

## Spray Timing of Spiromesifen and Buprofezin for Managing *Bemisia* Whiteflies in Cantaloupes

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### Abstract

Field experiments were conducted from 2004 to 2006 to evaluate thresholds for timing the spray application of spiromesifen and buprofezin for controlling *Bemisia* whiteflies in spring cantaloupes. Both novel insecticides provided residual control of whitefly nymphs while significantly preventing sooty mold contamination on melons when applications were initiated after populations exceeded a threshold of 2 adults per leaf or 0.5 large nymphs per 2-cm<sup>2</sup> leaf disc. Both spiromesifen and buprofezin, regardless of which threshold was used, provided residual suppression of whitefly immature population growth that was as good as or better than foliar and soil-applied neonicotinoid treatments. This study demonstrated that either of these two selective insecticides with unique modes of action can be used as an effective foliar alternative to the industry standard insecticides for managing whiteflies on spring cantaloupes.

### Introduction

*Bemisia* whiteflies, *B. tabaci* (Gennadius) and *B. argentifolii* Bellows & Perring, are a major pest of spring grown cantaloupes (*Cucumis melo* var. *cantalupensis* Naudin) in the southwestern United States and cause losses in fruit quality by contaminating marketable melons with honeydew and sooty mold (2,10,14). Consequently, growers have become dependent on insecticides to prevent economic losses (13). Imidacloprid (Admire), has been the most effective compound registered for whitefly control in cantaloupes and its sustained efficacy over the past 16 years has exceeded the expectations of many who speculated that whiteflies would quickly develop resistance (11). No field failures have been reported to date, in part, because imidacloprid has been used sparingly in other crops such as cotton (1). However, the registration of several new neonicotinoid compounds on cotton, cucurbits, and vegetables has expanded the number of foliar applied compounds available for whitefly control on all of these crops (12). Their present usage on all crops heightens selection pressure on this class of chemistry, particularly in multi-cropping communities throughout the southwest where these compounds can be applied to a number of successive whitefly generations on neighboring crops throughout the year. Given the tremendous value of the neonicotinoid chemistry, it is important that alternative modes of action be utilized in melon pest management programs to help sustain management of whiteflies in all crops.

Two selective foliar insecticides with novel modes of action have been developed that are effective in reducing whitefly populations. Buprofezin (Courier) is an insect growth regulator (IGR) that inhibits chitin synthesis (3,11), and spiromesifen (Oberon) is a newly registered IGR-like compound that inhibits lipid biosynthesis (4). Both compounds prevent the development of nymphs, and neither compound effectively controls adults (6). Efficacy studies have demonstrated that application of these compounds early in *Bemisia* population growth can provide residual control of nymphs on cantaloupes (5,7). However, University of Arizona pest management guidelines presently recommend that growers make only a single application of either insecticide during a single crop season to reduce selection pressure (12). Although action

thresholds have been developed for control of *Bemisia* adults with pyrethroids on cantaloupes (15), studies to determine the optimal spray timing for these compounds on spring cantaloupes has not been previously conducted. Thus, the objective of this study was to evaluate and compare spray timings based on a pre-determined threshold at which a single application of these compounds can be applied to effectively manage *Bemisia* whiteflies and prevent significant sooty mold contamination on melons.

### Small Plot Experiments (2004 to 2006)

From 2004 to 2006, complementary small plot experiments were conducted at the University of Arizona Yuma Agricultural Center Research Farm in Yuma, AZ. Cantaloupes (variety 'Gold Express') were direct seeded (19 March 2004, 16 March 2005, 6 April 2006) on 2.1-m row center and managed similarly to local growing practices. Individual plots measured two 4.2-m beds 21.3-m in length with a 4.2-m unplanted buffer between each plot.

