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Efficacy of Programs of Experimental and Registered Miticides for Twospotted Spider Mite [*Tetranychus urticae* Koch (Acari: Tetranychidae)] Management on Strawberry

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New and existing miticides were applied in various frequencies, concentrations, and combinations to control twospotted spider mites [*Tetranychus urticae* Koch (Acari: Tetranychidae)] in strawberry (*Fragaria ×ananassa* Duchesne) fields during winter 2010 and 2011. Experimental materials included formulations of the fungus-derived material *Paecilomyces fumosoroseus* Apopka strain 97, the bacteria-derived materials *Chromobacterium subtsugae* and *Burkholderia* sp. strain A396 and materials derived from traditional chemistry cyflumetofen, fenpyroximate (a new formulation), and abamectin (biologically derived) formulated with thiamethoxam. Registered materials included abamectin, abamectin formulated with bifenthrin, bifenazate, fenpyroximate, hexythiazox, and spiromesifen. Programs involving the biologically derived materials, excluding abamectin, formulated alone generally were less effective than other programs. Programs of some experimental and registered materials controlled twospotted spider mites effectively. With these successful chemistries available and given other chemistries available and the predatory mite biological control option, limitations in strawberry production due to spider mites should not occur.

Florida's climate is favorable for numerous nematode, weed, microbial, and arthropod pests of strawberry (*Fragaria ×ananassa* Duchesne) crops (Howard et al., 1985). Fungal diseases are the most destructive, but arthropods contribute considerable damage and require effective management. The most damaging arthropod is the twospotted spider mite [*Tetranychus urticae* Koch (Acari: Tetranychidae)].

Schemes of biological control exist in Florida to manage this pest without miticides (DeCou, 1994; van de Vrie and Price, 1994). Presently about 15% of the Florida strawberry crop is produced through the use of *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) biological agent to manage spider mites; the remainder of the crop is produced through the use of miticides. This work was undertaken to determine the response of twospotted spider mite populations in strawberry to programs of experimental and registered biologically and traditionally derived miticides.

Materials and Methods

Similar experiments were performed in the winters of 2010 and 2011 on the Gulf Coast Research and Education Center farm in Wimauma. 'Strawberry Festival' transplants were set in the field on 9 Oct. 2009 (2010 experiment) and on 5 Oct. 2010 (2011 experiment) in polyethylene mulched beds. Each plot consisted of 20 plants in two 10-plant rows per bed. In-row plant spacing was 15 inches.

A laboratory colony of twospotted spider mites was established from mites found on transplants and reared on bush lima beans. Strawberry plants were infested from this colony before treatments were applied. Experimental materials included formulations of the fungus-derived material *Paecilomyces fumosoroseus* Apopka strain 97 20% WDG (PFR-97®), the bacteria derived materials *Chromobacterium subtsugae* and *Burkholderia* sp. strain A396 and materials derived from traditional chemistry: Cyflumetofen SC (BAS92100I), fenpyroximate 5%EW (a new formulation), and abamectin (biologically derived) formulated with thiamethoxam 1.55SC (Agri-Flex®). Registered materials included abamectin 0.15EC (Agri-Mek®), abamectin formulated with bifenthrin 0.87EW (Athena®), bifenazate 50WS (Acramite®), fenpyroximate 5% EC (Portal®), hexythiazox 50DF (Savey®), and spiromesifen 2SC (Oberon®) and the spray adjuvants alkylaryl polyoxylkane ethers (AAPE) non-ionic surfactant (Induce®) and alkylaryl polyethoxyethanol sulfates and 1,2-propanediol (APSP) non-ionic surfactant/sticker (Cohere®). Treatments of both experiments included untreated controls; miticides and their application frequencies, concentrations, and combinations are described in Table 1 (2010 experiment) and Table 2 (2011 experiment).

Treatments were replicated four times in randomized complete-block designs. Miticides were applied using a hand-held sprayer with a spray wand outfitted with a nozzle containing a 45° core and a number 4 disc, pressurized by CO_2 to 40 psi and calibrated to deliver 100 gal of preparation per acre.

