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Effect of Pesticides on Pests Affecting Tropical Fruit

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Selected pesticides were evaluated for control of the spider mites (*Tetranychus* spp.,) infesting bananas, sri-lankan weevil (*Myllocerus undecimpustulatus*) infesting mangoes, armored scales (*Andaspis punicae* and *Chrysomphalus dyctiospermi*) infesting mangoes, and Persea mite (*Oligonychus perseae*) infesting avocados. *A. punicae* has an armor usually covered with the outer layers of the bark and regularly is located near lenticels. *C. dyctiospermi* is an economic pest in Florida to fruit and ornamentals. *Myllocerus undecimpustulatus* is a weevil introduced into the USA during 2000, and it has since spread to different counties in the state, causing damage to fruit crops and ornamentals. The Persea mite, *Oligonychus perseae*, is native to Mexico. It was discovered in Miami–Dade County during June 2007. Spider mites, *Tetranychus* spp., cause damage to the foliage of bananas. All trials were conducted at the Tropical Research and Education Center. We discuss the effectiveness and shortcomings of the tested products.

Most of the tropical fruit crops grown in Florida (litchi, longan, avocados, bananas, mangoes, etc.) have a set of resident and native pests for which integrated pest management programs have been developed. During the last 10 years, a constant influx of invasive pests has changed management inputs into these crops. Therefore, it is necessary to determine which pesticides will be effective to combat the new pests as well as to integrate their control with the current management tactics. For instance, *Tetranychus* spp. (Acari: Tetranychidae) are considered a minor pest of bananas, but can erupt into epidemics, causing damage to leaves. Mite outbreaks are usually due to insecticide-induced disruption and some mite epidemics have been triggered by road dust inhibiting the action of predators (Ostmark, 1974). *Tetranychus urticae* Koch is a considered by Pinese and Piper (1994) as a common pest of bananas. The Sri-lankan weevil, *Myllocerus undatus* (*undecimpustulatus*) (Coleoptera: Curculionidae) invaded south Florida during 2001 (Anonymous, 2001). The adult weevil feeds voraciously in the new foliage of many plant species, including litchi (*Litchi chinensis*), longan (*Euphoria longan*), mamey (*Pouteria sapota*), citrus (*Citrus* spp.), mango (*Mangifera indica*), Surinam Cherry (*Eugenia* spp.), and several ornamental palms (O'Brien et al., 2006; Liu et al., 2006). It is currently reported in several counties (Broward, Charlotte, Collier, Hendry, Lee, Miami-Dade, Orange, Palm Beach, Polk, and Sarasota) (O'Brien et al., 2006). Chemical control of this pest on corn, soybean and cotton with pesticides, such as Malathion, DDT, carbaryl, neem oil, is reported from India (Agarwal, 1990; Singh and Marwaha, 2000; Singh and Singh, 1992).

The exotic scale *Andaspis punicae* (Homoptera: Diaspididae) was detected in 1993 in Florida invading litchi groves, causing dieback of branches and reducing tree vigor, and eventually killing trees. During 2004, it was detected in Puerto Rico affecting litchis. The scale has also been associated with symptoms known as "corky bark" in Florida. It is also reported affecting *Euphoria longan*, *Mangifera indica, Annona cherimola* x *A. squamosa* and rambutan (*Nephelium lappaceum*) (Peña et al., 2005).

The persea mite (*Oligonychus perseae*) (Acari: Tetranychidae) is a pest of avocados in Mexico and damages avocados in arid regions. It is also found in California, Costa Rica, and Israel. (Hoddle, 1998), and was discovered infesting avocados in Miami–Dade around June 2007 (Peña, personal observation). Persea mites feed in colonies beneath protective webbing (i.e., nests) along midribs and veins on the undersides of leaves, and feeding damage produces characteristic circular necrotic spots (Hoddle, 1998). We report here the results from several pesticide efficacy tests against these pests.