Experiments consisted of foliar insecticide treatments representing different IRAC modes of action (Table 1). The foliar spray treatments were arranged in a RCB design and included an industry standard (imidacloprid applied to the soil) and an untreated control. Treatments were replicated four times in each experiment and were applied at two predetermined thresholds when *Bemisia* populations exceeded either an adult threshold of 2 adults per leaf or an immature threshold of 0.5 large nymphs per 2-cm<sup>2</sup> leaf disc (Table 2). Although the objective of this study was to apply only a single application, in 2004 two applications of spiromesifen and buprofezin were made in plots using the nymph threshold. This occurred because 1.2 inches of rain fell on the treated plants the day following the first application (8 May). Consequently, a second application was made on 5 June when the nymph densities exceeded the nymph threshold. Only a single insecticide application was made in 2005 and 2006. Imidacloprid (Admire 2F) was applied in each study by injecting the product 3 inches below the seed line through fertilizer shanks prior to seed placement in 280 liters/ha final solution. The foliar spray treatments were applied with a tractor-driven sprayer that delivered 200 liters/ha through four TX18 ConeJet nozzles per bed. All spray treatments included an adjuvant (Dyne-Amic, Helena Chemical Co.) at 0.06% v/v.

Table 1. Insecticides evaluated in small plot trials for efficacy to reduce *Bemisia* density and prevent fruit quality losses at harvest on spring cantaloupes, 2004 to 2006.

Insecticide, active ingredient	Product name (and manufacturer)	IRAC mode of action	Rate applied (g ai/ha)
Spiromesifen	Oberon 2SC (Bayer Crop Sciences)	23	145
Buprofezin	Courier 40SC (Nichino America, Inc.)	16	410
Acetamiprid	Assail 30SG (United Phosphorus, Inc.)	4A	85
Dinotefuron	Venom 70SG (Valent USA Corp.)	4A	200
Imidacloprid	Admire 2F (Bayer Crops Sciences)	4A	280

Table 2. Application dates for insecticides and spray thresholds used to time spray applications on spring cantaloupes, 2004 to 2006.

Experiment	Insecticides	Threshold	Application dates
2004	spiromesifen, buprofezin	adults	24 May
		nymphs	8 May, 5 Jun
2005	spiromesifen, buprofezin, acetamiprid	adults	1 Jun
		nymphs	14 May
2006	spiromesifen buprofezin, dinotefuron	adults	25 May
		nymphs	9 Jun

### Treatment Efficacy Evaluation and Statistical Analysis

To evaluate the efficacy of the insecticide treatments and spray timings, populations of whitefly adults and nymphs were evaluated at 7-day intervals beginning in April of each year and continuing until harvest. 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 (9,10). Densities of large nymphs (3rd and 4th instars) 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 the number of nymphs was counted on two 2-cm<sup>2</sup> leaf discs of each leaf using a dissecting microscope (17). Yields and quality were measured by harvesting the total number of mature, full slip cantaloupe fruit in a 15 row ft area within each plot every other day over a 2-week period (6 to 7 harvest dates). Quality was assessed by estimating the percentage of harvested fruit that were visibly contaminated with honeydew and sooty mold on at least 25 cm<sup>2</sup> of the fruit surface area using a plastic template used by commercial melon growers.

Experimental data for nymph densities, total fruit yields, and sooty mold contamination were analyzed separately for each year using analysis of variance with insecticide treatments as the classification variable (PROC GLM, SAS Institute Inc., Cary, NC). When appropriate to stabilize variances, means were transformed for nymph densities ( $\log[x+0.5]$ ) and percentage of contaminated fruit ( $\arcsine[\text{square root}(y)]$ ) before analysis of variance. When significant F-values were reported, means were separated by protected least significant difference test (PROC GLM, SAS Institute Inc.). Untransformed mean values for each life stage are presented in the figures and tables.

### Insecticide Spray Timing on *Bemisia* Population Densities and Fruit Contamination

In 2004, whitefly movement into the plots from surrounding commercial fields began during mid-May causing the adult spray threshold to trigger on 24 May. The nymph spray threshold treatments initially triggered on 8 May. However, as noted earlier, the thunderstorm that dropped unusually heavy rainfall on the plots significantly reduced whitefly populations in all plots. Thus, a second application was made to those treatments based on nymph densities on 5 June when the population appeared to recover (Fig. 1).

