Comparative Efficacy of Insecticide Combinations Against Whitefly Adults in Melons

John Palumbo, University of Arizona, Yuma Arizona

Abstract

Several large plot field studies were conducted in the spring of 2006 and 2007 to evaluate and compare the efficacy of several insecticides (used alone and in combinations) for knockdown and residual control of adult whiteflies in cantaloupes. Treatments were initiated when adult whitefly populations exceeded action threshold of 2 adults/ leaf. Evaluations of adult and immature control were made a various intervals following each application. The results of this study demonstrate that the synergized pyrethroid still provides the most significant knockdown activity on whitefly adults among registered alternatives in melons. In most cases, the addition of endosulfan (Thionex) with bifenthrinin provided 7-14 days of adult suppression below the action threshold. Residual control of adults was less effective following a second sequential application. Other alternative tank-mix partners with Capture were less effective, but might be useful to use in rotation with the Capture+Thionex treatments to provide adult knockdown. As we anticipated, adult and immature whitefly control did not differ among the bifenthrin formulations (Capture vs. generics). Finally, because of the risk of whitefly resistance and the heavy reliance on pyrethoids in all vegetable crops grown in the desert, new alternatives for adult whitefly control are needed.

Introduction

The use of insecticides is the primary strategy employed to control *Bemisia* whiteflies (sweetpotato whitefly, *B. tabaci* Genn. and Silverleaf whitefly, *B. argentifolii* Bellows & Perring) in desert melon crops. This has been particularly evident in during the past decade where whiteflies have shown the potential to cause millions of dollars in crop damage and lost yields. Several new classes of insecticide chemistry have been developed recently that effectively control whitefly populations and include the neonicotinoids (Admire, Venom and Platinum), insect growth regulators (Courier and Knack), and the new active ingredient Oberon. All of these compounds have selective activity against whitefly nymphals stages, but have limited activity against adults. Because of the whitefly adults ability to move onto melon crops during the growing season, it is often desirable for growers to apply products capable of suppressing adults, particularly near harvest.

Typically, synergized pyrethroid combinations have been the most efficacious alternatives for adult control. These spray mixtures involve combining high rates of pyrethroid insecticides with moderate to high rates of compounds from a different chemical class such as organophosphates, carbamates, organophosphates and cyclodienes. The increased efficacy of these mixtures can be attributed in part to the additive toxic effects of both compounds, but in many cases, greater toxicity may result from the inhibition of insecticide resistance mechanisms. Synergized pyrethroid sprays are primarily effective against adult whiteflies through contact action. Although nymphs are susceptible to these active ingredients control of immature populations on plants with conventional treatments is inherently difficult to achieve because nymphs reside on the under surface of leaves and are difficult to contact with sprays. The most common combination used in melon is a mixture of endosulfan with bifenthrin. PCAs have grown reliant on this combination and alternatives to endosulfan are needed to reduce resistance risks. Furthermore, recent regulatory actions threaten to limit the availability and use of endosulfan on melons. Finally, several generic formulations of bifenthrin are now available for PCAs to use in tank-mixtures. The objectives of these studies was to a) evaluate the efficacy of several tankmix- alterntives for use with bifenthrin against adult whiteflies and b) compare the relative efficacy of several new generic formulations combined with endosulfan for adult whitefly control.

Materials and Methods

Adult Control, Spring 2006: Cantaloupe plots planted with 'Valley Gold ' were established at the Yuma Agricultural Center on 6 Apr, 2006 and managed similarly to local growing practices. Plots consisted of two 84-inch beds, 50 ft long with a 15 buffer between each plot. The study was designed as a randomized complete block design with 4 replicates / treatment. The treatments and rates are shown below:

Treatment	Rate/ac
Assail 30WG	4 oz
Venom 70WG	4 oz
Oberon+Endosulfan	8.5 oz + 32 oz
Capture+Endosulfan	6.4 oz + 32 oz
Endosulfan	32oz
Untreated (UTC)	--

