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Development of Effective Chemical Controls For Aphid Vectors of Viruses on Citrus

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ABSTRACT

The brown citrus aphid, *Toxoptera citricida* Kirkaldy, an exotic and efficient vector of citrus tristeza virus, is predicted to invade the citrus industry in south Texas within the next few years. Although native aphid species are frequently found on citrus in south Texas, growers do not normally apply insecticides for aphid control. Efficacy tests of several chemicals were conducted against naturally occurring, native aphid populations in two separate field trials. Results indicate that the organophosphate, oxydemeton-methyl (Metasystox-R®), and the chloronicotinyl, imidacloprid (Provado® 1.6F), were efficacious against aphids and may fit in an integrated pest management program on citrus in the Lower Rio Grande Valley of Texas.

RESUMEN

Se pronostica que el áfido café de los cítricos, *Toxoptera citricida* Kirkaldy, un eficiente vector exótico del virus de la tristeza de los cítricos, invadirá la industria citrícola del sur de Texas dentro de pocos años. Aunque frecuentemente se presentan especies nativas de áfidos en los cítricos del sur de Texas, los agricultores normalmente no aplican insecticidas para su control. Se condujeron dos ensayos de campo para evaluar la eficacia de varios productos químicos en contra de poblaciones naturales de áfidos nativos. Los resultados indicaron que el producto organofosforado, oxidemetón metílico (Metasistox-R®), y el cloronicotinil, imidacloprid (Provado® 1.6F), fueron eficaces en contra de los áfidos y podrían utilizarse en un programa de manejo integrado de plagas de cítricos en el Bajo Valle del Río Grande en Texas.

Chemical suppression of colonizing aphids may play a valuable role in an integrated pest management program (IPM) for citrus in the Lower Rio Grande Valley (LRGV), especially against the highly efficient vector of citrus tristeza virus (CTV), the brown citrus aphid (BrCA), *Toxoptera citricida* Kirkaldy. The BrCA is well established in Florida and Belize and is expected to move into Texas in the next few years. The widespread use of sour orange rootstock in Texas, which is highly susceptible to severe strains of CTV, places the citrus industry in the LRGV in jeopardy, once the BrCA arrives (Powell and Pelosi 1993).

Research has shown that aphids can quickly develop resistance to insecticides and it is important to explore several chemical options to avoid resistance buildup (Eastop 1977, Kerns and Gaylor 1992). Two organophosphates, chlorpyrifos and oxydemeton-methyl, and a chloronicotinyl, imidacloprid, were tested for efficacy against aphids on LRGV citrus. Since a miticide application may be needed at the same time as an insecticide is used for aphid control, pyridaben, a miticide/insecticide was also included in these trials (French and Bruno 1996). Two separate chemical field trials were conducted against naturally occurring populations of the cotton aphid, *Aphis gossypii* Glover, and the spirea aphid, *Aphis spireacola* Patch, on young orange trees in 1997 at two different LRGV orchard sites. Beneficial insects in both groves were monitored for chemical disruption of naturally occurring aphid predator populations.

MATERIALS AND METHODS

Chemical Formulations and Rates: The insecticides tested were: chlorpyrifos (Lorsban® 4E) O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate, at a test rate of 0.25 lb ai/100 gal, (Dow Chemical, Midland, MI); imidacloprid (Provado® 1.6F) 1-[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine at a rate of 0.053 lb ai/ 100 gal, (Bayer Corp., Kansas City, MO); oxydemeton-methyl (Metasystox-R® SC) S-[2-Ethylsulfinyl)ethyl]) O,O-dimethyl phosphorothioate at two rates: 0.25 lb ai/100 gal and 0.375 lb ai/100 gal, (Gowan Co., Yuma, AR); pyridaben (Nexter® 75 WP) 2-tert-butyl-5-(4-tert-butylbenzyl-thio)-4-chloropyridazin-3(2H)-one (IUPAC), at a rate of 0.125 lb ai/100 gal, (BASF Corp., Research Triangle Park, NC). Chlorpyrifos was tested at the Tamm Lane grove only. An adjuvant, Silwet® (Helena Chemical, Memphis, TN), was added to all tank mixes at a rate of 0.015 percent volume/volume.

Plot Design and Application Procedure: The first site (Block D-2 at Texas A & M-Kingsville, Citrus Center's South Research Farm, Weslaco, TX) was an orchard of 'Marrs' orange planted in 1992. Chemicals were applied on May 15, 1997 against infestations of both the spirea and cotton aphid. Aphid species were not mixed on trees and the spirea aphid

colonies were larger than those of the cotton aphid. The second site (Tamm Lane, near Harlingen, TX) was a privately owned 'Valencia' orange orchard planted in 1994 and 1995. The spirea aphid was the only species detected on these young citrus trees. Chemicals were applied on June 6, 1997.

