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NEW INSECTICIDES FOR SILVERLEAF WHITEFLY, *BEMISIA ARGENTIFOLII* (HOMOPTERA: ALEYRODIDAE) CONTROL

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Abstract

A study was conducted in Imperial Valley, CA to evaluate insecticides for control of silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, in cotton. New insecticidal compounds, Oberon (spiromesifen) under development of Bayer Crop Science to control various insects and mites on corn, cotton, vegetables, fruit crops, and ornamentals, Calypso (thiacloprid) a chloronicotinyl (CNI) chemistry, pioneered by Bayer CropScience, Diamond (novaluron) a Benzoylphenyl urea compound under development by Crompton Corporation, XR-225 (gamma-cyhalothrin) a pyrethroid insecticide under development by Dow AgroSciences, and F0570 (zeta-cypermethrin) a pyrethroid insecticide under development of FMC Corporation, were compared to standard whitefly insecticides Assail (acetamiprid) a Cerexagri neonicotinoid insecticide, Danitol (fenpropathrin) a Valent BioSciences pyrethroid insecticide, and Warrior (lambda cyhalothrin) a Syngenta pyrethroid insecticide, for control efficacy of silverleaf whitefly adults and nymphs. All pyrethroid insecticides were applied in tank mixtures with Orthene (acephate) a Valent BioSciences organophosphate insecticide. The whitefly adult and nymphal post-treatment means for the pyrethroid insecticide treatments (gamma-cyhalothrin and zeta cypermethrin) and were not different from the untreated control. Assail, Calypso, and Oberon treatments provided the highest levels of control for silverleaf whitefly adults and nymphs.

Introduction

The silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, (Bellows et al. 1994) caused severe economic losses to cotton and other crops in the United States in 1991 with conservative estimates of direct dollar losses exceeding $200 million and the direct dollar loss to cotton producers in the Lower Rio Grande Valley of Texas was more than $80 million (Henneberry 1993). Direct dollar losses to cotton in Arizona in 1992 exceeded $100 million (Henneberry 1993). Whitefly-induced economic losses to cotton occur as a result of reduced cotton yield (Mound 1965) and contamination of lint with honeydew and sooty molds (Davidson et al. 1994). The whitefly-transmitted cotton leaf crumple disease, caused by cotton leaf crumple geminivirus (CLCV), can also cause extensive reduction in yield (Dickson et al. 1954, Duffus and Flock 1982).

The silverleaf whitefly is a prolific pest with a broad host range that has resulted in year round infestations on commercial crops in Southern California. Although chemical applications only provide temporary control of this pest (e.g. Chu et al. 1993, Natwick 1993, Godfrey et al. 1997, Chu et al. 1998 and Natwick 1999), and a long term solution that offers economical with environmental advantages is needed, the insecticides remain as the principal method of control of silverleaf whitefly in commercial crops, including cotton. Cotton insecticide efficacy research in 2003 was conducted to evaluate registered insecticides and new insecticidal compounds for control of silverleaf whitefly at the University of California Desert Research and Extension Center, Imperial Valley, CA.

Material and Methods

A stand of cotton, *Gossypium hirsutum* L. var. DPL 448B, was established at UC Desert Research & Extension Center 1 April 2003, Imperial Valley, CA. Twelve insecticide treatments and an untreated control were replicated four times in a randomized complete design. Each plots was 15 m long and 4 m wide. Insecticide treatments by registered trade name, or experimental number or name, are listed in Table 1. New insecticides (insecticides without a federal label for use on cotton) were Oberon (spiromesifen) under development of Bayer Crop Science to control various insects and mites on corn, cotton, vegetables, fruit crops, and ornamentals, Calypso (thiacloprid) a chloronicotinyl (CNI) chemistry, pioneered by Bayer CropScience, Diamond (novaluron) a Benzoylphenyl urea compound under development by Crompton Corporation, XR-225 (gamma-cyhalothrin) a pyrethroid insecticide under development by Dow AgroSciences, and F0570 (zeta cypermethrin) a pyrethroid insecticide under development of FMC Corporation. Helena Buffer PS at 1 pt/100 gal and Silwet L77 at 4 fl oz/100 gal were used with all insecticide spray treatments with the exception of an Assail treatment that was tank mixed with methylated seed oil as a substitute for Silwet L77.