The foliar spray treatments were applied with a CO_2 backpack sprayer that delivered 26 GPA at 60 psi, using 4 – TX18 ConeJet nozzles per bed. A single foliar application was made on 24 May. All spray treatments included DyneAmic at 0.06% v/v. Populations of adult and immature whiteflies were evaluated at 7 day intervals. Adult populations were estimated by taking leaf turn samples from the 5th terminal leaf on the primary melon vine of 10 randomly selected plants per replicate. Immature densities were estimated by sampling 5 plants / plot, where 4 leaves were collected from each plant on the 5th, 10th, 15th, and 20th leaves from the terminal on the primary vine. Leaves were taken into the laboratory where densities of eggs, nymphs, and eclosed pupae were counted on 2-cm^2 leaf discs of each leaf using a dissecting microscope. Data for adults were estimated as numbers of adults per leaf. Immature densities were averaged across all leaf positions on each sample date and reported as immature numbers per 2-cm^2 per leaf. Yields and quality were measured by harvesting the total number of full slip melons in a 12 row ft area within each replicate every other day over a 2 week period beginning on 21 Jun (7 harvest dates). Quality was assessed by estimating the percentage of harvested melons that were visibly contaminated with sooty mold on at least 25 cm^2 of the fruit surface area.

Bifenthrin and Alternative Insecticide Combination, Spring 2007: Cantaloupe plots planted with 'Gold Express' were established at the Yuma Agricultural Center on 27 Mar. 2007 and managed similarly to local growing practices. Plots consisted of two 84-inch beds, 45 ft long with a 7 buffer between each plot. The study was designed as a randomized complete block design with 4 replicates / treatment. The treatments and rates are shown below:

Treatment 1	Treatment 2	Rate 1	Rate 2
Capture	Thionex	6 oz	32 oz
Capture	Vydate L	6 oz	2 pts
Capture	Lannate SP	6 oz	1 lb
Capture	Dibrom	6 oz	16 oz
Capture	ABBA	6 oz	16 oz
Capture	MSR	6 oz	32 oz
Capture	Venom	6 oz	4 oz
Capture	-	6 oz	
Thionex	-	32 oz	
UTC	-		

The foliar spray treatments were applied with a CO_2 backpack sprayer that delivered 28 GPA at 50 psi, using 3 – TX18 ConeJet nozzles per bed. Foliar applications were made on 29 May and 12 June. All spray treatments included DyneAmic at 0.35% v/v. Populations of whitefly adults were evaluated at 2, 4, 7, 11 and 14 day intervals following each application. Adult populations were estimated by taking leaf turn samples from the 5th terminal leaf on the primary melon vine of 10 randomly selected plants per replicate. Immature densities were estimated at 14 days following each spray by sampling 5 plants / plot, where 3 leaves were collected from each plant on the 6th, 12th, and 18th nodes from the terminal on the primary vine. Leaves were taken into the laboratory where densities of eggs, and nymphs were counted on two, 2-cm^2 leaf discs of each leaf using a dissecting microscope. Data for adults were estimated as numbers of adults per leaf. Immature densities were averaged across all leaf positions on each sample date and reported as immature numbers per 2-cm^2 per leaf. Yields and quality were not measured.

Bifenthrin Formulation Comparison, Spring 2007: Cantaloupe plots planted with 'Gold Express' were established at the Yuma Agricultural Center on 27 March, 2007 and managed similarly to local growing practices. Plots consisted of two 84-inch beds, 45 ft long with a 7 ft buffer between each plot. The study was designed as a randomized complete block design with 4 replicates / treatment. The treatments included four 2EC formulations of bifenthrin (Capture, Dicipline, Fanfare, and Bifenture) all applied at the 6 oz /acre rate and in combination with endosulfan (Thionex) at the 32 oz /acre rate. Similar to the previous trial in 2007, foliar spray treatments were applied with a CO_2 backpack sprayer that delivered 28 GPA at 50 psi, using 3 – TX18 ConeJet nozzles per bed. Foliar applications were made on 29 May and 12 June. All spray treatments included DyneAmic at 0.35% v/v. Populations of whitefly adults and immatures were evaluated similarly to the previous 2007 trial. Yields and quality were not measured.