Samples for spider mite densities consisted of 10 randomly selected leaflets per plot and were collected from the middle one-third stratum of plants. Pretreatment samples were taken 3 Feb. (2010 experiment) or 3 Jan. (2011 experiment) and additional samples were taken approximately weekly thereafter although only data from selected sampling dates are presented (Tables 3 and 4). Samples were taken to the laboratory where twospotted spider mites were brushed from the leaflets onto rotating sticky discs and counted on one-tenth of the disc surface to estimate the

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Table 1. Schedule of treatment applications, 2010.

Treatment		Date of treatment application						
Product[z]	Amount/acre	4 Feb.	11 Feb.	18 Feb.	25 Feb.	3 Mar.	11 Mar.	17 Mar.
Non-treated	---							
Abamectin 0.15EC	16 fl oz		X	X			X	X
Bifenazate 50WS	16 oz		X					
Bifenazate 50WS (twice)	16 oz	X				X		
Abamectin 84SC + AAPE[y]	3.42 fl oz		X		X	X		
Abamectin/thiamethoxam 1.55SC + AAPE	10.66 fl oz		X			X		
Fenpyroximate 5% EC (twice)	32 fl oz		X			X		
Fenpyroximate 5% EC	32 fl oz		X					
Abamectin/bifenthrin 0.87EW + AAPE	13.5 fl oz		X					
Abamectin/bifenthrin 0.87EW + AAPE	17.0 fl oz		X					
Hexythiazox 50DF	6 oz	X						
Paecilomyces fumosoroseus								
Apopka strain 97 20% WDG	16 oz		X	X	X			
P. fumosoroseus Apopka strain 97	8 oz							
20% WDG + Abamectin 0.15EC	5 fl oz		X	X	X			
Abamectin 0.15EC	10 fl oz		X	X	X			
Spiromesifen 2SC + AAPE	12 fl oz		X			X		

[z]A "+" sign indicates the products were combined.
[y]AAPE is alkylaryl polyoxylkane ethers, non-ionic surfactant, applied at 32 fl oz per acre.

Table 2. Schedule of treatment applications, 2011.

Treatment		Date of treatment application						
Product[z]	Amount/acre	6 Jan.	20 Jan.	27 Jan.	2 Feb.	10 Feb.	17 Feb.	23 Feb.
Non-treated	---							
Abamectin 0.15EC	16 fl oz		X	X			X	X
Bifenazate 50WS + AAPE[y]	16 oz	X			X			
Cyflumetofen SC (twice)	6.85 fl oz		X			X		
Cyflumetofen SC (twice)	13.7 fl oz		X			X		
Cyflumetofen SC (four times)	3.43 fl oz		X	X			X	X
Cyflumetofen SC (four times)	6.85 fl oz		X	X			X	X
Cyflumetofen SC (once)	13.7 fl oz		X					
Cyflumetofen SC + APSP[x]	6.85 fl oz		X					
APSP	16 fl oz		X					
Fenpyroximate 5% EW	32 fl oz		X		X			
Fenpyroximate 5% EC	32 fl oz		X			X		
Spiromesifen 2SC + AAPE	12 fl oz		X			X		
Hexythiazox 50DF	6 oz	X						
Chromobacteria subtsugae								
94.5% EP + AAPE	1 gal		X	X	X	X	X	
C. subtsugae 94.5% EP + AAPE	3 gal		X	X	X	X	X	
Burkholderia sp. strain A396								
94.46% EP + AAPE	1 gal		X	X	X	X	X	
Burkholderia sp. strain A396								
94.46% EP + AAPE	3 gal		X	X	X	X	X	

[z]A "+" sign indicates the products were combined.
[y]AAPE is alkylaryl polyoxylkane ethers, non-ionic surfactant, applied at 32 fl oz per acre.
[x]APSP is alkylaryl polyethoxyethanol sulfates and 1,2-propanediol, non-ionic surfactant/sticker, applied at 16 fl oz per acre.

average numbers of mites per leaflet. Data were transformed using $\log_{10}(x+1)$ prior to ANOVA and means were separated by Fisher's Protected LSD ($P \leq 0.05$). Non-transformed means are reported.

Results and Discussion

Both experiments began when mite densities on plants were low and the mites were well distributed among the plants of the various treatments (2010 experiment: Mean motile spider mites per treatment was 2.8 to 10.0; 2011 experiment: Mean motile spider mites per treatment was 1.5 to 8.8). No phytotoxicity attributable to any treatment program was found.

