

# Comparison of Neonicotinoid Use Patterns for Silverleaf Whitefly Management in Melons and Broccoli

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## Abstract

*Studies were conducted in 1998 and 1999 to evaluate three neonicotinoid insecticides for control of silverleaf whiteflies in melons and broccoli plots at the Yuma Agricultural Center. The results of these studies demonstrate that these insecticide uses offer vegetable growers management alternatives for controlling whiteflies comparable to what they have experienced with Admire®. In our spring trials, we applied Platinum® at planting, as a split application, and as a sidedress application. All methods provided whitefly efficacy similar to that provided by Admire. However, the split and sidedress applications provided more consistent residual control than Platinum applied at planting. Because of the mobility of the product in the soil, growers may have more flexibility for effectively applying the material post-planting. In addition, Assail, was applied as a foliar spray at various densities. Under spring growing conditions, applications of Assail provided significant whitefly control when initiated at low densities. Under high whitefly densities on fall melons and broccoli, application of Assail was capable of significantly reducing existing immature populations. These evaluations suggests that Platinum and Assail may be promising alternatives to Admire. We presume that it may allow growers to use the product in a responsive manner as a side dress (Platinum) or as a foliar (Assail) rather than having to rely on prophylactic Admire applications at planting.*

## Introduction

Over the past three years, silverleaf whiteflies have not been a significant problem to vegetable growers largely because of the availability of imidacloprid (Admire®). This class of chemistry (neonicotinoids) has activity against many sucking insect pests and has good systemic activity in the plant. Thus it is appropriate for soil applications in some crops. However, because Admire is relatively immobile in the soil, efficient plant uptake is dependant on precise placement of the chemical within the root zone (Mullins 1993). The systemic activity of Admire against insects may vary depending on the crop, formulation, and application method.

Recently, there has also been a release by the agrochemical industry of several new products within the neonicotinoid chemistry that have shown activity on whiteflies and aphids in vegetables. These compounds are toxicologically similar to Admire, but differ in their route of activity. Acetamiprid (Assail®) is a neonicotinoid insecticide that has excellent systemic activity as a foliar spray, but only marginal activity when applied to the soil. In contrast, thiamethoxam (Platinum®) is similar to Admire in that it has activity when applied to soil. However, previous research shows that unlike Admire, Platinum is mobile in the soil making it more amenable to post-planting application. Furthermore, it has shown promising activity when applied as a foliar spray (Actara®).

The purpose of these studies were to compare the relative efficacy of three neonicotinoid insecticides, imidacloprid (Admire), thiamethoxam (Platinum) and acetamiprid (Assail), against whiteflies on melons and broccoli. Because Platinum is more mobile in the soil, we wanted to compared it with Admire as a soil application, both at planting and as a side dress treatment. We included comparisons with Assail applied as a foliar spray.

## Materials and Methods

**Spring Melon Trials:** Cantaloupe plots ‘Durango’ were established at the Yuma Agricultural Center on April 7 in 1998, and on Mar 22 in 1999. All plots were managed similarly to local commercial growing practices. Plots consisted of four, 80 inch beds, 60 ft long with a 15 buffer between each plot. The study was designed as a randomized complete block design with 4 replicates/treatment. Treatments for both trials were applied as follows:

Neonicotinoid	Application timing	Method	Rate	
			1998 Trial	1999 Trial
1. Admire2F	At plant	At planting	16 oz/acre	16 oz/acre
2. Admire 2F	Split	At planting	8 oz/acre	8 oz/acre
		Side dress	8 oz/acre	8 oz/acre
3. Admire 2F	Post-plant	Sidedress	16 oz/acre	16 oz
4. Platinum 2SC	At plant	At planting	2 oz/acre	8 oz /acre
5. Platinum 2SC	Split	At planting	2 oz/acre	4 oz /acre
		Side dress	2 oz/acre	4 oz /acre
6. Platinum 2SC	Post-plant	Sidedress	4 oz/acre	8 oz /acre
7. Assail 70WP		foliar spray	0.10 lb ai/acre	--

Admire and Platinum were applied to plots at planting by injecting the chemical 3" below the seed and furrow irrigating to a stand. Side dress applications were made when plants had approximately 15-16 leaves/ primary vine. The product was applied near the bed shoulder at approximately 5-6 " below the soil. Plots were irrigated 2 days following side dress. Assail was applied with a hydraulic sprayer delivering 50 GPA at 40 psi.

Insect data were collected from plants growing in the middle two beds of each plot. In the 1998 trial, immature whitefly populations were estimated at 50, 65, and 90 days after planting (DAP). The samples were collected from the following locations along one randomly selected primary vine in each plot: Crown (18th leaf from the apex of the vine), mid-vine (10th leaf from the apex of the vine) and terminal (4th leaf from the apex of the vine). Egg and nymph populations were assessed as follows. As vines reached appropriate lengths, 10 leaves from each sampling location were removed from the plants, placed in plastic bags, and transported immediately to the laboratory. The underside of each leaf was then divided into 4 sectors, and all eggs, small nymphs (crawlers and 2nd instar), large, and red-eyed nymphs (3rd and 4th instar REN) within a 100 mm<sup>2</sup> area of each sector were counted under a stereo microscope.

In the 1999 trial, populations of whitefly adults and immatures were evaluated at 5, 18, 27 May and 2, 11, and 24 June. The methods for assessing population densities were similar to methods used in the 1998 study. Melon yields and quality were estimated at 2-3 day intervals from June 23- July 9 by recording the number of marketable melons in 20 row ft and assessing fruit size, sooty mold contamination and soluble solids.