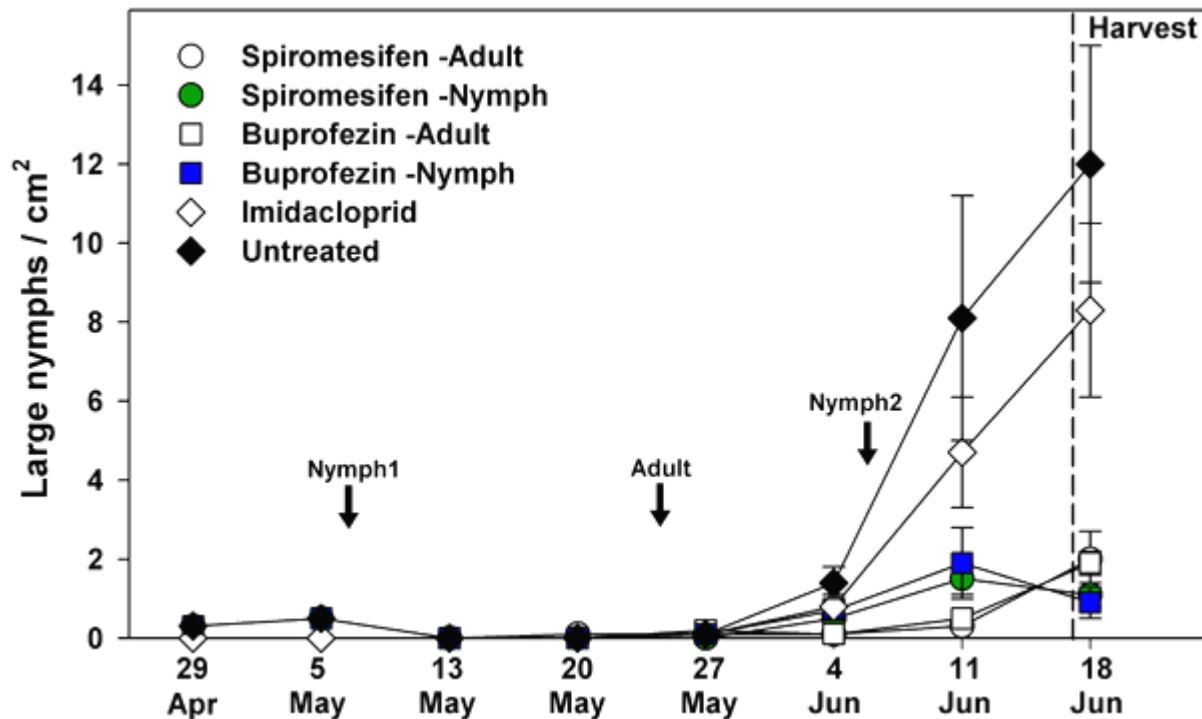


Fig. 1. Average ( $\pm$  SEM) *Bemisia* whitefly nymph densities on spring cantaloupes prior to and following insecticide sprays using adult and nymphs thresholds for timing applications, 2004. Arrows indicate when sprays for adult and nymph threshold were applied. Dashed vertical line indicates when harvest was initiated.

Following the insecticide sprays, *Bemisia* nymph densities remained low, and were significantly reduced in all the spray treatments compared with the untreated check by harvest on 16 June. When averaged across sample dates, differences in nymph densities among spiromesifen and buprofezin treatments were not observed, regardless of which threshold was used (Table 3). Yield estimates made during the harvest period (16 to 28 June) showed that average fruit yields per 15 ft did not differ significantly among the insecticide threshold treatments (Table 3). Similar estimates were observed in 2005 and 2006 as well (Tables 4 and 5). The lack of yield responses among treatments was not unexpected since whitefly feeding pressure was low during fruit set and maturation. However, feeding by *Bemisia* nymphs prior to and during harvest can result in excessive sooty mold accumulation on maturing fruit (14). Consequently, fruit quality was significantly reduced in the Admire treatment and the untreated check (Table 3). All the spray treatments, regardless of spray timing, had significantly less sooty mold contamination on fruit which was consistent with lower whitefly densities that had developed at harvest (Table 3).