Silverleaf whitefly adults were sampled using the leaf turn method (Naranjo & Flint 1995) from 10 plants at random in each plot. Silverleaf whitefly nymphs were counted on single leaf disks of 1.65 cm^2 from the lower left hand quadrant on the undersides of 5^{th} node leaves extracted from 10 plants at random in each plot. Leaf samples were taken weekly from 3 June through 4 August 2003. On 8 September 2003, seed cotton was hand picked from 0.002 acre per plot, data were recorded, and yield as seed cotton per acre was calculated. Seed cotton samples were ginned and percentages of lint turnout and pounds of lint per acre were calculated.

Post-treatment means for silverleaf whitefly adult and nymph densities, seed cotton and lint weights, and percentages of lint turnout were analyzed using ANOVA (MSTAT-C 1989). The Least Significant Differences Test (LSD) was employed for means separations.

Results and Discussion

Post-treatment means for silverleaf whitefly adults were lower ($P \leq 0.05$) in the untreated control than for insecticide treatments except gamma-cyhalothrin + Orthene 97 and zeta-cypermethrin + Orthene 97, Table 2. Whitefly adult post-treatment means for the Calypso 4SC, Assail 70 WP + MSO, and Assail 70 WP + Silwet L77 treatments were lower than other insecticide treatments except Oberon 2 SC at 0.133 lb (AI)/acre, Danitol 2.4 EC + Orthene 97, and Diamond 0.83 EC at 0.013 lb (AI)/acre. Oberon 2 SC at 0.109 lb and 0.125 lb (AI)/acre had a lower adult post-treatment mean than Diamond 0.83 EC at 0.026 lb (AI)/acre, gamma-cyhalothrin + Orthene 97, Warrior + Orthene 97, and zeta-cypermethrin+Orthene 97.

Post-treatment means for silverleaf whitefly nymphs were lower ($P \leq 0.05$) in the untreated control than for all insecticide treatment except Diamond 0.83EC at 0.026 lb (AI)/acre, gamma-cyhalothrin + Orthene 97 and zeta-cypermethrin + Orthene 97, Table 3. Whitefly nymph post-treatment means for Assail 70 WP + MSO was lower than all insecticide treatments except Oberon 2 SC at 0.109 lb and 0.133 lb (AI)/acre, Assail 70 WP + Silwet L77, and Calypso 4 SC. The gamma-cyhalothrin + Orthene 97 treatment had more whitefly nymphs that all other treatments except zeta-cypermethrin + Orthene 97, Diamond 0.83 EC at 0.026 lb (AI)/acre, and Warrior + Orthene 97.

Only Assail 75 WP + MSO, Oberon 2 SC at 0.125 lb and 0.133 lb (AI)/acre, and Calypso 4 SC had means for pounds of seed cotton per acre and pounds of lint per acre that were greater ($P \leq 0.05$) than the untreated control, Table 4. Seed cotton yield and lint yield were negatively correlated to whitefly nymphal population levels, Figures 1 and 2. Therefore, the highest means for pounds of seed cotton per acre and were from treatments that had the lowest numbers of silverleaf whitefly nymphs. The untreated control had a lower mean for lint turnout percentage than all insecticide treatments except gamma-cyhalothrin + Orthene 97, zeta-cypermethrin + Orthene 97, Diamond 0.83 EC at 0.026 lb (AI)/acre, Danitol 2.4 EC + Orthene 97, and Warrior + Orthene 97. Percentages of lint turnout were negatively correlated to whitefly nymphal population levels, Figures 3. Therefore, the highest means for percentage lint turnout and were from treatments that had the lowest numbers of silverleaf whitefly nymphs.

Whitefly adult and nymph means for gamma-cyhalothrin + Orthene 97 and zeta-cypermethrin + Orthene 97 were not different from the untreated control. The Assail treatments, Calypso, and the Oberon treatments provided the highest levels of control for silverleaf whitefly nymph, the most damaging stage of the insect. Diamond 0.83 EW may be useful for silverleaf whitefly control in cotton, not because it performed well in this study, but like other insect growth regulators, it shows better efficacy in larger plots than were possible in this study.

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Table 1. List of Treatments and Rates for Whitefly Control in Cotton, 2003.