**Fall Melon 1999:** Cantaloupe plots ‘Mission’ were established at the Yuma Agricultural Center on Aug 18 and managed similarly to local growing practices. Plots consisted of four 84 inch beds, 75 ft long with a 10 buffer between each plot. The study was designed as a randomized complete block design with 4 replicates/treatment. Treatments were applied as follows: 1) Admire applied at planting at 16 oz/acre; 2) Platinum applied at planting at 9 oz / acre; 3) Platinum applied at planting at 11 oz / acre; and 4) an untreated control. Admire and Platinum were applied to plots at planting by injecting the chemical 2" below the seed and sprinkler irrigating to a stand. Subsequent irrigations used furrow irrigation.

Insect data were collected from plants growing in the middle two beds of each plot. Immature whitefly populations were estimated at 25, 40, and 55 days after planting (DAP). The samples were collected from the following locations along one randomly selected primary vine in each plot: Crown (18th leaf from the apex of the vine), mid-vine (10th leaf from the apex of the vine) and terminal (4th leaf from the apex of the vine). Egg and nymph populations were assessed as follows. As vines reached appropriate lengths, 10 leaves from each sampling location

were removed from the plants, placed in plastic bags, and transported immediately to the laboratory. The underside of each leaf was then divided into 4 sectors, and all eggs, small nymphs (crawlers and 2nd instar), large, and red-eyed nymphs (3rd and 4th instar REN) within a 1 cm<sup>2</sup> area of each sector were counted under a stereo microscope.

Plant growth and fruiting measurements of treated and untreated melon were taken at 42 and 55 DAP. The number of nodes on primary vines, total blooms and fruit per plant were measured from 5 plants from each plot at 42 DAP. At 55 DAP, total numbers of leaves and fruit, and fruit diameter were measured on whole plants.

**Fall Broccoli 1999:** Broccoli plots 'Capitan' were established at the Yuma Agricultural Center on Aug 31 and managed similarly to local growing practices. Plots consisted of four, 42 inch beds, 75 ft long with a 2 bed buffer between each plot. The study was designed as a randomized complete block design with 4 replicates/ treatment. Treatments were applied as follows: 1) Admire applied at planting at 16 oz/acre; 2) Platinum applied at planting at 9 oz / acre; 3) Platinum applied at planting at 11 oz / acre; 4) Assail (0.75 lb ai/acre) applied as a foliar spray and an 5) untreated control. Admire and Platinum were applied to plots at planting (Aug 31) by injecting the chemical 2" below the seed and sprinkler irrigating to a stand. Subsequent irrigations used furrow irrigation. Assail was applied with a hydraulic sprayer delivering 33 GPA at 40 psi on 30 Sep and 12 Oct.

Insect data were collected from plants growing in the middle two beds of each plot. Immature whitefly populations were estimated at 25, 40, 50 and 60 days after planting (DAP). The samples were collected from the leaves near the lower of the plant in each plot. Egg and nymph populations were assessed as follows. As vines reached appropriate lengths, 5 leaves from each sampling location were removed from the plants, placed in plastic bags, and transported immediately to the laboratory. The underside of each leaf was then divided into 2 sectors, and all eggs, small nymphs (crawlers and 2nd instar), large, and red-eyed nymphs (3rd and 4th instar REN) within a 1 cm<sup>2</sup> area of each sector were counted under a stereo microscope. Plant growth of treated and untreated melon was measured by taking dry wt samples at 40 and 60 DAP. Dry wt samples were measured by collecting 10 consecutive plants within a row from each plot, and placing the plants in a drying oven at 180 °F for 48 hrs. Yield measurements were taken on 24 Nov. by recording the number of heads (>4" diam.) and their weight in 10 row ft within each plot.

**Data Analysis** Whitefly counts in all studies were transformed  $\log_{(n+0.5)}$  prior to analysis of variance to stabilize variances which were found to be heterogenous. Untransformed means are presented in figures and tables. Whitefly population densities averaged on each sample date, yields and quality data at each harvest were analyzed as a one-way analyses of variance (PROC GLM, SAS Institute), with means compared where appropriate using the Ryan-Einot-Gabriel-Welsch multiple F-test (P=0.05) (PROC GLM, SAS Institute ).

## Results and Discussion

**Spring Melon 1998:** Population numbers in all treatments were low early in the season, but began to increase rapidly near harvest. Figure 1 shows immature whitefly densities at 50, 65 and 90 days after planting (DAP) relative to neonicotinoid treatments. At 50 DAT, whitefly densities were low in all treatments (< 3 nymphs / cm<sup>2</sup>), but differed among treatments. Densities in the soil applied Admire and Platinum treatments were significantly lower than the untreated control. The At-planting treatments contained the lowest numbers of immatures. Side dress treatments had been applied 7 days prior to this sample. The foliar NI 25 treatment had not been sprayed yet, and as expected was similar to the control.

Densities in the untreated plots increased little at 65 DAT (Figure 1). Densities of large nymphs (REN) began to increase in treated plots, but were still significantly lower than the control. Eclosed pupal cases, which indicate successful development of adult whiteflies were consistently low in the Platinum plots, regardless of application timing. The side dress Admire (16 oz) application did not differ from the control. Overall, the split application Admire treatment contained the lowest numbers of whitefly immatures.

By 90 DAP, immature densities in the untreated control had increased to very high numbers (Figure 2). Densities of small and large nymphs were lowest in the Assail plots which had been treated 21 days previously. Densities of pupal cases in the Assail plots did not differ from the other neonicotinoid treatments, in part due to the high densities established on plants prior to application. The systemic activity of this compound applied as a foliar spray obviously provided excellent efficacy against established and colonizing whiteflies. Immature densities in the Platinum plots did not differ significantly among treatments, with the exception nymphs in the split application

treatment. Whitefly densities did not differ significantly among Admire treatments, but were significantly lower than the control.