Table 3. Average ( $\pm$  SEM) large nymph densities and yield and quality estimates for insecticide spray threshold treatments applied to spring cantaloupes, 2004.

Treatment	Spray threshold	<i>Bemisia</i> densities	Melon yields and quality	
		Avg. large nymphs/cm <sup>2</sup>	Avg. fruit/15 row ft	Percent contaminated fruit
spriomesifen	adult	0.4 $\pm$ 0.1 b	31.8 $\pm$ 2.3 a	0.0 $\pm$ 0.0 c
spriomesifen	nymph	0.5 $\pm$ 0.1 b	31.8 $\pm$ 2.5 a	5.3 $\pm$ 2.0 c
buprofezin	adult	0.4 $\pm$ 0.1 b	30.8 $\pm$ 1.1 a	7.6 $\pm$ 2.9 c
buprofezin	nymph	0.6 $\pm$ 0.2 b	29.8 $\pm$ 2.2 a	9.9 $\pm$ 5.1 c
imidacloprid	—	2.3 $\pm$ 0.7 a	34.8 $\pm$ 2.9 a	42.8 $\pm$ 6.2 b
untreated	—	3.6 $\pm$ 0.9 a	34.3 $\pm$ 3.5 a	78.4 $\pm$ 3.9 a
<i>F value</i>		6.87	0.76	40.59
<i>Pr. &gt; F</i>		0.0016	0.5942	<.0001

Means within a column followed by the same letter are not significantly different (df = 3, 5;  $\alpha$  = 0.05; protected least significant difference test, LSD, PROC GLM, SAS Institute Inc., Cary, NC).

Table 4. Average ( $\pm$  SEM) large nymph densities and yield and quality estimates for insecticide spray threshold treatments applied to spring cantaloupes, 2005.

Treatment	Spray threshold	<i>Bemisia</i> densities	Melon yields and quality	
		Avg. large nymphs/cm <sup>2</sup>	Avg. fruit/15 row ft	Percent contaminated fruit
spriomesifen	adult	0.8 $\pm$ 0.2 b	22.5 $\pm$ 1.2 a	0.0 $\pm$ 0.0 b
spriomesifen	nymph	0.7 $\pm$ 0.1 b	20.0 $\pm$ 0.8 a	0.0 $\pm$ 0.0 b
buprofezin	adult	0.8 $\pm$ 0.2 b	23.3 $\pm$ 1.4 a	0.0 $\pm$ 0.0 b
buprofezin	nymph	0.8 $\pm$ 0.1 b	25.5 $\pm$ 1.0 a	0.0 $\pm$ 0.0 b
acetamiprid	adult	1.0 $\pm$ 0.2 b	22.8 $\pm$ 2.6a	1.0 $\pm$ 1.0 b
acetamiprid	nymph	1.0 $\pm$ 0.2 b	22.0 $\pm$ 2.7 a	1.4 $\pm$ 1.2 b
imidacloprid	—	1.8 $\pm$ 0.2 a	25.3 $\pm$ 2.7 a	3.9 $\pm$ 2.2 b
untreated	—	2.1 $\pm$ 0.4 a	23.5 $\pm$ 2.7 a	14.6 $\pm$ 3.1 a
<i>F value</i>		10.05	0.86	3.24
<i>Pr. &gt; F</i>		<.0001	0.5562	0.0171

Means within a column followed by the same letter are not significantly different (df = 3, 7;  $\alpha$  = 0.05; protected least significant difference test, LSD, PROC GLM, SAS Institute Inc., Cary, NC).

Table 5. Average ( $\pm$  SEM) large nymph densities and yield and quality estimates for insecticide spray threshold treatments applied to spring cantaloupes, 2006.