Results and Discussion

Adult Control, Spring 2006: Adult populations were high for a spring trial. We initiated the foliar sprays when adult numbers exceeded the 2-adult / leaf threshold on 24 May. All spray treatments provided significant adult knockdown at 2 and 4 DAT (days after application) compared with the untreated check (Table 1). By 7 DAT the whitefly populations began to rebound and only the Capture+Thionex and Thionex treatments had significantly fewer adults than the UTC. Similarly, only the Capture+Thionex combination maintained the adult population below the action threshold at 4 and 7 DAT, and by 14 DAT none of the treatments were significantly lower than the untreated check. Measurements of eggs showed that all the treatments significantly reduced egg densities at 7 DAT (Table 2). At 14 DAT, only the Venom and Oberon + Endosulfan treatments had significantly lower egg densities than the UTC. By 21 DAT none of the treatments had a significant effect on egg densities. In contrast, all treatments significantly reduced nymph densities at 14 and 21 DAT (Table 2). Insecticidal effects on nymph densities were not observed beyond 21 DAT. This was likely a result of diminished residual on leaf surfaces coupled with the late season migration of adults from a neighboring field similar to what we experienced in our action threshold study. Yields did not differ statistically among treatments, but differences in sooty mold contamination were observed (Table 3, Figure 1). Among all spray treatments, Oberon+Thionex provided the most consistent protection from honeydew and sooty mold contamination. This lack of fruit protection among the treatments was largely a reflection of the build-up of adult whiteflies and subsequent immature colonization on young leaves, just prior to and during harvest. A second foliar application would have presumably prevented the heavy sootymold contamination observed in the treatments mid-way through harvest.

Bifenthrin and Alternative Insecticide Combinations, Spring 2007: Adult populations were light this spring and we initiated our spray treatments at numbers just below the action threshold (1.7 / leaf). Following the first application, all treatment maintained adult numbers below the 2 adult/ leaf threshold for 7 days (Table 4, Figure 2). Although all treatments had significantly lower numbers than the UTC at 11 DAT, only the Capture+Thionex treatment maintained adult numbers below the threshold. By 14 DAT, none of the treatments were significantly different from the UTC, but again the Capture +Thionex and Thionex alone treatments were below 2 adults/ leaf. Following the second spray, only the Capture+Thionex treatment provided adult suppression below the threshold for at 7 days although all the spray treatments had significantly fewer adults/leaf than the UTC (Table 5, Figure 2). At 11 and 14 DAT, all treatments had fewer adults than the UTC, but none of them maintained numbers below the threshold. When averaged across both applications, only the Capture+Thionex maintained adult numbers below the 2 adult/leaf threshold. Measurements of immature at 14 days following each application showed that egg and nymph densities varied significantly among the treatments (Table 6). The Capture+Thionex, Thionex and Capture and Venom treatments provided the most consistent control of eggs and nymphs. The Capture + MSR, Lannate and Vydate provide inconsistent control relative to the UTC. The low immature densities observed with the Thionex treatments reflects the reduction in oviposition via adult mortality, and subsequently, preventing the establishment of immature populations on leaves. In contrast, the Capture+Venom treatment prevented immature colonization by the combined effects on adult mortality and through direct translaminar activity against early instar nymphs feeding on the leaves.

Bifenthrin Formulation Comparison, Spring 2007: Adult populations were a little heavier in this 2007 spring trial and spray treatments were initiated at 2.9 adults/leaf. The bifenthrin +Thionex treatments sprayed in this trial provided significant reductions in adult numbers for 14 days after both applications (Table 7). Following the first application, the Capture and Bifenture treatments provided significantly better adult knockdown than the Discipline and Fanfare treatments at 4 and 7 DAT (Figure3), but all the treatments maintained adult numbers near the threshold for 14 days. Following the second application, differences among the bifenthrin treatments were not observed (Table 7). However, beyond 4 DAT, none of the treatments were able to maintain adult numbers below the threshold (Figure 3). When averaged across both applications, all the bifenthrin+Thionex treatments maintained adult numbers at statistically comparable levels. Similarly, the bifenthrin+Thioniex provided comparable control of immature densities at 14 days following each application (Table 8).