Because the large whitefly densities occurred late in the season, declines in plant productivity were not seen until about 10 days into harvest. Consequently, vine decline in the control plants was greater than 80% and no further sampling was conducted. Foliage ratings at that time showed that the Assail plots were in the best shape (<20% vine decline) and the Admire and Platinum treatments were beginning to show signs of serious decline (>50%). Differences in melon numbers were not observed.

**Spring Melon 1999:** Population numbers in all treatments were moderate-high during the study and increased rapidly near harvest in the untreated plots. Figures 3-5 show the seasonal whitefly densities relative to application of neonicotinoid treatments. On the first three sample dates, adult numbers did not differ among the treatments (Figure 3). However on the final two sample dates for adults (June 2 and 11), adult numbers per leaf were lowest in the Platinum treatments. The split application of Admire did not differ from the untreated check on these dates. Similarly egg densities were highest in the at planting treatments and Admire split application suggesting less residual control. In fact the Platinum side dress application appeared to provide significantly better control of eggs at harvest than all other treatments.

Colonization by immature whiteflies was significantly effected by application timing. Small nymph densities were greatest in the Admire split application, particularly in the midvine and crown leaves (Figure 4). The Platinum split and sidedress applications along with the Admire at planting application provided the most significant control of small nymphs on primary vines. A very similar trend was observed for large and red-eyed nymphs on midvine and crown leaves of primary vines (Figure 5). The Admire split and sidedress applications provided minimal residual activity and appeared to allow whitefly nymphs to readily colonize plants throughout the season. These trends in immature colonization are also supported by out estimates of eclosed pupae found on crown leaves (Figure 5), suggesting that fewer immature whiteflies completed development in the Platinum split and sidedress treatments.

Figure 6 shows the impact of each neonicotinoid treatment on melon yield and quality. Sugars appeared to be most effected in the Admire and Platinum at planting treatments. Similarly, sooty mold contamination was heaviest in these treatments. Marketable yield estimates were similar for all treatments, except for the Admire sidedress which did not differ from the untreated check. The yields in the untreated check were reduced greater than 50% when compared with the at plant applications of Platinum and Admire.

**Fall Melon and Broccoli:** In the fall melon test, whitefly population numbers in all treatments were high at stand establishment and adults continued to migrate into plots for several weeks. Table 1 shows immature whitefly densities at 25, 40 and 55 days after planting (DAP) relative to the neonicotinoid treatments. At each sampling interval, whitefly densities in the Admire and Platinum treatments were not significantly different from each other, however these treatments were significantly lower than the untreated control. Based on egg densities observed at 55 DAT, the 11 oz Platinum treatment appeared to provide similar residual to the Admire treatment,. The whitefly control measured in this study was further reflected in the plant growth and fruiting measurements (Table 2). All neonicotinoid treatments provided significantly superior plant protection when compared with the untreated check. We were unable to take yield measurements because plants in the untreated check were either severely wilted or dead in all replicates at 70 DAP. There were no observable differences in fruit yield among the neonicotinoid treatments.

Results in our fall broccoli trial were very similar. All neonicotinoid soil treatments provide excellent control of whiteflies, and plant growth and yield responses did not differ among the soil treatments. The untreated check contained significantly more whitefly colonization, and this resulted in significant reduction in yield. The applications of Assail resulted in significant reductions of immature densities, with an approximate 7-10 day residual. Because sprays were not initiated until 30 DAP, plant growth was unable to recover to the same level as measured in the soil applications.

The results of these studies are encouraging. First, they demonstrated that Assail applied as a foliar spray can provide excellent residual activity to prevent whitefly colonization in spring melons. The fit in fall melons and broccoli appears to be more limited, and timing early in plant growth will be important. We assume that application numbers will be limited on future labels for resistance management purposes. Thus, we need to determine its best fit with other products used in whitefly management programs.

Furthermore, the results of these studies are encouraging because they further validate the hypothesis that Platinum may be used as a post planting, sidedress application. Previous studies have suggested that this product is more mobile in the soil than Admire, and these studies also support those findings. Both the sidedress and split application appeared to provide season-long residual against whiteflies on spring melons, similar to the Admire and

Platinum at planting treatments. Because of Admire's lack of mobility in soils, sidedress treatments provided inconsistent residual activity, particularly late in the season. Finally, the fact that the Platinum and Assail are capable of preventing significant whitefly colonization in the absence of additional treatments suggests that they may be reliable and effective alternatives to be used with Admire, Applaud and other whitefly management tactics.

### **Acknowledgment**

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Figure 1. Immature whitefly densities on spring cantaloupes treated with chloronicotinyls at planting (Ap), at Sidedress (Sd) or as foliar spray.