Treatment	Lb (AI)/acre	Oz/acre	Treatment dates in 2003
1. Non-Treated	--------	--------	----------
2. Oberon 2 SC	0.109	7.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
3. Oberon 2 SC	0.125	8.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
4. Oberon 2 SC	0.133	8.5 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
5. Assail 70 WP + Silwet L77	0.101 + 0.03%v/v	2.3 dry + 4 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
6. Assail 70 WP + MSO	0.101 + 0.13%v/v	2.3 dry+ 16.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
7. Calypso 4 SC	0.0939	3.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
8. Diamond 0.83EC	0.013	2.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
9. Diamond 0.83EC	0.026	4.0 fl	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
10. XR-225 + Orthene 97	0.0125 + 0.5	3.2 fl+ 8.25 dry	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
11. Warrior + Orthene 97	0.025 + 0.5	3.2 fl+ 8.25 dry	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
12. F0570 0.8 EW + Orthene 97	0.025 + 0.5	4.0 fl+ 0.52 dry	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul
13. Danitol 2.4 EC + Orthene 97	0.20 + 0.5	10.7 fl + 8.25 dry	11, 18, 25 Jun, 1, 8, 15, 22, 29 Jul

Helena Buffer PS at 1.0 pt/100 gal added to each spray mixture and Silwet L77 at 0.13%v/v added to each spray mixture except treatment number 6, which received MSO, methylated seed oil.

Table 2. Whitefly Adults per Cotton Leaf Following Insecticide Treatments to Cotton, Holtville, CA, 2003.

Treatment	Lb (AI)/acre	PTM[yz]
Check	--------	16.18 abc
Oberon 2 SC	0.109	11.66 cde
Oberon 2 SC	0.125	11.19 cde
Oberon 2 SC	0.133	7.59 ef
Assail 70 WP + Silwet L77	0.101 + 0.03%v/v	5.51 f
Assail 70 WP + MSO	0.101 + 0.13%v/v	4.73 f
Calypso 4 SC	0.0939	4.28 f
Diamond 0.83EC	0.013	8.62 def
Diamond 0.83EC	0.026	14.14 bc
XDE-225 + Orthene 97	0.0125 + 0.5	21.19 a
Warrior + Orthene 97	0.025 + 0.5	13.77 bcd
F0570 0.8 EW + Orthene 97	0.025 + 0.5	17.38 ab
Danitol 2.4 EC + Orthene 97	0.20 + 0.5	7.61 ef

Mean separations within columns followed by the same letter are not significantly different (LSD; $P < 0.05$).

[y] Post-treatment means.

[z] Log transformed data used for analysis; reverse transformed means are included in the table.

Table 3. Silverleaf Whitefly Nymphs per cm^2 of Cotton Leaf, Holtville, CA 2003.

Treatment	Lb(AI)/acre	PTM[yz]
Check	--------	7.20 a
Oberon 2 SC	0.109	0.76 efg
Oberon 2 SC	0.125	0.88 def
Oberon 2 SC	0.133	0.53 fg
Assail 70 WP + Silwet L77	0.101 + 0.03%v/v	0.48 fg
Assail 70 WP + MSO	0.101 + 0.13%v/v	0.33 g
Calypso 4 SC	0.0939	0.36 fg
Diamond 0.83EC	0.013	1.96 bcd
Diamond 0.83EC	0.026	3.38 ab
XDE-225 + Orthene 97	0.0125 + 0.5	6.54 a
Warrior + Orthene 97	0.025 + 0.5	2.56 bc
F0570 0.8 EW + Orthene 97	0.025 + 0.5	3.51 ab
Danitol 2.4 EC + Orthene 97	0.20 + 0.5	1.38 cde

Mean separations within columns followed by the same letter are not significantly different (LSD; $P < 0.05$).

[y] Post-treatment means.

[z] Log transformed data used for analysis; reverse transformed means are included in the table.

Table 4. Pounds of Seed Cotton and Lint per Acre and Percentages of Lint Turnout per Acre, Holtville, CA, 2003.

Treatment	Lb(AI)/acre	Seed Cotton/Acre	Lint/Acre	% Turnout
Check	--------	1055.10 de	375.40 de	35.49 e
Oberon 2 SC	0.109	1186.11 bcde	440.36 bcde	37.48 abc
Oberon 2 SC	0.125	1452.66 abc	538.32 abc	37.08 abcd
Oberon 2 SC	0.133	1493.75 ab	555.21 ab	37.25 abcd
Assail 70 WP + Silwet L77	0.101 + 0.03%v/v	1348.85 abcd	513.71 bcd	37.93 abc
Assail 70 WP + MSO	0.101 + 0.13%v/v	1697.04 a	652.46 a	38.46 a
Calypso 4 SC	0.0939	1468.21 abc	560.24 ab	38.14 ab
Diamond 0.83EC	0.013	1341.74 abcd	505.34 bcd	37.61 abc
Diamond 0.83EC	0.026	1126.89 bcde	413.67 cde	36.64 cde
XDE-225 + Orthene 97	0.0125 + 0.5	900.52 e	326.40 e	35.93 de
Warrior + Orthene 97	0.025 + 0.5	1114.33 cde	398.73 de	35.91 de
F0570 0.8 EW + Orthene 97	0.025 + 0.5	1065.58 de	383.84 de	35.77 de
Danitol 2.4 EC + Orthene 97	0.20 + 0.5	1357.7 abcd	499.29 bcd	36.84 bcde

Mean separations within columns followed by the same letter are not significantly different (LSD; $P < 0.05$).