Conclusions: These trials demonstrate that the synergized pyrethroid still provides the most significant knockdown activity on whitefly adults among registered alternatives in melons. In most cases, the addition of endosulfan (Thionex) with bifenthrin provided 7-14 days of adult suppression below the action threshold. Residual control of adults with these combinations appeared to less effective following a second sequential application. This is consistent with anecdotal comments made by PCAs in Yuma who claim that adults are more difficult to control with each successive application of synergized pyrethoid. Thionex applied alone provided comparable adult activity in some cases, and Capture+Venom provided xomparabel control of immature. We were optimistic that at least one of the alternative combinations would stand out as an effective alternative to Thionex. Although the other alternative tank-mix partners with Capture were less effective, combinations with Vydate, Lannate, Dibrom or ABBA might be useful to use in rotation with the Capture+thionex treatments to provide adult knockdown. As we anticipated, adult and immature whitefly control did not differ among the bifenthrin formulations (Capture vs. generics). Finally, because of the risk of whitefly resistance and the heavy reliance on pyrethoids in all vegetable crops grown in the desert, new alternatives for adult whitefly control are needed.

Acknowledgments

Funding for this project was provided through a grant from the *California Melon Research Board.* Additional support was provided by Bayer CropSciences, FMC, Valent, AmVac, Cerexagri, and MANA. I gratefully acknowledge the excellent assistance from the personnel at the Yuma Agricultural Center including my research assistants Andreas Amaya, Luis Ledesma, Leonardo Chavez, Javier Ruis, and YAC farm manager, Jesus Pereria.

Table 1. Control of whitefly adults following a single application with various insecticide treatments, spring 2006.

		Avg. Whitely Adults / Leaf					
		Pre	*2 DAT*	*4 DAT*	*7 DAT*	*14 DAT*	*21 DAT*
Treatment	**Rate/ac**	**24-May**	**26-May**	**28-May**	**31-May**	**7-Jun**	**14-Jun**
Assail 30WG	4 oz	3.7	1.4 b	6.0 bc	5.1 a	2.9 a	4.8 a
Venom 70WG	4 oz	3.7	0.6 b	2.3 de	6.8 a	2.8 a	5.7 a
Oberon+Thionex	8.5 oz+32 oz	3.7	1.4 b	2.6 cde	4.3 ab	2.7 a	5.1 a
Capture+Thionex	6.4 oz+32 oz	3.7	0.4 b	1.5 e	1.8 b	4.3 a	6.5 a
Thionex	32 oz	3.7	1.2 b	4.1 cde	2.4 b	2.9 a	6.7 a
UTC	.	3.7	8.0 a	11.8 a	7.7 a	5.1 a	8.2 a

Means followed by the same letter are not significantly different (protected LSD; $p>0.05$)

Table 2. Control of whitefly immatures following a single application with various insecticide treatments, spring 2006.

		Eggs / cm^2 / Leaf			Nymphs / cm2 / Leaf		
		7 DAT	*14 DAT*	*21 DAT*	*7 DAT*	*14 DAT*	*21 DAT*
Treatment	**Rate/ac**	**31-May**	**7-Jun**	**14-Jun**	**31-May**	**7-Jun**	**14-Jun**
Assail 30WG	4 oz	1.3 cd	4.0 abc	8.1 a	0.2 a	1.0 b	3.2 b
Venom 70WG	4 oz	0.5 d	1.9 c	6.4 a	0.2 a	0.2 b	1.9 b
Oberon+Thionex	8.5 oz+32 oz	0.5 d	3.4 bc	7.0 a	0.2 a	0.4 b	1.2 b
Capture+Thionex	6.4 oz+32 oz	1.1 cd	4.1 abc	11.3 a	0.4 a	1.2 b	3.9 b
Thionex	32 oz	2.1 bc	4.7 abc	9.9 a	0.5 a	1.6 b	4.9 b
UTC	.	3.5 a	6.6 a	11.1 a	0.6 a	4.4 a	9.3 a

Means followed by the same letter are not significantly different (protected LSD; $p>0.05$)

Table 3. Fruit yield and quality in treated cantaloupe plots, spring 2006

		Yields	Quality
Treatment	Rate/ac	Total avg. fruit / plot	% Melons with sooty mold
Assail 30WG	4 oz	24.3 a	65.6 bc
Venom 70WG	4 oz	29.0 a	47.8 c
Oberon+Thionex	8.5 oz+32 oz	26.3 a	29.6 d
Capture+Thionex	6.4 oz+32 oz	26.0 a	48 c
Thionex	32 oz	22.5 a	50.9 c
UTC	.	27.3 a	88.9 a