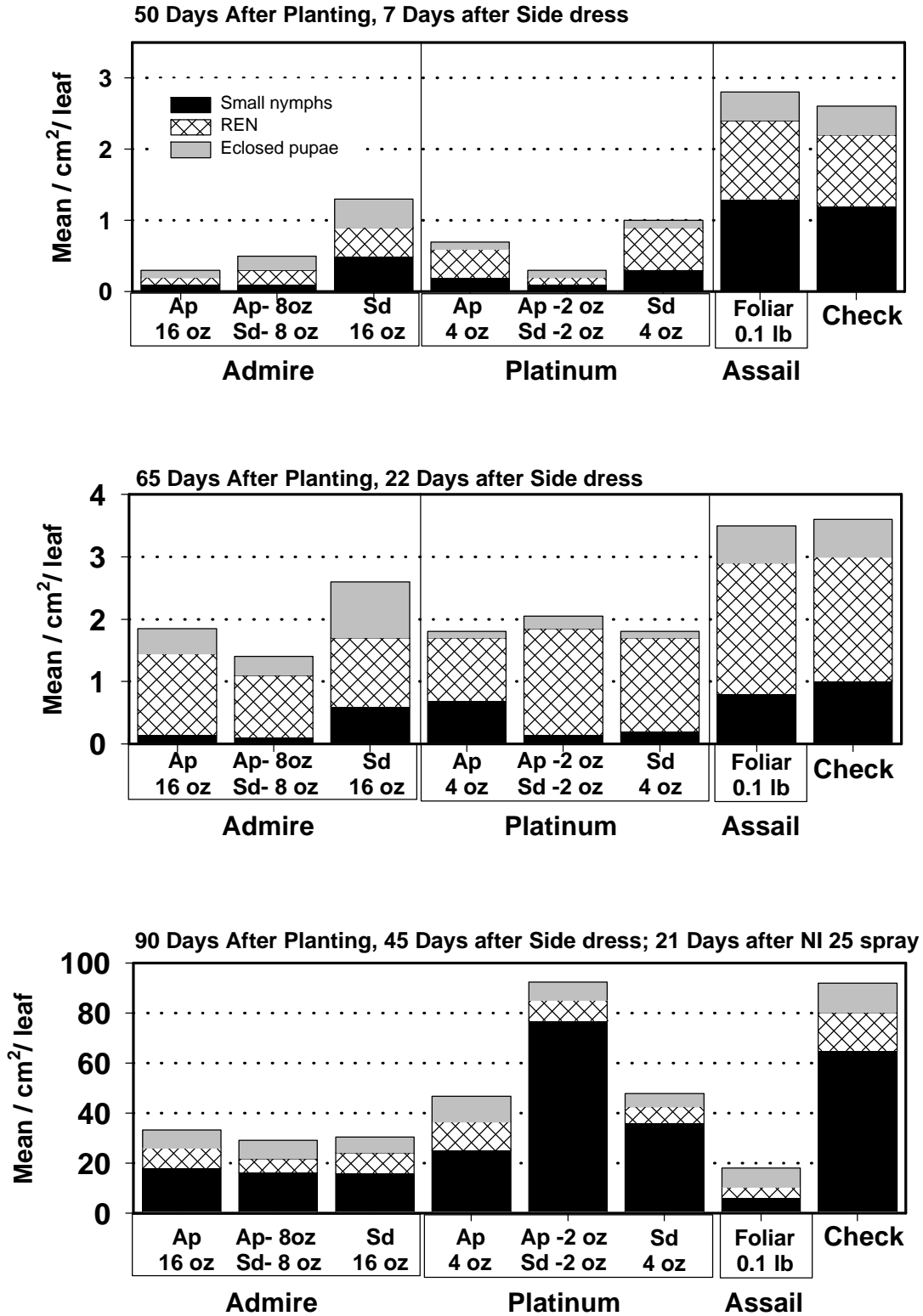


Figure 2. Immature whitefly densities (Mid-vine leaf) on spring cantaloupes treated with chloronicotyls at planting (Ap), as side dress (Sd) or foliar; 90 Days After Planting, 45 Days after Side dress, 21 Days After the Foliar NI-25 application

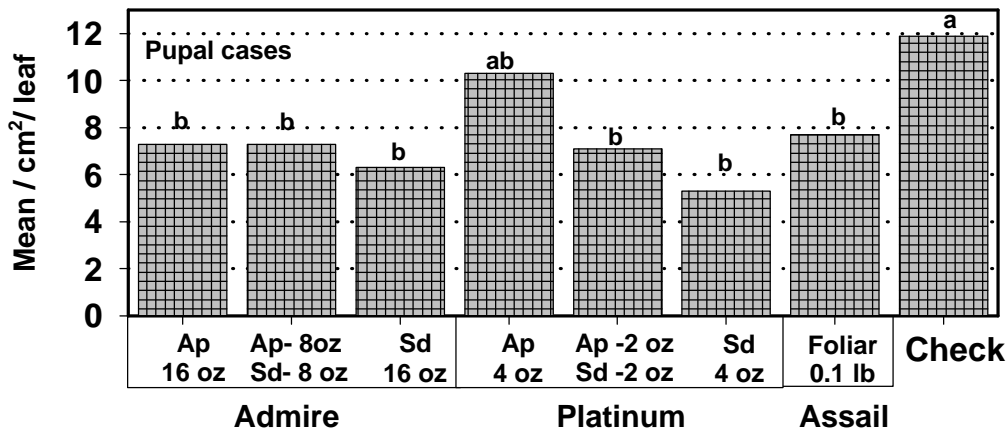
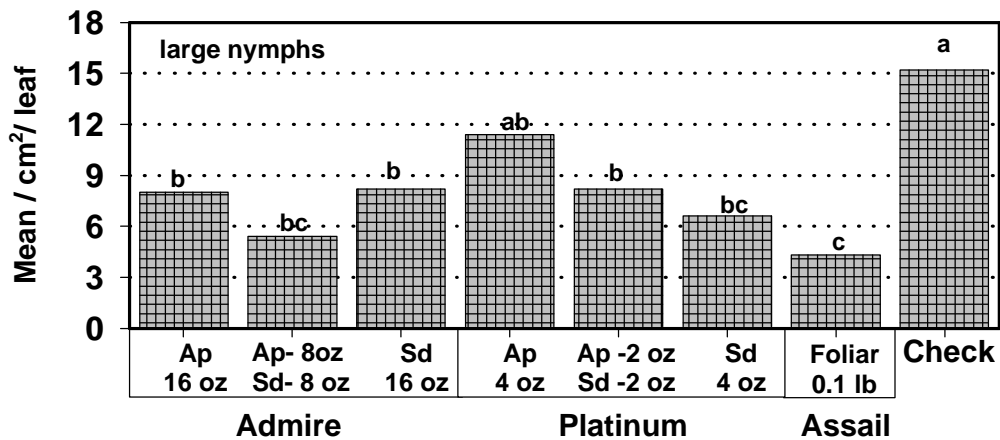
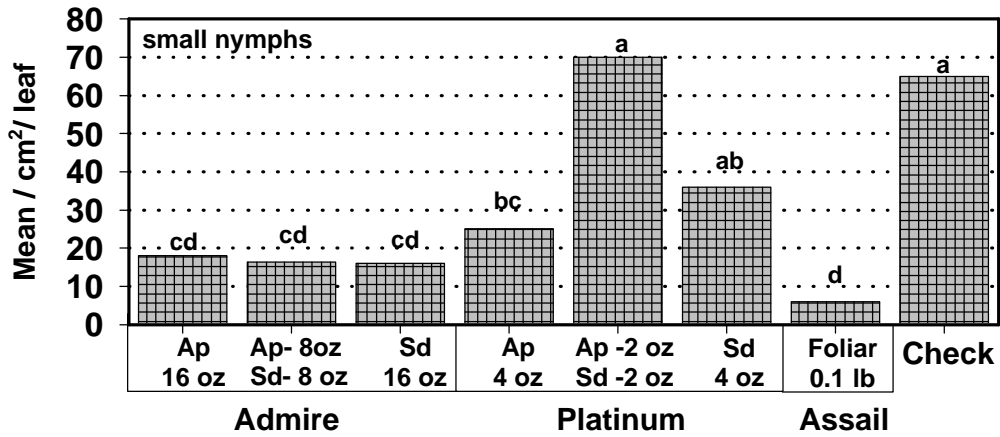