2010 Experiment. Results of the 2010 experiment are presented in Table 3. Throughout the experiment all treatment programs performed well except *P. fumosoroseus* Apopka strain 97 20% WDG. Two weeks after the last of the initial applica-

Table 3. Response of mites to miticidal treatments, 2010.

Treatment		No. mites/leaflet[y]			
Product[z]	Amount/acre	3 Feb.	24 Feb.	9 Mar.	24 Mar.
Non-treated	---	4.0 a	13.0 ab	51.3 a	68.5 a
Abamectin 0.15EC	16 fl oz	6.5 a	1.0 e	3.5 bc	0.8 d
Bifenazate 50WS	16 oz	3.0 a	3.0 c–e	6.8 bc	3.0 cd
Bifenazate 50WS (twice)	16 oz	3.8 a	1.8 e	2.0 bc	0.5 d
Abamectin 84SC + AAPE[x]	3.42 fl oz	6.3 a	10.5 a–d	1.0 bc	8.5 cd
Abamectin/thiamethoxam 1.55SC + AAPE	10.66 fl oz	6.5 a	4.5 b–e	5.0 b	2.3 cd
Fenpyroximate 5% EC (twice)	32 fl oz	8.0 a	4.8 c–e	10.3 bc	65.3 c[w]
Fenpyroximate 5% EC	32 fl oz	2.8 a	3.0 c–e	3.0 bc	9.8 c
Abamectin/bifenthrin 0.87EW + AAPE	13.5 fl oz	5.5 a	2.8 c–e	2.0 bc	7.0 cd
Abamectin/bifenthrin 0.87EW + AAPE	17.0 fl oz	3.8 a	2.0 c–e	0.8 bc	3.0 cd
Hexythiazox 50DF	6 oz	5.5 a	2.5 c–e	2.3 bc	4.0 cd
Paecilomyces fumosoroseus Apopka strain 97 20% WDG	16 oz	8.8 a	20.5 a	27.0 a	36.5 ab
P. fumosoroseus Apopka strain 97 20% WDG + Abamectin 0.15EC	8 oz 5 fl oz	10.0 a	7.8 a–c	4.3 b	14.3 bc
Abamectin 0.15EC	10 fl oz	3.0 a	12.8 b–e	5.3 b	4.8 cd
Spiromesifen 2SC + AAPE	12 fl oz	5.3 a	2.3 de	0.0 c	2.0 cd

[z]A "+" sign indicates the products were combined.
[y]Data were transformed $\log_{10}(x+1)$ prior to ANOVA; non-transformed means are reported. Mean separation within columns by Fisher's Protected LSD ($P \leq 0.05$).
[x]AAPE is alkylaryl polyoxylkane ethers, non-ionic surfactant, applied at 32 fl oz per acre.
[w]This value is the result of one plot's unexplained, unusually high TSM density which first appeared on 16 Feb. and persisted through the remainder of the experiment.

Table 4. Response of mites to miticidal treatments, 2011.

Treatment		No. mites/leaflet[y]			
Product[z]	Amount/acre	3 Jan.	31 Jan.	14 Feb.	28 Feb.
Non-treated	---	8.8 a	14.3 a	89.8 a	277.5 a
Abamectin 0.15EC	16 fl oz	8.5 a	0.5 e	3.0 d–f	6.8 g–i
Bifenazate 50WS + AAPE[x]	16 oz	1.5 a	3.0 c–e	18.3 de	36.8 e–h
Cyflumetofen SC (twice)	6.85 fl oz	1.8 a	1.3 de	3.0 de	5.8 hi
Cyflumetofen SC (twice)	13.7 fl oz	9.5 a	1.8 c–e	1.0 ef	7.5 f–i
Cyflumetofen SC (four times)	3.43 fl oz	7.5 a	5.5 b–e	3.5 ef	5.5 hi
Cyflumetofen SC (four times)	6.85 fl oz	5.8 a	0.8 e	0.0 f	3.8 i
Cyflumetofen SC (once)	13.7 fl oz	2.8 a	1.3 e	1.8 ef	9.3 hi
Cyflumetofen SC + APSP[w]	6.85 fl oz	2.3 a	16.3 a–c	22.3 cd	78.0 e–g
APSP	16 fl oz	2.8 a	14.3 ab	72.5 ab	237.8 a
Fenpyroximate 5% EW	32 fl oz	4.0 a	10.5 ab	6.8 cd	54.5 c–e
Fenpyroximate 5% EC	32 fl oz	4.5 a	2.0 c–e	5.3 de	34.3 d–f
Spiromesifen 2SC + AAPE	12 fl oz	2.8 a	0.5 e	0.5 ef	2.8 i
Hexythiazox 50DF	6 oz	2.0 a	13.8 ab	57.5 ab	196.0 ab
Chromobacteria subtsugae 94.5% EP + AAPE	1 gal	4.3 a	10.3 a–d	54.5 ab	196.3 ab
C. subtsugae 94.5% EP + AAPE	3 gal	2.8 a	16.0 ab	22.5 bc	87.5 b–d
Burkholderia sp. strain A396 94.46% EP + AAPE	1 gal	5.0 a	9.0 ab	42.5 ab	207.3 ab
Burkholderia sp. strain A396 94.46% EP + AAPE	3 gal	1.5 a	12.8 a	35.5 ab	125.8 a–c