A completely randomized design with four replications of insecticide treatments was used at each location. Chemical treatments were applied to single tree plots. Four unsprayed trees at the Tamm Lane orchard and six unsprayed trees at the Citrus Center orchard were selected at random and served as controls. Three to four terminals with aphid colonies were identified and marked with flagging tape in each tree. Chemicals were mixed in tap water and applied to each tree until runoff using a Koke-Kap® CO_2 portable backpack sprayer, at 40 psi. Depending on the size of the tree, this equaled approximately 0.50 to 0.75 liters of solution applied per tree.

Aphid and Beneficial Counts: The number of aphids per leaf for each marked terminal were counted the day prior to chemical applications. The numbers of live aphids per leaf of each marked terminal were counted at intervals of 1, 3, 7, and 14 days after treatment (DAT). At 30 DAT, the overall efficacy of chemicals was judged by the number of aphids re-establishing on new growth terminals. The presence of ants (Hymenoptera: Formicidae) was also noted for each treatment since ants are known to tend aphid colonies for their honeydew and their presence can deter predators (Dean 1953, Vinson and Scarborough 1989). The total number of lady beetles (Coleoptera: Coccinellidae), green lace wing larvae (Neuroptera: Chrysopidae) and syrphid fly larvae (Diptera: Syrphidae) were counted on each terminal throughout the trial period.

Statistical Methods: Data for live aphids per leaf for each treatment and sample date were subjected to analysis of variance and means were compared using the Waller-Duncan K-ratio T-Test ($P = 0.05$) (SAS Institute 1995).

RESULTS AND DISCUSSION

Citrus Center Orchard Trial: Initial aphid knockdown and residual control was excellent with the oxydemeton-methyl (low rate) and the imidacloprid + Silwet® spray treatments. Trends in the data suggest that oxydemeton-methyl (high rate) and pyridaben treatments were slightly less effective (Table 1). Aphid populations did not re-establish on insecticide treated sprayed trees throughout the trial duration.

Predator populations comprised of lady beetle adults and larvae and syrphid fly larvae were present in most treatments throughout the trial duration. Some mortality of the syrphid fly,

Table 1. Chemical efficacy test against Aphis spireacola Patch and A. gossypii Glover on 'Marrs' orange, applied May 15, 1997 at Block D-2, Texas A & M Kingsville Citrus Center, South Research Farm, Weslaco, TX.

			DAT[z]				
Treatment[y]	Rate:	Pre-count	+1	+3	+7	+14	+30
	lb ai/100 gal		Mean Number of Live Aphids/Leaf				
Oxydemeton-methyl	0.25	8.12a[x]	0.19b	0.00b	0.00b	0.00a	0.00b
Oxydemeton-methyl	0.375	6.33a	2.76ab	1.51b	0.93b	0.00a	0.00b
Pyridaben	0.125	6.07a	1.58b	0.59b	0.58b	0.00a	0.00b
Imidacloprid	0.053	6.67a	0.27b	0.40b	0.04b	0.11a	0.00b
Control	0.00	7.84a	4.45a	5.36a	3.14a	0.60a	1.36a

[z]Number of days after treatment.

[y]Each treatment was replicated four times in a random block design, applied to foliar runoff with a Koke-Kap CO_2 portable back-pack sprayer at 40 psi.

[x]Treatment means within columns not showing a common letter are significantly different as separated by Waller-Duncan K-Ratio t-test ($P = 0.05$).

Table 2. Number of beneficial insects[z] on sprayed and unsprayed 'Marrs' orange trees, Block D-2, Texas A & M-Kingsville, Citrus Center, Weslaco, TX., May 14 through June 15, 1997.

	Oxydemeton-methyl (Low Rate)		Oxydemeton-methyl (High Rate)		Pyridaben		Imidacloprid		Control	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Precount	6	0	4	0	7	0	8	0	6	0
1-DAT[y]	0	0	15	0	3	1	7	2	28	0
3-DAT	3	1	33	0	15	1	2	4	7	0
7-DAT	4	0	22	1	2	0	0	0	8	0
14-DAT	2	0	9	0	3	0	10	0	3	0
30-DAT	0	0	2	0	7	0	4	0	0	0
Total	15	1	85	1	35	2	31	6	52	0

[z]Beneficial insects popultions were: Syrphid fly larvae, *Pseudodoros clavatus* Fabricius and the following lady beetles: Harmonia or multicolored Asian lady beetle, *Harmonia axyridis* Pallas; Convergent lady beetle, *Hippodamia convergens* Guerin-Meneville; Blood-Red lady beetle, *Cycloneda sanguinea* L.; Lousiana lady beetle, *Scymnus louisiana* J. Chapin.

[y]DAT = Days after treatment.