Figure 3. Seasonal adult abundance and egg densities relative to timing of Admire and Platinum applications Yuma Agricultural Center, 1999.

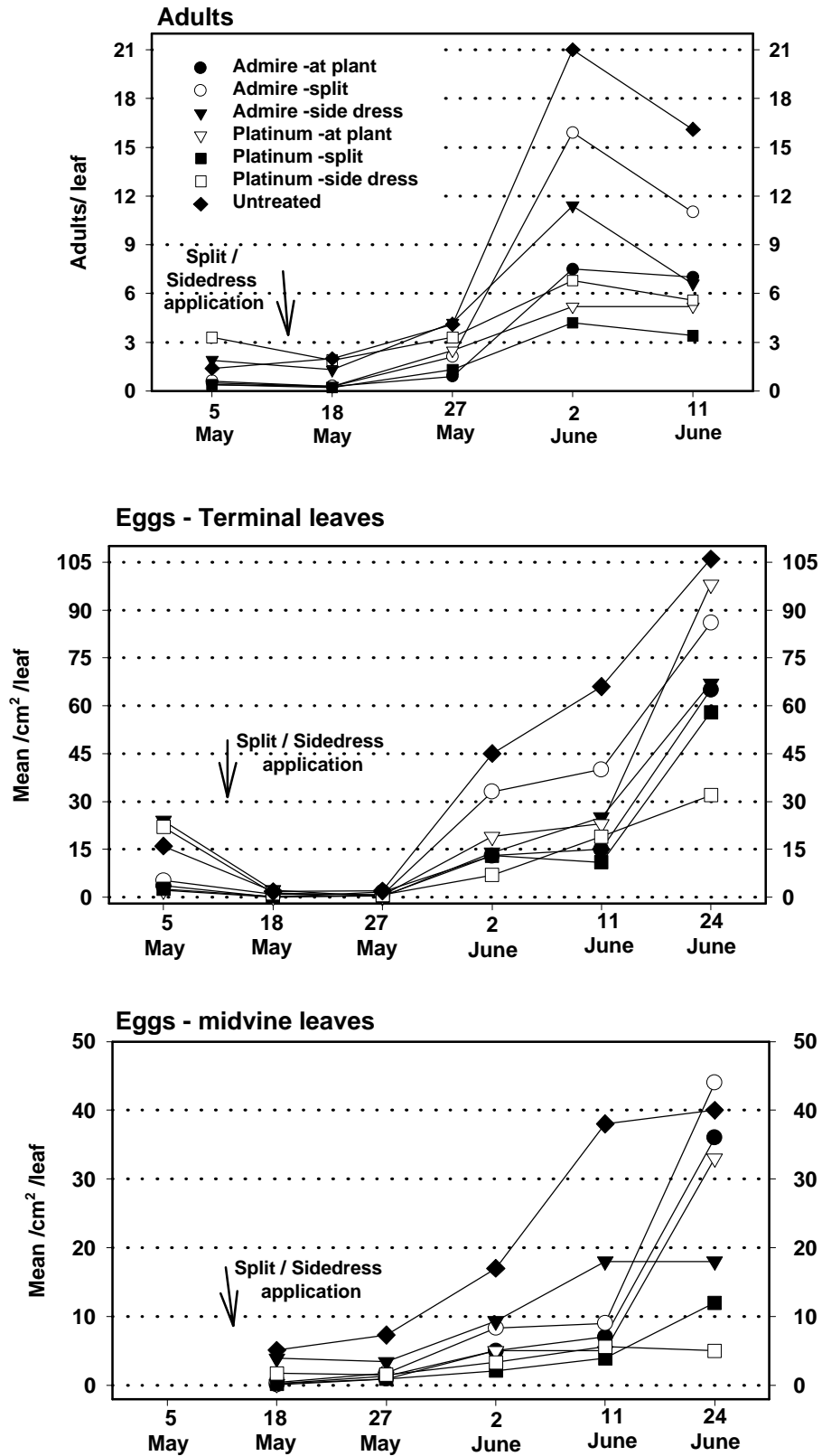


Figure 4. Seasonal abundance of small whitefly nymphs relative to timing of Admire and Platinum applications, Yuma Agricultural Center, 1999.