Treatment	Spray threshold	<i>Bemisia</i> densities	Melon yields and quality	
		Avg. large nymphs/cm <sup>2</sup>	Avg. fruit/15 row ft	Percent contaminated fruit
sprimesifen	adult	3.3 $\pm$ 0.9 c	28.0 $\pm$ 1.7 a	29.4 $\pm$ 4.0 bc
sprimesifen	nymph	1.7 $\pm$ 0.4 c	28.0 $\pm$ 1.6 a	19.9 $\pm$ 1.7 c
buprofezin	adult	3.9 $\pm$ 0.5 c	25.0 $\pm$ 1.6 a	32.2 $\pm$ 5.7 bc
buprofezin	nymph	3.7 $\pm$ 1.7 c	30.0 $\pm$ 2.8 a	20.9 $\pm$ 0.7 c
dinotefuron	adult	4.0 $\pm$ 0.5 c	31.3 $\pm$ 2.2 a	27.9 $\pm$ 2.5 bc
dinotefuron	nymph	2.9 $\pm$ 0.6 c	28.5 $\pm$ 2.8 a	35.1 $\pm$ 9.1 bc
imidacloprid	—	7.1 $\pm$ 2.3 b	30.0 $\pm$ 1.6 a	57.1 $\pm$ 2.0 ab
untreated	—	13.3 $\pm$ 4.3 a	25.0 $\pm$ 3.1 a	71.3 $\pm$ 7.1 a
<i>F</i> value		12.33	1.70	3.03
<i>Pr.</i> > <i>F</i>		<.0001	0.1638	0.0228

Means within a column followed by the same letter are not significantly different (df = 3, 7;  $\alpha$  = 0.05; protected least significant difference test, LSD, PROC GLM, SAS Institute Inc., Cary, NC).

In 2005, whitefly pressure was considerably lower than the previous spring. Reductions in large nymph densities were comparable for both the adult and nymph thresholds following treatments, regardless of insecticide used (Fig. 2, Table 4). Similar to the previous year, yield estimates at harvest (17 to 29 June) showed that average fruit yields were not significantly different among the treatments, but sooty mold contamination was statistically greater on melons in the untreated check. Fruit quality was excellent in the buprofezin and spiromesifen spray treatments which had no detectable sooty mold contamination (Table 4).