Means followed by the same letter are not significantly different (protected LSD; *p>0.05*)

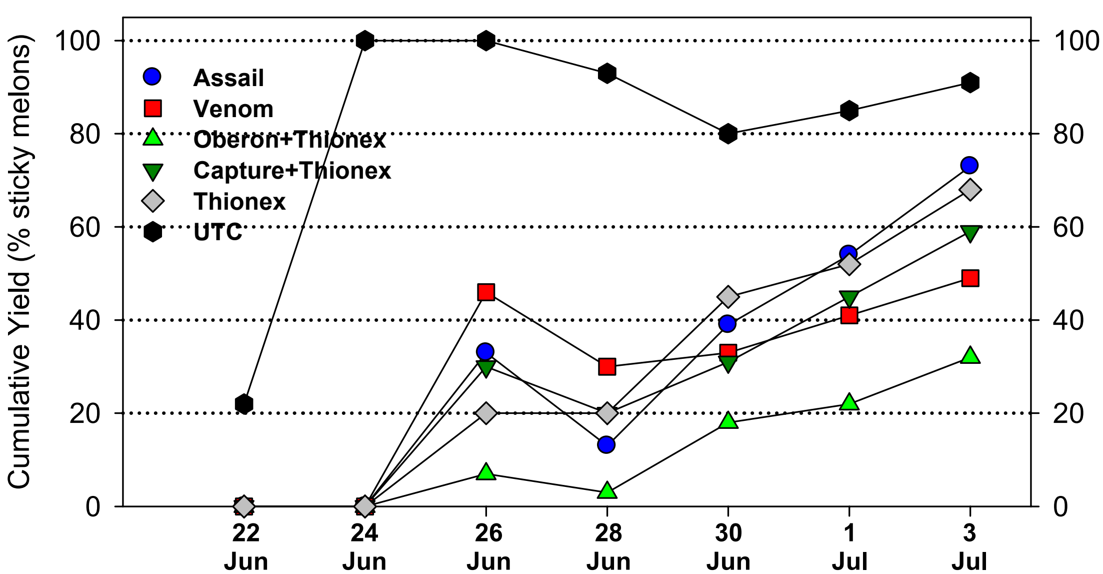

Figure 1. Cumulative sooty mold contamination on fruit during harvest on spring melons, 2006.

Table 4. Adult whitefly numbers / leaf on cantaloupes treated with bifenthrin combinations, Application # 1, Spring 2007

		Avg. Adults / Leaf					
		Pre-counts	***2 DAT***	***4 DAT***	***7 DAT***	***11 DAT***	***14 DAT***
Treatment	**Date**	**27-May**	**31-May**	**2-Jun**	**5-Jun**	**9-Jun**	**12-Jun**
Capture+Thionex	6 oz+32 oz	1.7	0.1 cd	0.2 c	0.4 b	1.1 d	1.4 a
Capture+Vydate	6 oz+2 pts	1.7	0.5 cd	0.5 bc	0.8 b	2.2 cd	3.3 a
Capture+Lannate	6 oz+3 pts	1.7	0.8 bc	0.6 bc	0.9 b	3.0 bcd	2.7 a
Capture+Dibrom	6 oz+16 oz	1.7	0.6 bcd	1.0 bc	0.9 b	3.2 bcd	2.4 a
Capture+ABBA	6 oz+16 oz	1.7	1.3 ab	1.4 b	1.1 b	2.4 bcd	2.1 a
Capture+MSR	6 oz+32 oz	1.7	0.6 cd	1.1 bc	1.5 b	3.7 bc	3.3 a
Capture+Venom	6 oz+4 oz	1.7	0.1 d	0.5 bc	1.2 b	4.7 ab	3.9 a
Capture	6 oz	1.7	0.5 cd	0.9 bc	0.8 b	2.5 bcd	2.8 a
Thionex	32 oz	1.7	0.2 cd	0.3 c	0.6 b	2.4 bcd	1.8 a
UTC	-	1.7	1.9 a	2.9 a	3.2 a	6.1 a	3.9 a