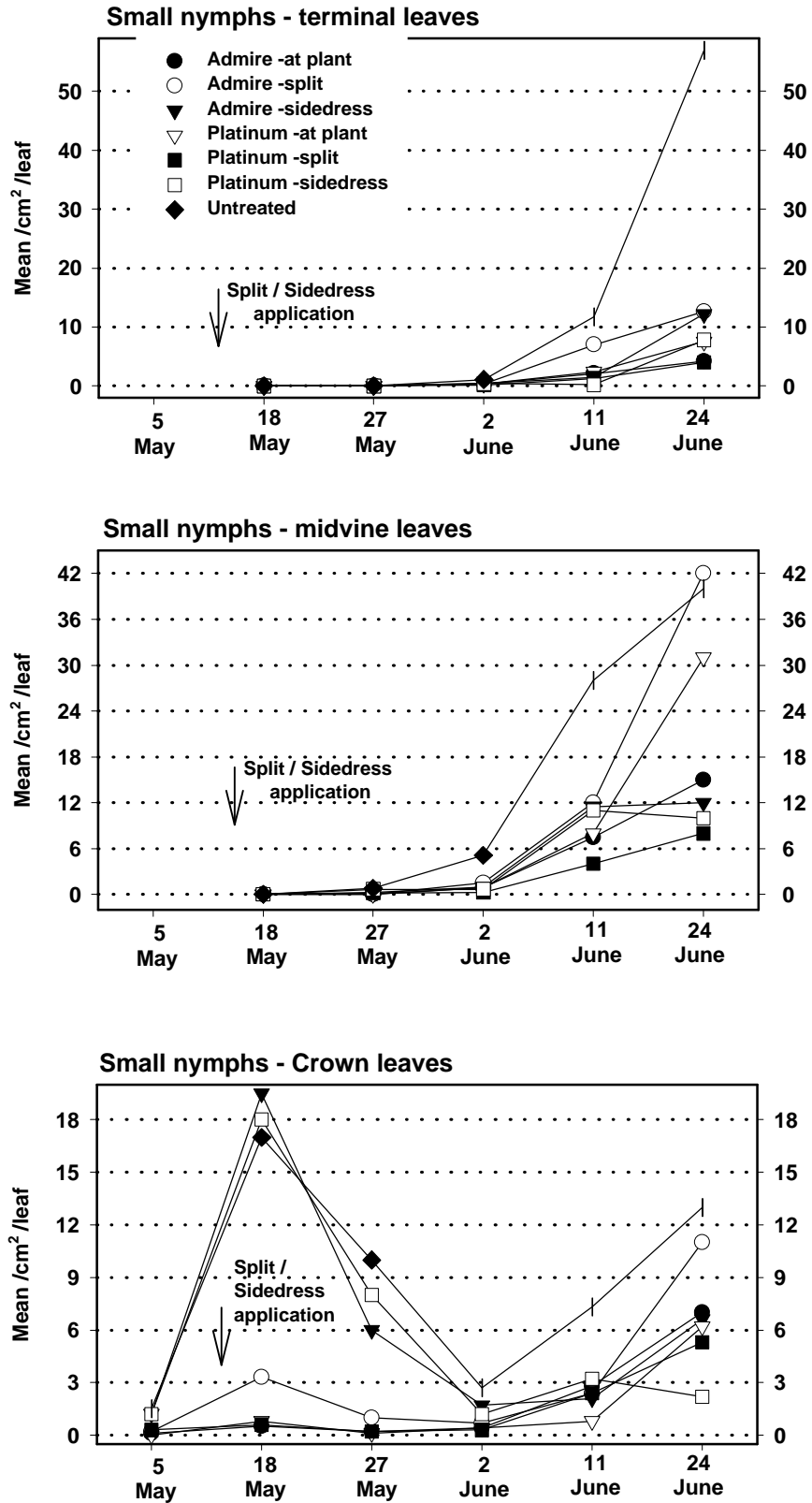


Figure 5. Seasonal abundance of large nymphs and eclosed pupae relative to timing of Admire and Platinum Applications, Yuma Agricultural Center, 1999.