[z]A "+" sign indicates the products were combined.
[y]Data were transformed $\log_{10}(x+1)$ prior to ANOVA; non-transformed means are reported. Mean separation within columns by Fisher's Protected LSD ($P \leq 0.05$).
[x]AAPE is arkylaryl polyoxylkane ethers, non-ionic surfactant, applied at 32 fl oz per acre.
[w]APSP is alkylaryl polyethoxyethanol sulfates and 1,2-propanediol, non-ionic surfactant/sticker, applied at 16 fl oz per acre.

tions had been made (24 Feb.), lowest densities of mites occurred when abamectin 0.15EC, bifenazate 50WS, abamectin/thiamethoxam 1.55SC plus AAPE surfactant, fenpyroximate 5% EC, abamectin/bifenthrin 0.87EW plus AAPE, hexythiazox 50DF, or spiromesifen 2SC plus AAPE were applied. After the end of all programs of application (24 Mar.), excellent control of mites was still occurring where abamectin 0.15EC, abamectin 84SC plus AAPE, bifenazate 50WS, abamectin/thiamethoxam 1.55SC plus AAPE, abamectin/bifenthrin 0.87EW plus AAPE, hexythiazox 50DF, or spiromesifen 2SC plus AAPE had been applied.

2011 Experiment. Results of the 2011 experiment are presented in Table 4. Four days after the last of the initial applications had been made (24 Jan.) there were no significant differences among treatments (data not presented). One week later (31 Jan.) greatest reductions in mites occurred where abamectin 0.15EC, bifenazate 50WS plus AAPE, cyflumetofen SC (excluding cyflumetofen SC plus APSP surfactant/sticker), spiromesifen 2SC plus AAPE, or fenpyroximate 5% EC had been applied. After the end of all programs of application, lowest densities of mites were still occurring in those treatments except the programs where bifenazate 50WS plus AAPE or fenpyroximate 5% EC were applied. There were no significant differences detected, on any of the sampling dates (Table 4), in numbers of mites found on the untreated check plants and numbers found on plants treated with 1) a single application of APSP surfactant/sticker, 2) a single application of hexythiazox 50DF (although it performed very well in experiment 1), 3) multiple applications of *Chromobacteria subtsugae* 94.5% EP at the lower preparation concentration plus AAPE, and 4) multiple applications of *Burkholderia* sp. Strain A396 94.46% EP plus AAPE.

Several successful programs of application for spider mite control were observed, most involving the miticides of traditional chemistry and involving biologically derived abamectin. Generally unsuccessful performance occurred with the remaining biologically derived experimental materials. With these successful chemistries available and given other chemistries available and the predatory mite biological control option, limitations in strawberry production due to spider mites should not occur.

Literature Cited

DeCou, G.C. 1994. Biological control of twospotted spider mite (Acarina: Tetranychidae) on commercial strawberry in Florida with *Phytoseiulus persimilis* (Acarina: Phytoseiidae). Fla. Entomol. 77:34–41.

Howard, C.M., A.J. Overman, J.F. Price, and E.E. Albregts. 1985. Diseases, nematodes, mites, and insects affecting strawberries in Florida. Fla. Agr. Expt. Sta. Bul. 857.

van de Vrie, M. and J.F. Price. 1994. Manual for biological control of twospotted spider mites on strawberry in Florida. Univ. of Fla. Dover Res. Rpt. DOV 1994-1.