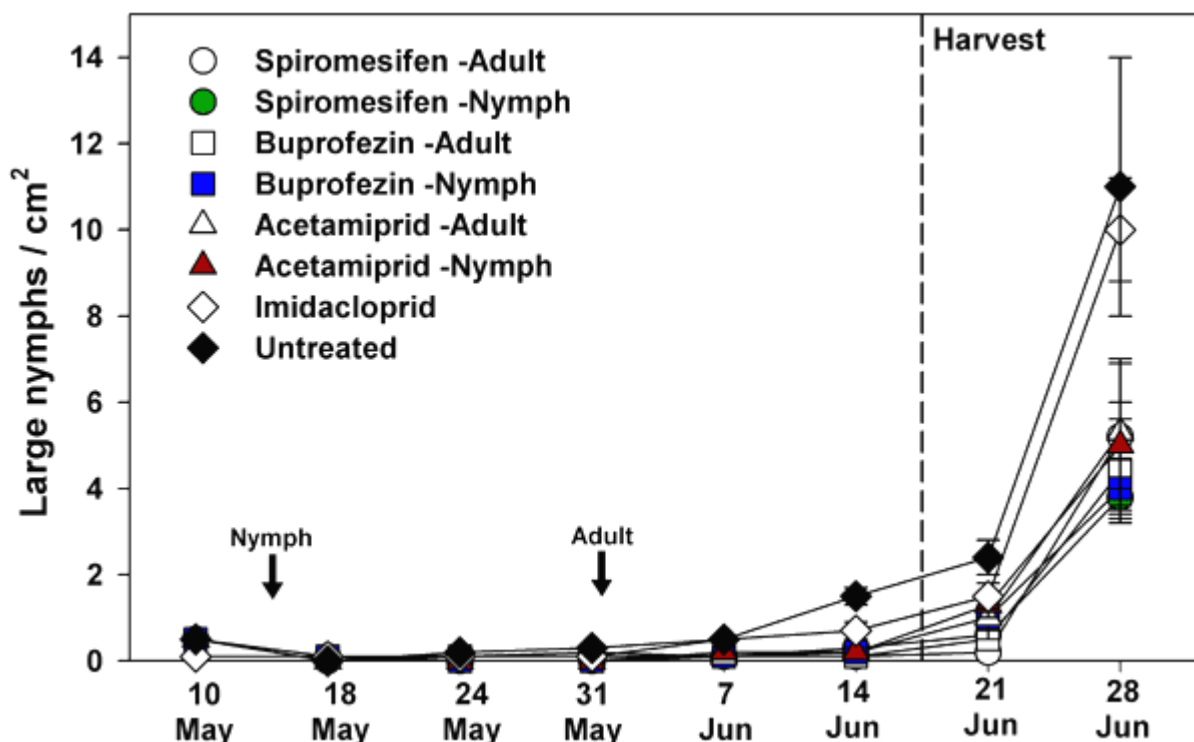


Fig. 2. Average ( $\pm$  SEM) *Bemisia* whitefly nymph densities on spring cantaloupes prior to and following insecticide sprays using adult and nymphs thresholds for timing applications, 2005. Arrows indicate when sprays for adult and nymph threshold were applied. Dashed vertical line indicates when harvest was initiated.

In an attempt to encourage larger whitefly numbers, cantaloupes were planted in April in the 2006 study, outside of the normal commercial planting window (January to March). Adult whitefly abundance on plants were very light for the first 6 weeks following seedling emergence, but by late May a large population of adults moved into the experimental area from an adjacent melon field that had been recently been harvested. This triggered the adult threshold (25 May), with the nymph threshold triggering sprays about 2 weeks later. As harvest approached, all spray treatments had maintained nymph populations at significantly lower densities compared with the untreated check (Fig. 3). Adult populations again migrated from an adjacent harvested melon field and quickly overwhelmed the test plots (> 60 adults per leaf). Under these conditions, a commercial melon grower would have been advised to spray the plants with an adulticide prior to harvest to knockdown the adult populations and suppress immature colonization. As a result of the late adult pressure, coupled with very warm temperatures (average 31°C), nymph densities developed quickly during the harvest period (22 June-4 July) and fruit contamination was higher in the insecticide treated plots compared to 2004 and 2005. When averaged across sample dates, all of the spray treatments significantly reduced nymph densities on cantaloupe plants compared to the untreated control and had significantly less sooty mold contamination (Table 5). Despite the variability in fruit contamination among treatments, significant differences in fruit contamination were not detected between the adult and nymph thresholds for either spiromesifen or buprofezin. This was likely a consequence of both treatment effects and whitefly distribution.

