treated with highly effective insecticides, but this probably reflects persistence of mummies that were present before the spray application. On other dates, in general, higher levels of parasitism were found on untreated plants or on plants treated with chemicals that were not effective for aphid control, i. e., pirimicarb and RH-7988. The dramatic decline in the aphid population on the untreated plants by 5 June attests to the effectiveness of natural enemies. However, much damage had already occurred and plants did not recover fully. Yield (Table 5) was significantly reduced without aphicides. No differences in yield were detected among the aphicide treatments.

Most of the highly specific chemicals tested here controlled melon aphid very well. In the past, emphasis has often been on chemicals that would control most or every pest at-

Table 4. Percentage of melon aphids parasitized by date, mean of four plots, (mummies/aphids + mummies), 1996.

Treatment	Rate: lb [a.i.]/acre	15 May	23 May	29 May	5 June	12 June
Endosulfan	1.00	11.4 a[z]	0.0 c	0.0 b	0.0 c	0.9 c
Imidacloprid + Kinetic[y]	0.04	1.7 a	0.5 bc	0.0 b	1.1 c	0.2 c
Pirimicarb	0.25	1.1 a	0.6 b	11.0 a	32.2 b	11.9 ab
Pymetrozine	0.04	6.1 a	0.0 c	0.2 b	3.4 c	3.6 bc
Pymetrozine + Kinetic	0.04	28.6 a	0.0 c	0.0 b	0.0 c	0.2 c
Pymetrozine	0.07	0.0 a	0.0 c	0.0 b	0.0 c	0.3 c
RH-7988 + Kinetic	0.18	0.4 a	3.0 a	8.2 a	32.4 ab	16.7 a
Untreated	NA	0.8 a	2.2 a	10.6 a	50.0 a	29.3 a

[z]Mean separation in columns by Waller-Duncan k-ratio t-test, k = 100 (ca. 5% level).
[y]Organosilicant wetting and spreading agent, 0.094% v:v.

Table 5. Effect of aphid control on yield of muskmelon.

Treatment	Rate: lb [a.i.]/acre	Total weight (lb/plot)	Total no. of melons/plot	Weight (lb/melon)
Endosulfan 3EC	1.00	636.25 a[z]	112.25 a	5.67
Pymetrozine 50 WP + Kinetic[y]	0.04	714.25 a	127.25 a	5.61
RH-7988 50 WP + Kinetic	0.18	568.50 a	109.50 a	5.19
Untreated	NA	403.50 b	80.25 b	5.03

[z]Numbers within columns followed by the same letter are not significantly different, Waller-Duncan k-ratio t-test, k = 100 (ca. 5% level).
[y]Organosilicant wetting and spreading agent, 0.094% v:v.

tacking a particular crop. Now, with the increased emphasis on IPM, sustainable agriculture, environmental safety, and management of resistance, highly specific chemicals that affect only the target pest and are not harmful to other insects and animals in the environment are finding a place in vegetable production. By preserving beneficial insects, other pests not affected by the specific chemical may be kept at manageable levels by their natural enemies.

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EXPERIENCE WITH EMAMECTIN BENZOATE FOR CONTROL OF LEPIDOPTERA PEST SPECIES IN FLORIDA VEGETABLE PRODUCTION

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Abstract. **Extensive testing with emamectin benzoate in Florida has demonstrated its excellent effectiveness for controlling Lepidoptera pest species on vegetable crops. Testing in Florida began in 1988 and has continued in each successive year. Beginning in 1995, the performance of emamectin benzoate has been evaluated in commercial cabbage, head lettuce, and celery fields in Florida and other states under an Environmental Protection Agency (EPA) approved experimental use permit (EUP). Results of research and EUP trials demonstrate control of all major economically important Lepidoptera species in commercial vegetable production. Results from recent trials conducted in Florida and best-use guidelines for emamectin benzoate are presented.**

Emamectin benzoate is a novel semi-synthetic insecticide that is derived from a natural fermentation product, avermectin B_1 (Dybas and Babu, 1988). Laboratory bioassays have demonstrated that it is highly toxic to a broad range of Lepidoptera pest species at very low concentrations (Dybas et al., 1988). The primary route of intoxication in Lepidoptera larvae is through ingestion; however, there is some contact activity.

The avermectins act by disrupting nerve impulses by a unique mode of action (Turner and Schaeffer, 1989). No cross-resistance between emamectin benzoate and any registered insecticide has been documented. Larvae characteristically stop feeding shortly after ingestion of emamectin benzoate and become irreversibly paralyzed. Maximum mortality usually occurs within four days after ingestion.

Emamectin benzoate penetrates the cuticle of plants through translaminar movement, which provides long residual activity against phytophagous insects. Residues that remain on plant surfaces rapidly photodegrade, which minimizes exposure to beneficial arthropods. The characteristics of long residual activity against phytophagous Lepidoptera species and short residual activity against predatory and parasitic species are compatible with integrated pest management programs (Jansson and Dybas, in press).

A 0.16 EC (1.9% emulsifiable concentrate) and a 5 SG (5% soluble granule) formulation of emamectin benzoate have been developed. Target crop groupings include: leafy vegetables (lettuce and celery); cole crops (cabbage, broccoli, cauliflower, and brussels sprouts); and fruiting vegetables (tomato and pepper). The field use rates will be from 0.0075 to 0.015 lb ai/acre.

In May 1995, the U.S. Environmental Protection Agency (EPA) granted an Experimental Use Permit (EUP) for emamectin benzoate. In May 1996, a section 18 emergency exemption to permit usage of emamectin benzoate (tradename: PROCLAIM® 5 SG) in Hawaii for control of diamondback moth larvae on cabbage was approved by the U.S. EPA.

Field research trials with emamectin benzoate have been conducted on cole crops and leafy vegetables throughout Florida since 1988 and on fruiting vegetables since 1989. Field trials have been conducted with both the 0.16 EC and 5 SG formulations, with full-season usage of emamectin benzoate, and with rotation with other insecticides. Application in field trials was by ground application equipment and by aircraft. Results from three of the most recent field trials conducted on cole crops, leafy vegetables, and fruiting vegetables are presented.

Materials and Methods

The efficacy of emamectin benzoate 0.16 EC (0.0075 lb ai/acre) applied weekly for the entire season (six applications) and every other week in rotation with *Bacillus thuringiensis* subsp. *aziawi* (Xentari®) (1.0 lb formulated product/