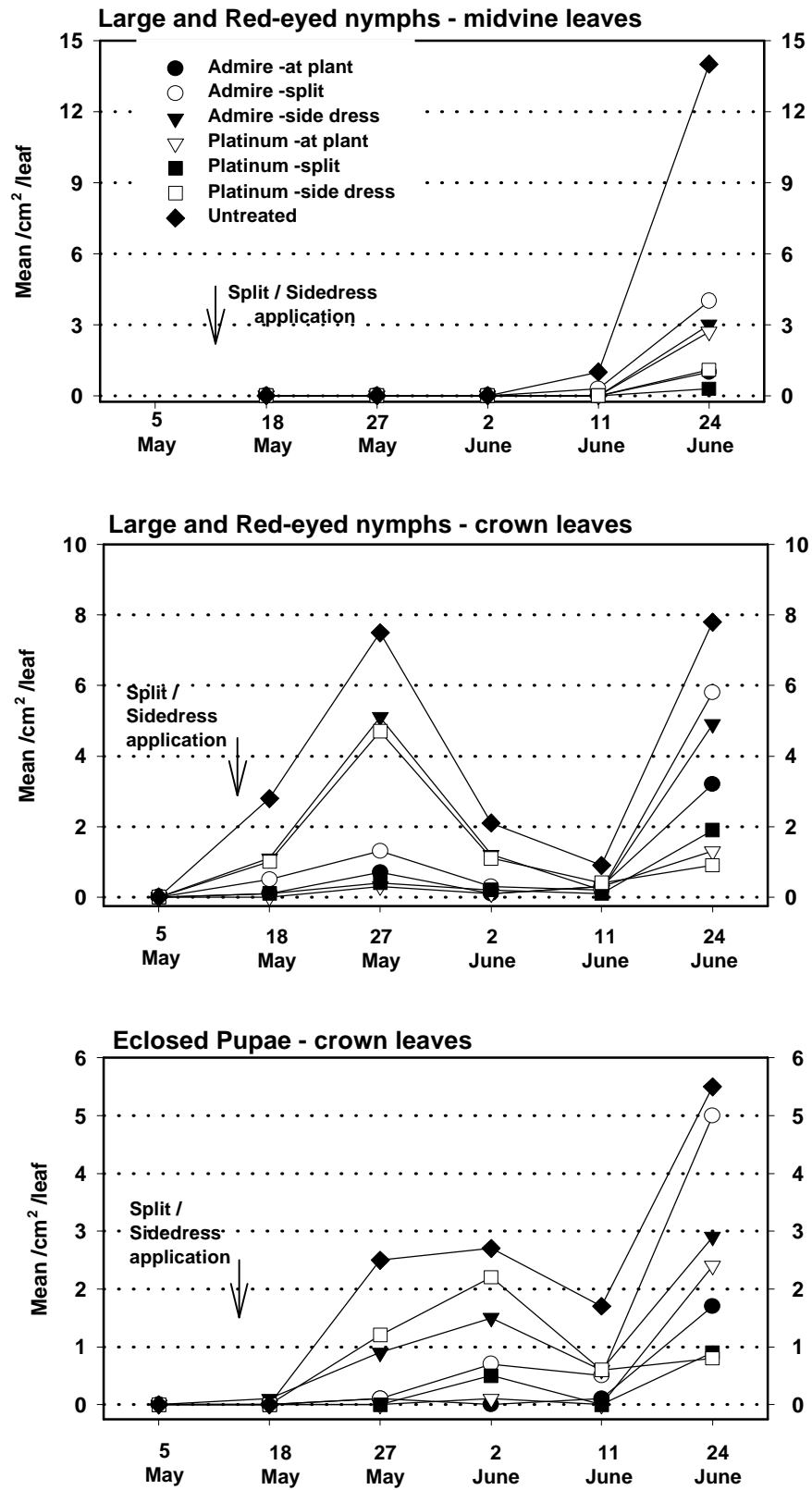
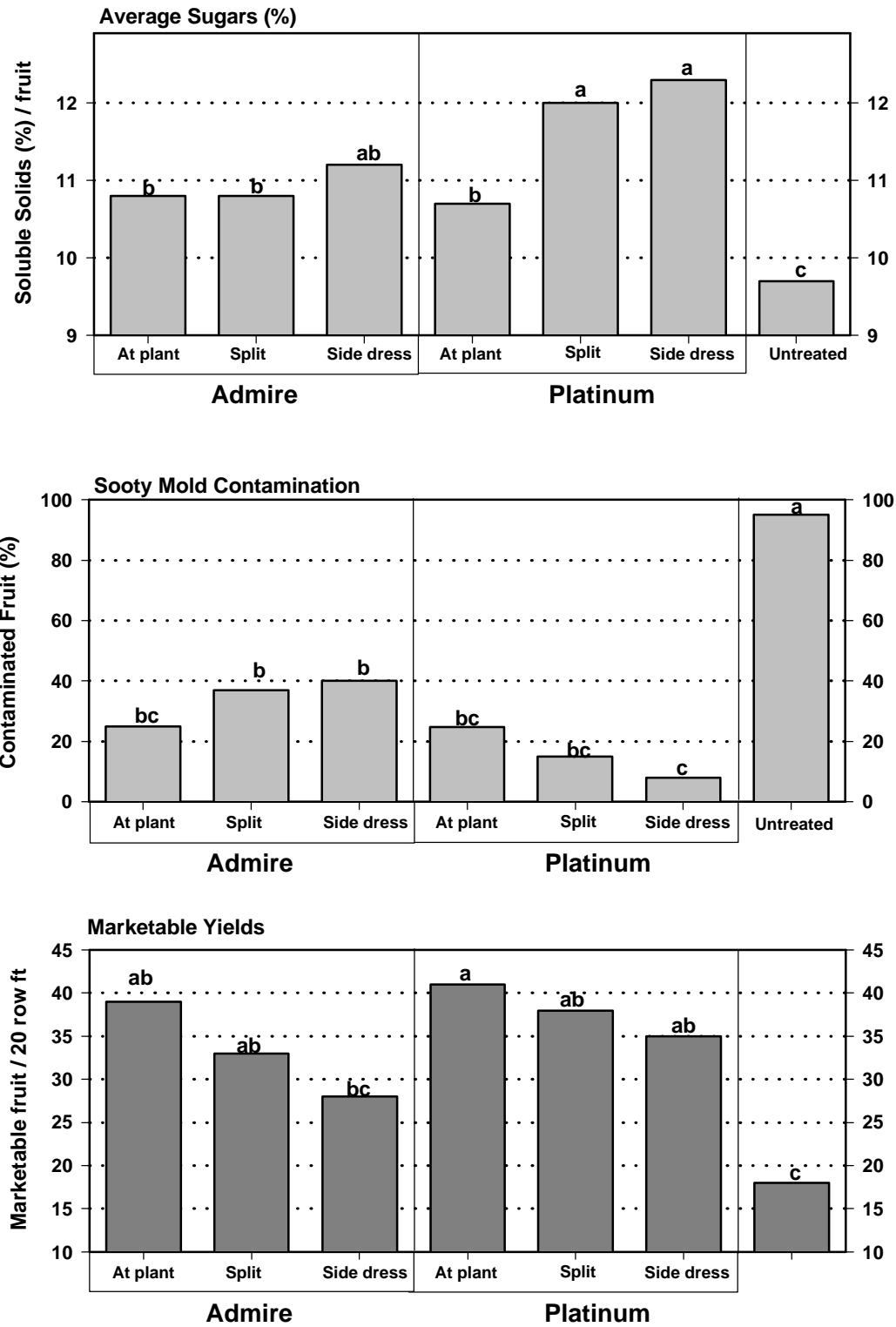