Means followed by the same letter are not significantly different (protected LSD; $p>0.05$)

Table 5. Adult whitefly numbers / leaf on cantaloupes treated with bifenthrin combinations, Application # 2, Spring 2007

		Avg. Adults / Leaf					
		2 DAT	***4 DAT***	***7 DAT***	***11 DAT***	***14 DAT***	
Treatment	**Date**	**14-Jun**	**16-Jun**	**19-Jun**	**23-Jun**	**26-Jun**	**Seasonal Average**
Capture+Thionex	6 oz+32 oz	0.2 e	0.6 d	1.8 d	3.7 c	8.2 cd	1.8 d
Capture+Vydate	6 oz+2 pts	1.1 bcde	3.3 bd	6.4 bcd	10.1 bc	17.4 bc	4.6 b
Capture+Lannate	6 oz+3 pts	1.6 bc	2.3 bcd	6.0 bcd	10.9 bc	12.6 bcd	4.1 bc
Capture+Dibrom	6 oz+16 oz	2.2 b	3.6 bc	7.5 bc	11.1 bc	11.3 cd	4.4 bc
Capture+ABBA	6 oz+16 oz	2.1 b	3.9 bc	7.2 bc	10.6 bc	14.9 bcd	4.7 b
Capture+MSR	6 oz+32 oz	1.3 bcd	3.9 bc	8.4 b	14.6 b	13.1 bcd	5.1 b
Capture+Venom	6 oz+4 oz	0.8 cde	2.0 bcd	5.6 bcd	11.3 bc	11.6 cd	4.2 bc
Capture	6 oz	1.4 bcd	3.2 bcd	8.4 b	14.5 b	22.8 ab	5.8 b
Thionex	32 oz	0.4 de	1.4 cd	3.6 cd	4.9 c	8.2 d	2.2 cd
UTC	-	4.6 a	7.3 a	13.5 a	25.30	33.4 a	10.1 a

Means followed by the same letter are not significantly different (protected LSD; *p>0.05*)

Table 6. Whitefly immature densities 14 d following applications with various insecticide treatments, spring 2007.

		Avg. immatures / cm^2 / leaf			
		Jun 12 (14 DAT#1)		Jun 26 (14 DAT#2)	
Treatment	**Date**	**Eggs**	**Nymphs**	**Eggs**	**Nymphs**
Capture+Thionex	6 oz+32 oz	0.8 f	0.5 de	3.3 e	1.5 f
Capture+Vydate	6 oz+2 pts	4.2 b	1.0 bcd	12.5 ab	6.1 bc
Capture+Lannate	6 oz+3 pts	2.3 cde	1.1 bc	11.5 abc	5.0 bcde
Discipline+Dibrom	6 oz+16 oz	1.9 cdef	0.8 bcd	6.5 bcde	3.7 cdef
Capture+ABBA	6 oz+16 oz	2.5 cd	1.0 bcd	8.4 bcde	5.6 bcd
Capture+MSR	6 oz+32 oz	2.5 cd	1.2 ab	7.7 bcde	5.0 bcde
Capture+Venom	6 oz+4 oz	1.6 def	0.3 e	3.9 de	1.4 f
Capture	6 oz	2.1 cdef	0.8 bcd	6.3 bcde	3.1 def
Endosulfan	32 oz	1.0 ef	0.7 cde	4.4 cde	2.9 ef
UTC	-	5.9 a	1.7 a	16.9 a	10.3 a

Means followed by the same letter are not significantly different (protected LSD; $p>0.05$)