Materials and Methods

***Tetranychus*.** Selected pesticides were evaluated for control of the spider mites infesting bananas at the Tropical Research and Education Center, Homestead, FL. Individual experimental units consisted of seven banana plants per treatment, planted in 2-gal pots. The plants were fertilized once with Osmocote (14–14–14) and irrigated every other day, applying water to the soil. By the time we conducted the trial, the plants were 2 ft tall. Mites were brought from banana fields, inspected under the microscope, and mobile predators were removed from the leaves. One 1-inch leaf section infested with mites was placed on top of the banana plants on each experimental plant. Because of unwanted infestation with phytoseiid predators, all plants were applied with 1 mL of Ambush per gallon to kill the predators. Ten days after verifying that the predators were reduced, a pre-treatment count was taken on 17 Apr. 2007. One leaf was collected from each plant per treatment and three 2.9-cm-diameter circles were excised per leaf. Mite densities per leaf area were determined under the microscope, followed by a single application of the pesticides on 23 Apr. 2007. Spray treatments (Table 1) were applied using hand sprayers at approximately 25 psi at an application rate of 100 gal/acre. Each treatment was replicated seven times with each replicate being an individual plant and three sub-replicates per

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Table 1. Effect of acaricides against spider mites infesting bananas.

Treatment	Dose per acre	Before spraying	7 DAS[z]	14 DAS
Acramite 50WS	16 oz	60.14	0.71 b[y]	6.10 ab
BG Oil	2 gal	69.24	7.05 ab	10.24 ab
Cinnacure	0.25 gal	34.29	4.57 ab	3.05 ab
Cinnacure (2x)	0.5 gal	77.71	6.52 ab	4.57 ab
Envidor 16 oz	16 oz	55.14	2.29 b	1.10 b
Envidor 20 oz	20 oz	55.00	1.48 b	2.14 b
Fujimite	2 pints	61.14	5.24 ab	12.33 a
Kanemite	31 oz	78.29	1.43 b	5.05 ab
Novaluron 0.83EC	12 oz	70.81	3.62 ab	5.29 ab
Untreated control	---	63.10	10.43 a	4.19 ab
P <		0.8703	0.0127	0.0134

[z]DAS = days after spray.
[y]Numbers within a column followed by the same letter were not statistically significant. Newman–Keuls test (α = 0.05).

plant. Treatments were evaluated 7 (1 May), 14 (8 May), 22 (15 May) d after application of the products. Because we observed a high number of predators infesting the plants during 15 May, data are only reported before spray and 7 and 14 d after spray. Data were analyzed by GLM and means separated by Student–Newman–Keuls test.

***Myllocerus undecimpustulatus*—Experiment 1.** The trial was conducted at the Tropical Research and Education Center, Homestead. Two treatments (Table 3) were replicated four times in a randomized complete-block design. Each replicate consisted of three mango trees. Treatments were applied with a hand-gun sprayer operating at 350 psi and delivering 100 gpa of finished spray (~1 gal/tree). Another set of trees were sprayed with water as a control treatment. Four hours after treatment, twenty 5-cm-long branches with new leaf flush from the treated (n = 22/treatment) and the nontreated plants were placed in petri dishes (13-cm diameter) lined with filter paper and then exposed to approximately 1–3 adults of *Myllocerus* (field collected). Weevil survival was inspected 1, 2, and 3 d after. Data were analyzed by GLM procedure and means separated by Newman–Keuls test (α = 0.05).

***Myllocerus undecimpustulatus*—Experiment 2.** Experimental treatments were applied to mango tree plots in a randomized block design consisting of five single-tree replicates per each × 20 ft and were 6 years old. Plot boundaries were separated by at least two tree rows. An untreated plot was included in the experiment for comparison. All treatments were applied with a handgun sprayer at 400 psi. The spray was directed to the foliage. Weevils were collected from infested mango trees located in Cutler Ridge, Miami. Mango treated and untreated leaves were collected 1, 3, and 7 d after spray and placed in individual petri dishes (8.5-cm diameter) lined with filter paper. Two randomly selected adults were introduced into each plastic petri dish (n = 20) labeled for the respective treatments. The weevils exposed to the different treatments were observed daily for mortality. Dead insects were held for several days to confirm the fungal activity indicated by an expression of mycelia from the joints of dead insects. Analysis of data was performed on arcsine transformation of the percent mortality or percent adults with mycelial growth. Data were analyzed using ANOVA with mean separation by DMRT. The trees were sprayed for a second time and leaves from treated and untreated trees collected 7, 10, and 14 d after. Weevil treatment and mortality evaluation, done as explained before.

Table 2. Effect of acaricides on phytoseiid predators on banana plants infested with spider mites.