Figure 6. Melon Yield and Quality Estimates relative to timing of Admire and Platinum applications, Yuma Agric. Center, 1999



**Table 1. Whitefly Densities on Fall Melons Treated with Neonicotinoids At Planting, Yuma Agricultural Center, Fall 1999.**

Treatment	Days After Planting	Mean whiteflies / cm <sup>2</sup>			
		Eggs	Small Nymphs	Large Nymphs	Pupal cases
Untreated	25	217.8 a	269.6 a	5.1 a	–
Admire 16 oz		34.5 b	31.8 b	0 b	–
Platinum 9 oz		21.6 b	41.0 b	0.1 b	–
Platinum 11 oz		34.3 b	14.2 b	0.2 b	–
Untreated	40	82.8 a	144.1 a	6.5 a	4.5 a
Admire 16 oz		16.1 b	5.5 b	0.2 b	0.2 b
Platinum 9 oz		12.8 b	3.7 b	1.9 b	0.4 b
Platinum 11 oz		24.4 b	8.7 b	0.6 b	0.4 b
Untreated	55	90.1 a	88.0 a	2.3 a	3.0 a
Admire 16 oz		17.6 c	21.6 b	1.7 a	1.7 a
Platinum 9 oz		43.7 b	32.0 b	1.7 a	1.7 a
Platinum 11 oz		11.2 c	19.2 b	1.5 a	1.0 a

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

**Table 2. Plant Growth and Fruiting Measurements on Fall Melons Treated with Neonicotinoids At Planting, Yuma Agricultural Center, Fall 1999.**

Treatment	42 DAP			55 DAP		
	Nodes on 1 <sup>o</sup> Vine	Blooms per plant	Fruit per plant	Leaves per plant	Fruit per plant	Fruit diam. (in)
Untreated	9.2 b	0 b	0.2 b	26.3 b	1.3 a	0.9 a
Admire 16 oz	17.9 a	5.6 a	2.2 a	63.9 a	3.0 b	4.0 b
Platinum 9 oz	17.3 a	3.3 a	2.3 a	67.7 a	3.3 b	3.7 b
Platinum 11 oz	17.0 a	3.4 a	2.0 a	65.0 a	3.3 b	3.0 b

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

**Table 3. Whitefly Densities on Broccoli Treated with Neonicotinoids, Yuma Agricultural Center, Fall 1999.**

DAP <sup>a</sup>	Life stage	Whitefly densities (mean/cm <sup>2</sup> )				
		Untreated	Admire	Platinum- 9 oz	Platinum-11 oz	Assail
25	Egg	225.2 a	3.8 b	2.9 b	12.5 b	–
	Nymph	165.8 a	7.4 b	5.6 b	16.8 b	–
40 (7 DAT 1)	Egg	17.7 a	1.7 c	1.2 c	0.7 c	8.6 b
	Nymph	27.8 a	2.1 c	1.6 c	1.7 c	9.3 b
50 (7 DAT 2)	Egg	5.4 a	0.7 c	0.2 c	0.2 c	2.3 b
	Nymph	13.9 a	1.6 b	0.8 b	0.8 b	1.9 b
60 (14 DAT 2)	Egg	2.8 a	1.2 ab	0.4 b	0.2 b	2.7 a
	Nymph	17.9 a	6.0 b	3.6 b	3.2 b	11.7 ab

Means followed by the same letter within the same row are not significantly different ANOVA(LSD  $p>0.05$ )

<sup>a</sup> DAT in parenthesis refers to the number days following the foliar applications of Assail

**Table 4. Plant Growth and Fruiting Measurements on Fall Melons Treated with Neonicotinoids At Planting, Yuma Agricultural Center, Fall 1999.**

Treatment	Plant dry wt (g)		Harvest Estimates (Mean/10 row ft)		
	40 DAP	60 DAP	No. heads <sup>a</sup>	Total weight (kg)	Weight per head (g)
Untreated	4.6 b	64.3 b	4.3 a	0.2 a	43.3 c
Admire	17.1 a	181.9 a	20.0 c	2.95 c	147.5 a
Platinum 9 oz	20.7 a	215.6 a	22.0 c	2.87 c	131.2 a
Platinum 11 oz	15.8 a	208.2 a	20.0 c	2.81 c	140.5 a
Assail	6.6 b	81.7 b	12.3 b	1.35 b	109.8 b

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

<sup>a</sup> The number of heads with a diameter of 4" or greater.