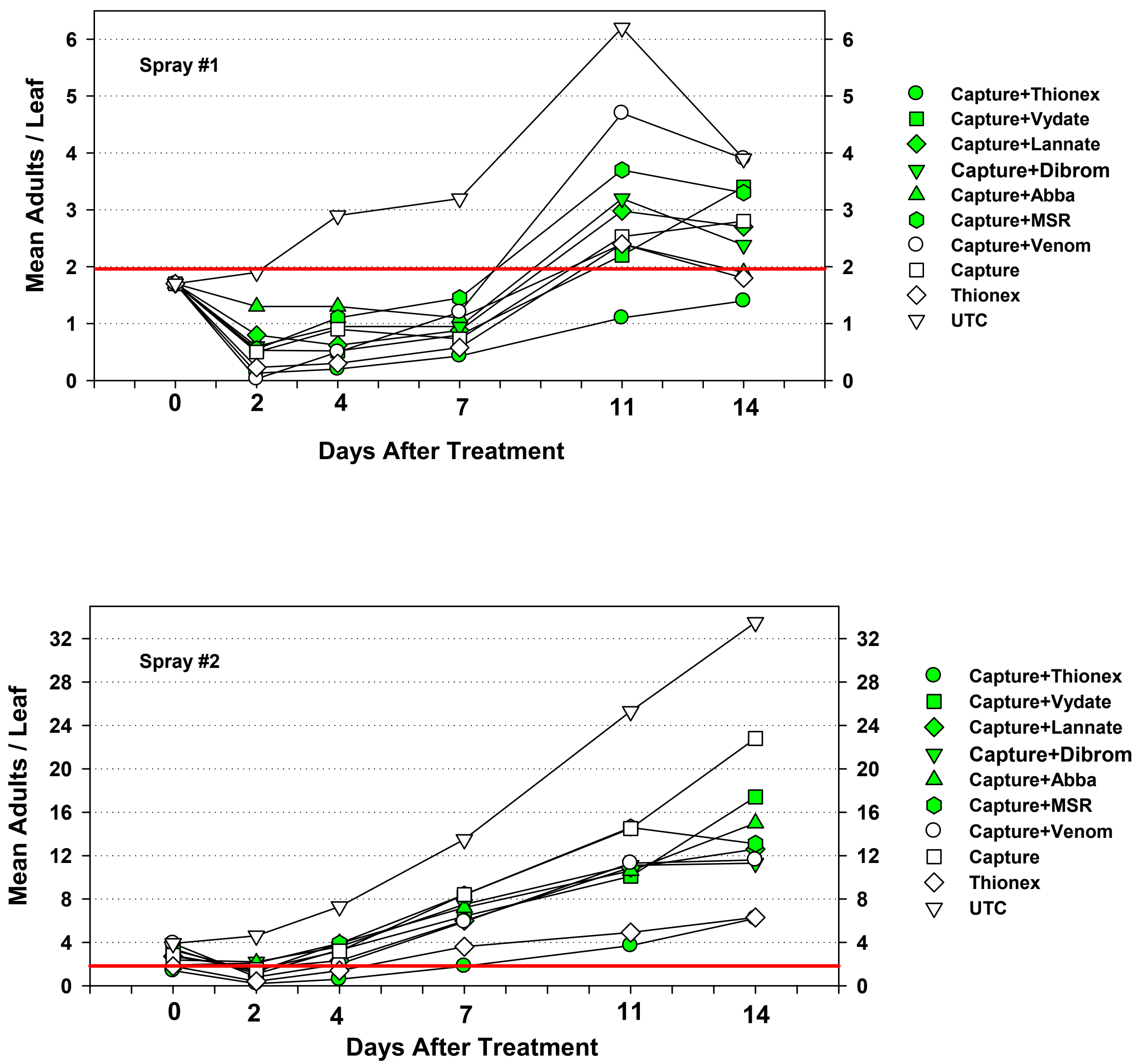

Figure 2. Adult whitefly numbers / leaf following insecticide applications on spring melons, 2007

Table 7. Adult whitefly numbers / leaf on cantaloupes treated with various bifenthrin formulations following 2 applications, Spring 2007