Treatment	Before spray	7 DAS[z]	14 DAS
Acramite 50WS	0.619	0.71 ab[y]	0.38 c
BG Oil	0.048	0.86 ab	0.76 bc
Cinnacure	0.619	1.47 ab	1.91 b
Cinnacure (2x)	0.381	1.81 a	3.38 a
Envidor 16 oz	0.286	0.33 ab	0.14 c
Envidor 20 oz	1.286	0.14 ab	0.33 c
Fujimite	0.476	0.00 b	0.00 c
Kanemite	0.191	0.52 ab	0.29 c
Novaluron 0.83EC	0.143	1.24 ab	1.00 bc
Untreated control	0.524	1.38 ab	2.95 a
P <	0.2263	0.0255	0.0001

[z]DAS = days after spray.
[y]Numbers within a column followed by the same letter were not statistically significant. Newman–Keuls test (α = 0.05).

***Andaspis punicae* and *C. dyctiospermi*.** Two armored scales were found infesting an 8-year-old mango orchard at the University of Florida Tropical Research Center, Homestead. *Andaspis punicae* has an armor usually covered with the outer layers of the bark and regularly located near lenticels. *C. dyctiospermi* is an economic pest in Florida to fruit and ornamental industries. A section of this orchard was used for this study. Plots consisted of four groups of six trees, cv. Kent, with three plants serving as sample trees. Trees were infested with both scale species, causing necrosis of lateral buds and contributing to tree decline. Treatments (Table 7) consisted of one application of Knack, Applaud 1x and 2x with 1% citrus oil, Novaluron 0.83 EC, Admire, and a nonsprayed control. All applications of the test materials were made with a handgun sprayer with the exception of Admire. Admire was applied as a drench to the soil in a circular fashion around the canopy drip line. The sprayer was calibrated to deliver 100 gpa at 2.2 mph. Because of the "clustering" habits of the scales, and erratic crawler densities, populations (adults and crawlers) were monitored 1 d before the treatment and monitored 24, 31, 39, 52, and 59 d after treatment by collecting two branches per tree. Each branch was subdivided into 5-cm segments and the numbers of live scales and crawlers within the segment were counted under a microscope by lifting the armor of each scale. Data were subjected to two-way analysis of variance and means separated by LSD (P =0.05).

***Oligonychus perseae*.** Selected pesticides were evaluated for control of the persea mite, *O. perseae,* at the Tropical Research and Education Center, Homestead, FL, between Nov. 2007 and Jan. 2008. Individual experimental units consisted of six cv. Catalina avocado trees, planted in 5-gal pots. The plants were fertilized once with Osmocote (14–14–14) and irrigated every

Table 3. Effect of pesticides on survival of *Myllocerus undecimpustulatus* adults (4).

Treatment	Dose/acre	Weevils surviving 1 DAT[z]	3 DAT	5 DAT
Sevin 80 S	1 lb	1.55 a[y]	1.05 b	0.50 c
Imidan 70 SWB	1 lb	1.66 a	1.33 ab	0.91 b
Untreated	---	1.31 a	1.50 a	1.47 a

[z]DAT = Days after treatment.
[y]Numbers within a column followed by the same letter were not statistically significant (Newman–Keuls test; α = 0.05).

Table 4. Mean number of dead *Myllocerus undecimpustulatus* adults per petri dish 7 d after first spray (5).

Treatment	Dose/acre	*Myllocerus* adults dead (no.)		
		1DAT[z]	3DAT	7DAT
Fury	0.031 gal	0.05 b[y]	0.20 b	1.15 b
Imidan	2 lb	0.42 a	1.57 a	2.00 a
Untreated	---	0.05 b	0.10 b	0.45 c
B. bassiana	6.75×10^5 spores	0.00 b	0.00 b	0.33 c

[z]DAT = days after treatment.
[y]Means in a column followed by a different letter were significantly different (DMRT; $P = 0.05$)

Table 5. *Myllocerus undecimpustulatus* weevil mortality recorded 7 to 14 d after second spray (6).