Table 3. Chemical efficacy test against Aphis spireacola Patch on 'Valencia' orange, applied June 6, 1997 at Tamm Lane, Harlingen, TX.

Treatment[y]	Rate	Precount	DAT[z] +1	+3	+7	+14	+30
	lb ai/100 gal		Mean Number of Live Aphids/Leaf				
Oxydemeton-methyl	0.25	9.60a[x]	0.70c	0.00b	0.00b	0.00a	0.00c
Oxydemeton-methyl	0.375	4.70a	1.23c	0.28b	1.26ab	0.00a	17.14b
Pyridaben	0.125	6.73a	7.64b	3.90ab	4.73ab	0.01a	45.07a
Imidacloprid	0.053	8.12a	0.90c	0.00b	0.00b	0.00a	21.36ab
Chlorpyrifos	0.25	4.97a	0.71c	3.73ab	3.77ab	0.00a	10.25bc
Control	0.00	10.03a	18.77a	9.30a	6.89a	0.00a	23.15ab

[z]Number of days after treatment.

[y]Each treatment was replicated four times in a random block design, applied to foliar runoff with a Koke-Kap CO_2 portable back-pack sprayer at 40 psi

[x]Treatment means within columns not showing a common letter are significantly different as separated by Waller-Duncan K-Ratio t-test (P=0.05).

Table 4. Number of beneficial insects[z] on sprayed and unsprayed 'Valencia' orange trees, Tamm Lane, Harlingen, TX., June 5 through July 6, 1997.

	Oxydemeton-methyl (Low Rate)		Oxydemeton-methyl (High Rate)		Pyridaben		Imidacloprid		Chlorpyrifos		Control	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Precount	7	0	5	0	3	0	4	0	9	0	5	0
1-DAT[y]	2	2	2	1	2	2	0	3	0	7	3	0
3-DAT	1	5	9	2	2	3	3	3	4	4	13	0
7-DAT	1	0	4	0	0	5	3	3	8	0	9	0
14-DAT	2	0	1	0	3	2	6	0	0	0	11	0
30-DAT	0	0	17	0	23	2	30	0	14	0	23	0
Total	13	7	38	3	33	14	46	9	35	11	64	0

[z]Beneficial insects popultions were: Syrphid fly larvae, *Pseudodoros clavatus* Fabricius and lacewig larvae, *Chrysoperla rufilabris* Burmeister.

[y]DAT = Days after treatment.

Pseudodoros clavatus Fabricius, was recorded initially in the imidacloprid treatment (Table 2). The lady beetles included the Harmonia or multicolored Asian lady beetle, *Harmonia axyridis* Pallas; Convergent lady beetle, *Hippodamia convergens* Guerin-Meneville; Blood-red lady beetle, *Cycloneda sanguinea* L.; and the Louisiana lady beetle (*Scymnus louisianae* J. Chapin). Abundant plant refuge for lady beetles was provided at the Citrus Center site in tall stands of false ragweed, *Panthenium hysterophorus* L, which supported another aphid food source, *Uroleucon pseudambrosiae* Olive.

Tamm Lane Orchard Trial: Initial aphid knockdown was excellent in all treatments except with pyridaben (Table 3). Both oxydemeton-methyl treatment rates (0.25 and 0.375 lb ai/100 gal) and the imidacloprid treatment provided effective residual aphid control through 7 DAT; however, the chlorpyrifos lost residual efficacy by 3 DAT (Table 3). Aphid populations re-established by 30 DAT on new flushes in all test plot trees except those treated with the low rate of oxydemeton-methyl (0.25 lb ai/100 gal). Some initial mortality of predators occurred following all treatments, with the highest total levels occurring with the pyridaben and chlorpyrifos treatments (Table 4). Populations of predators were primarily syrphid fly larvae, *Psedadorus clavatus* Fabricius, and an occasional green lacewing larvae, *Chrysoperla rufilabris* Burmeister. Lady beetles were not seen on trees in this location where the orchard floor was kept clean. The Tamm Lane orchard, which was irrigated during the trial period, showed a major resurgence in aphid populations at the 30 DAT, as new growth terminals developed on most of the young orange trees (Table 3). Concomitant with the resurgance of aphid populations increased numbers of syrphid fly larvae and green lacewing larvae were also recorded (Table 4). The Tamm Lane orchard had aphid-tending ants on most of the trees throughout the test period.

SUMMARY

Of the four chemicals evaluated, the organophosphate, oxydemeton-methyl and the chloronicotinyl, imidacloprid, provided excellent "knock-down" and residual suppression of aphid populations with minimal disruption to predators. The application of one of these chemicals, followed by the other at the end of two to three weeks, may extend aphid suppression. Rotation applications of oxydemeton-methyl and imidacloprid may delay chemical resistance by aphids, as they are of two different chemical classes. These two products could fit into an IPM program should the BrCA invade LRGV citrus.

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