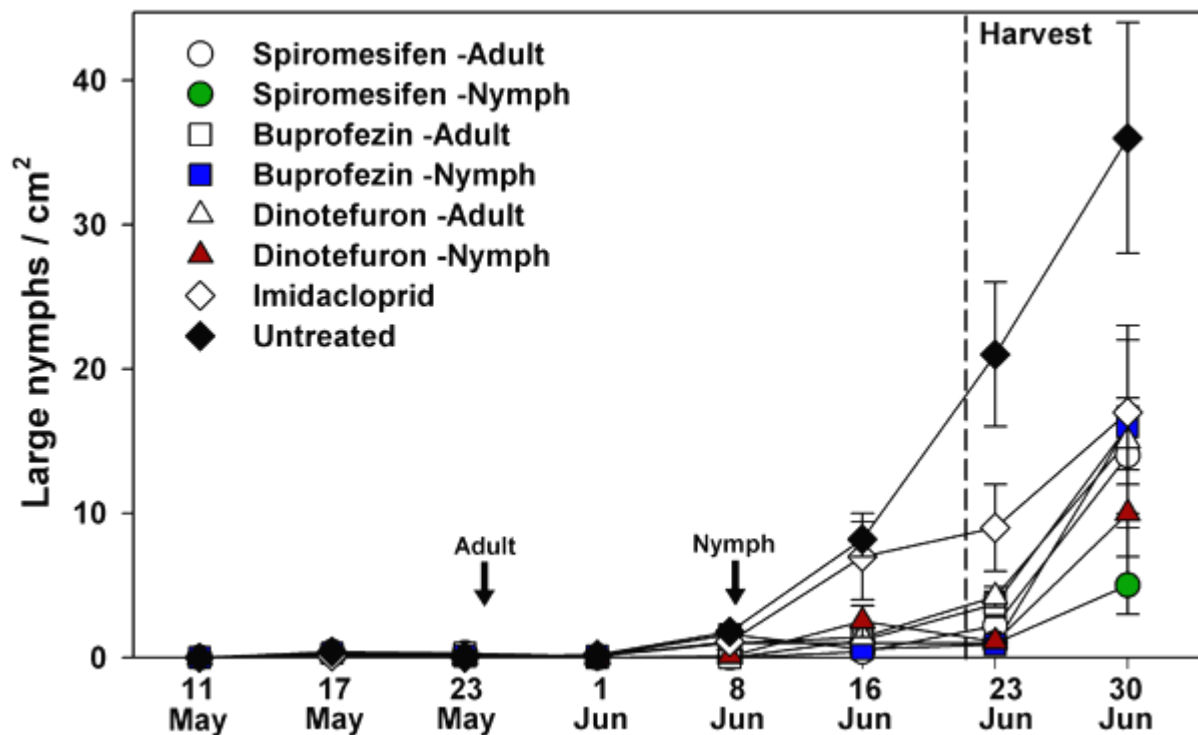


Fig. 3. Average ( $\pm$  SEM) *Bemisia* whitefly nymph densities on spring cantaloupes prior to and following insecticide sprays using adult and nymphs thresholds for timing applications, 2006. Arrows indicate when sprays for adult and nymph threshold were applied. Dashed vertical line indicates when harvest was initiated.

### Summary, Conclusions, and Recommendations

These experiments demonstrate that spiromesifen and buprofezin can be effective foliar alternatives to the neonicotinoid insecticides currently used for controlling *Bemisia* whiteflies in spring cantaloupes. Previous efficacy trials have shown that both compounds provided residual control of nymphs for more than 21 days (5,6) and this study is further evidence of that. Perhaps more importantly, this study clearly showed that a single application of spiromesifen or buprofezin applied early in whitefly population growth can prevent significant losses in cantaloupe fruit quality.



In this study, it was hypothesized that either of these two life stages would serve as an appropriate trigger for the application of these two selective insecticides even though they are not efficacious against the *Bemisia* adults (3,4). Research has shown that spring cantaloupes were protected from whiteflies and sooty mold contamination when nymph densities were maintained under 0.5 nymphs/cm<sup>2</sup> (14). These same studies suggested that adult abundance was strongly correlated with nymph densities; where regression analysis showed that estimates of nymph densities at 0.5 nymphs/cm<sup>2</sup> predicted an abundance of about 2 adults per leaf. From a practical perspective, an adult-based threshold would be more ideal for making spray decisions because a simple and reliable sampling procedure already exists for adult whiteflies (8,9). Spray decisions based on nymph sampling can be challenging due to the small size of *Bemisia* nymphs and the lack of a clearly defined sample unit for sampling large flowering or fruiting cantaloupe plants (16).

The conclusions drawn from this study support the hypothesis that an adult-based threshold can be used with IGR-like compounds such as spiromesifen and buprofezin to control whitefly populations and prevent significant losses in cantaloupe fruit quality comparable to a threshold that relies on nymph sampling. Under normal commercial planting conditions such as in 2004 and 2005, spray treatments applied using the 2-adult-per-leaf threshold provided good, consistent residual whitefly control through harvest. When melons were planted later than usual in 2006, all of the spray treatments, regardless of threshold used contained higher levels of fruit contamination than is commercially acceptable. This was largely due to warmer temperatures and to late whitefly colonization near harvest. Under similar conditions, a melon grower would be advised to treat with a synergized pyrethroid in order to suppress adult colonization (10). This further emphasizes the need to continue adult sampling following applications of spiromesifen or buprofezin, as well as the necessity to provide additional control of adult populations migrating into fields late in the season before harvest begins. This is particularly critical when growers consider following university IPM guidelines which restrict the use of IGR-like compounds to a single application per crop season.

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