Treatment	*Myllocerus* adults dead (no.)		
	7 DAT[z]	10 DAT	14 DAT
Fury	0.00 b	0.05 bc	0.50 c
Imidan	0.65 a	1.30 a	1.90 a
Untreated	0.00 b	0.25 b	1.25 b
Beauveria bassiana	0.00 b	0.00 c	0.30 c

[z]DAT = days after treatment.
[y]Means in a column followed by a different letter were significantly different (DMRT; $P = 0.05$)

other day, applying water to the soil. By the time we conducted the trial, the plants were 3 ft tall. Mites were brought from a commercial avocado grove and infested leaves placed on top of the canopy of the experimental trees. Six individual trees were allocated per treatment. One day before treatment, two leaves were collected per tree and placed individually in a plastic bag, numbered, and brought to the laboratory where mite density was counted on 2- to 3-inch-diameter circles per leaf, for a total of four subreplicates collected per tree, during each evaluation day (n = 24 reps/treatment). A pre-treatment count was taken on 27 Nov., followed by a single application of the pesticides on 29 Nov. 2007. Spray treatments (Table 9) were applied using hand sprayers at approximately 25 psi at an application rate of 100 gal/acre. Treatments were evaluated 7 (6 Dec.), 14 (13 Dec.), 21 (20 Dec. 2007), 35 (3 Jan. 2008) and 42 (10 Jan. 2008) d after application of the products. The data were expressed as mites per area, analyzed using PROC GLM, and means separated by using Student–Newman–Keuls test.

Results

Banana

Tetranychus. The acaricides Acramite, Envidor and Kanemite reduced the egg stage and mobile mite stages at 7 d after treatment. Fourteen days after spray, the two doses of Envidor significantly reduced egg and mobile stages of mites compared to the untreated control (Tables 1 and 2). Seven and 14 days after acaricide application, the number of predators per leaf were similar to the untreated control when the acaricide Cinnacure was applied (Table 3). This experiment will be repeated in Aug. 2007 using the same acaricides that provided the best control during the experiment reported here.

***Myllocerus undecimpustulatus*—First trial.** The treatments Sevin and Imidan had similar number of weevils surviving than the untreated control during the first 3 d following treatment (Table 4). Weevil survival was significantly lower for both treatments compared to the control 5 d after application of the pesticides. Weevil mortality was significant for both chemical products 3 to 5 d after treatment. Despite of these results, it was considered that a higher dose of both products should be tested in the near future against this weevil.

***Myllocerus undecimpustulatus*—Second trial.** Imidan 70 W provided higher mortality than Fury 1.5 EC or *Beauveria bassiana*. Imidan and Fury provided significantly better mortality than the untreated control 7 d after spray (Tables 5 and 6).

Mango

Andaspis and C. dytiospermi. A significant difference was observed between Knack (5 oz/acre) treatment and the unsprayed control 24 d after treatment. However, 31 d after treatment, Knack, Applaud 1x and 2x, and Novaluron had significantly fewer live

Table 6. Number of live scales per 5 cm of branch before and after treatment with insecticides.

Treatment	Dose/acre	1 DBS[z]	24 DAS[z]	31 DAS	39 DAS	52 DAS	59 DAS
Untreated		0.48 a[y]	0.29 b	50.67 a	7.04 a	6.52 a	16.71 a
Knack+ citrus oil	5 oz + 1 gal	1.29 a	2.76 a	0.29 b	0.38 b	0.62 b	0.67 b
Applaud 1x + citrus oil	1.14 oz + 1 gal	1.10 a	1.05 ab	0.71 b	0.57 b	1.10 b	0.95 b
Applaud 2x + citrus oil	2.28 oz + 1 gal	1.81 a	0.57 ab	0.24 b	0.71 b	0.86 b	0.71 b
Admire	16 oz	2.00 a	0.71 ab	36.90 a	0.57 b	0.29 b	0.62 b
Novaluron	14 oz	0.81 a	0.76 ab	12.05 b	0.19 b	0.48 b	1.10 b

[z]DBS = days before spray; DAS = days after spray. 1 Day before spray: 21 July 2003; 24 DAS = 14 Aug.; 31 DAS = 21 Aug.; 39 DAS = 28 Aug.; 52 DAS = 10 Sept.; 59 DAS = 17 Sept.
[y]Numbers within a column followed by the same letter were not statistically different (LSD = 0.05).

Table 7. Number of crawlers per 5 cm of branch before and after treatment with insecticides (8).