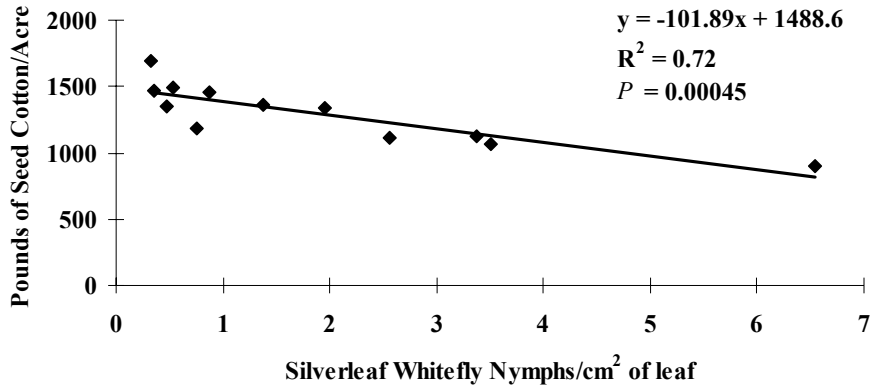

Figure 1. Effect of Silverleaf Whitefly Nymphal Population on Seed Cotton Yield.

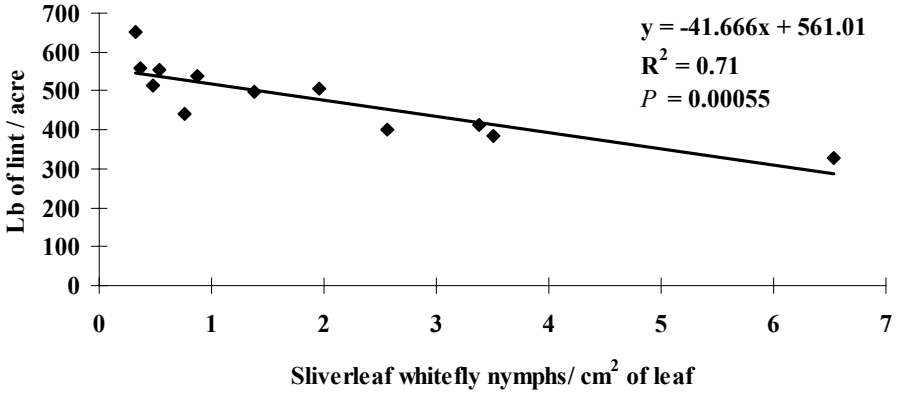

Figure 2. Relationship of Cotton Lint Yield to Silverleaf Whitefly Nymphal Levels.

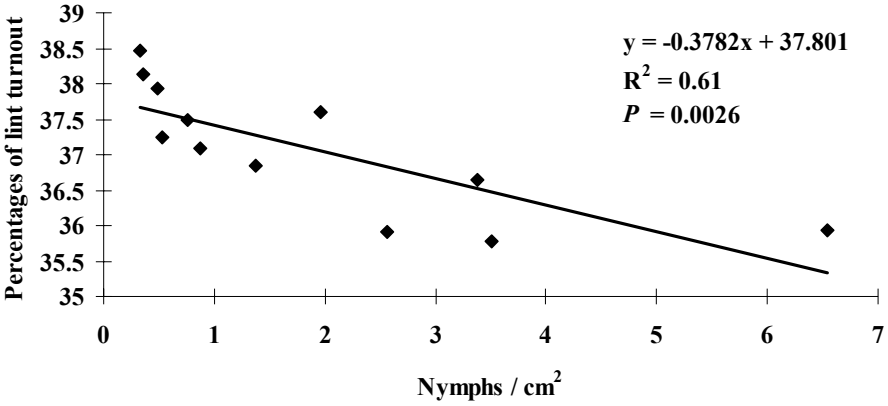

Figure 3. Relationship of Percentage Lint Turnout to Silverleaf Whitefly Nymphal Levels.