	Avg. Adults / Leaf											
	Pre	*2 DAT*	*4 DAT*	*7 DAT*	*11 DAT*	*14 DAT*	*2 DAT*	*4 DAT*	*7 DAT*	*11 DAT*	*14 DAT*	
Treatment	**27 May**	**31 May**	**2 Jun**	**5 Jun**	**9 Jun**	**12 Jun**	**14 Jun**	**16 Jun**	**19 Jun**	**23 Jun**	**26 Jun**	**Seasonal Average**
Capture+Thionex	2.9	0.2 b	0.3 c	0.5 c	2.0 b	1.9 b	0.2 b	1.0 b	2.8 b	6.8 b	5.5 b	2.1 b
Dicipline+Thionex	2.9	0.3 b	0.6 bc	1.5 b	2.1 b	2.5 b	0.4 b	1.4 b	4.1 b	7.9 b	7.0 b	2.8 b
Fanfare+Thionex	2.9	0.2 b	1.1 b	1.3 b	2.6 b	3.0 b	0.3 b	1.4 b	4.3 b	7.0 b	7.1 b	2.8 b
Bifenture+Thionex	2.9	0.3 b	0.7 bc	1.0 bc	2.5 b	2.2 b	0.5 b	1.5 b	3.0 b	8.2 b	6.7 b	2.6 b
UTC	2.9	4.2 b	4.3 a	4.0 a	6.5 a	5.6 a	5.3 a	9.6 a	12.5 a	21.3 a	17 a	9.1 a

Means followed by the same letter are not significantly different (protected LSD; *p>0.05*)

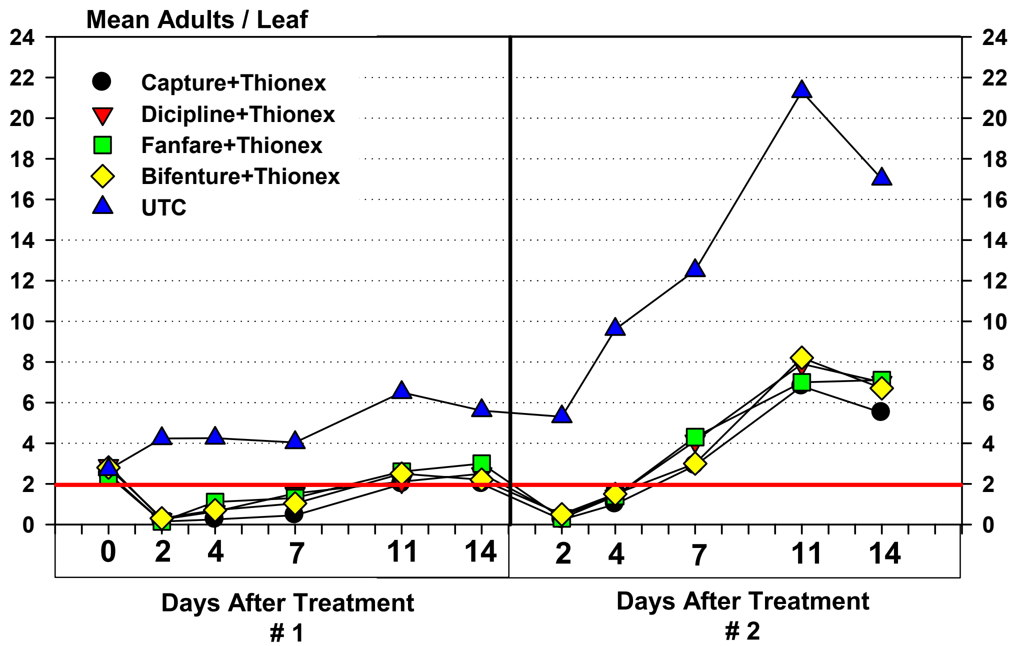

Figure 3. Adult whitefly numbers / leaf following insecticide applications on spring melons, 2007

Table 8 Whitefly immature densities 14 d following applications with various insecticide treatments, spring 2007.

	Avg. immatures / cm² / leaf			
	Jun 12 (14 DAT#1)		Jun 26 (14 DAT#2)	
Treatment	**Eggs**	**Nymphs**	**Eggs**	**Nymphs**
Capture+Thionex	1.7 b	0.8 a	3.3 b	1.5 b
Dicipline+Thionex	1.8 b	1.1 a	4.3 b	1.5 b
Fanfare+Thionex	1.6 b	1.0 a	4.4 b	1.7 b
Bifenture+Thionex	2.0 b	1.3 a	2.4 b	1.9 b
UTC	8.0 a	3.9 a	10.7 a	7.3 a

Means followed by the same letter are not significantly different (protected LSD; *p>0.05*)