Treatment	1 DBS[z]	24 DAS	31 DAS	39 DAS	52 DAS	59 DAS
Untreated	0.048 a[y]	0.10 a	0.20 a	0.00 a	0.10 a	0.00 a
Knack + citrus oil	0.33 a	0.05 a	0.00 a	0.00 a	0.00 a	0.00 a
Applaud 1x + citrus oil	0.00 a	0.05 a	0.10 a	0.00 a	0.00 a	0.00 a
Applaud 2x + citrus oil	0.20 a	0.00 a	0.10 a	0.00 a	0.05 a	0.00 a
Admire	0.00 a	0.05 a	0.00 a	0.05 a	0.00 a	0.00 a
Novaluron	0.00 a	0.05 a	0.20 a	0.00 a	0.05 a	0.00 a

[z]DBS = days before spray; DAS = days after spray.
[y]Numbers within a column followed by the same letter were not statistically different (LSD = 0.05).

Table 8. Number of persea mites per 28-mm-diameter circle of avocado leaf before and after treatment.

Treatment	Dose/acre	Before spray	7 DAS[z]	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS
Untreated control		10.96 a[y]	39.75 a	52.08 a	71.50 a	63.71 a	36.25 a	22.29 a
Acramite 50 WS	1 lb	11.25 a	14.75 b	18.08 b	21.21 b	36.38 b	30.83 a	15.96 ab
BG oil	2 gal	12.00 a	13.46 b	10.00 b	8.42 b	8.29 c	15.88 ab	9.88 ab
Envidor SC	20 oz	12.42 a	1.54 b	0.33 b	0.79 b	0.38 c	0.79 b	0.04 b
Envidor SC	16 oz	10.21 a	5.58 b	2.58 b	3.88 b	1.71 c	3.88 b	0.58 b
Agrimek 0.15% EC + oil	10 oz + 1 gal	15.04 a	3.42 b	0.88 b	0.17 b	0.25 c	4.08 b	1.25 b
P <		0.9863	0.0001	0.0001	0.0001	0.0001	0.0020	0.0041

[z]DBS = days before spray.
[y]Numbers within a column followed by the same letter were not statistically significant. Newman–Keuls test ($\alpha = 0.05$).

Table 9. Number of persea mite eggs per 28-mm-diameter circle of avocado leaf before and after treatment .

Treatment	Before spray	7 DAS[z]	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS
Untreated control	34.71 a[y]	66.67 a	66.67 a	75.13 a	66.38 a	35.79 a	29.13 a
Acramite 50 WS	38.83 a	14.08 b	27.25 b	25.67 b	52.46 a	32.38 ab	26.67 a
BG oil	34.04 a	21.08 b	15.83 bc	11.75 b	11.42 b	15.83 ab	10.88 a
Envidor SC	36.63 a	1.33 b	0.21 c	0.54 b	0.38 b	1.58 b	0.38 a
Envidor SC	37.92 a	10.33 b	5.25 c	9.96 b	5.00 b	11.00 ab	1.42 a
Agrimek 0.15% EC + oil	39.58 a	2.92 b	0.42 c	0.38 b	0.46 b	6.00 ab	1.67 a
P <	0.9985	0.0001	0.0001	0.0001	0.0001	0.0170	0.0200

[z]DAS = days after spray.
[y]Numbers within a column followed by the same letter were not statistically significant. Newman–Keuls test ($\alpha = 0.05$).

scales per 5 cm than the untreated control (Table 7). Trees drenched with Admire had the highest scale density 31 d after treatment. Between 39 thorugh 59 d after treatment, scale densities were lower on those branches treated with the insecticides than on the untreated control. Crawler densities of both scales did not differed from the control treatments between 24 through 59 d after treatement, showing that crawler counts may not be the most reliable evaluation technique to measure pesticide effectiveness in mango under southern Florida conditions (Table 8).

Persea mite. All treatments provided a significant reduction of the persea mite during 7, 14, 21, and 28 d after application of the products. Envidor SC (16 and 20 oz) as well as Agrimek + oil were significantly different from the control at 35 and 42 d after treatment (Table 9). All treatments provided a reduction on the number of eggs per area during 7, 14, 21 and 28 d after treatment. BG Oil, Envidor SC (16 and 20 oz) as well as Agrimek + oil had a lower number of eggs compared with the untreated control at 35 and 42 d after treatment (Table 10).

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