Field Performance of Admire® Against Silverleaf Whitefly on Commercial Iceberg Lettuce, 1993-1998

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Abstract

Whitefly populations in the Yuma area have been reduced to levels that growers can cost-effectively manage. Data from our studies suggest that these declines in pest populations are largely attributed to the use of Admire 2F (imidacloprid) soil treatments. Relative to the outbreaks in 1993-1994, whitefly populations during the past four growing seasons have remained at sub-economic levels on lettuce crops throughout the growing areas in Yuma This chemical has provided excellent control of whiteflies on fall lettuce, and aphids on spring lettuce. After 6 years of evaluation in commercial fields, the product appears to remain highly efficacious, maintaining good residual activity. Studies in 1998 on fall broccoli and melons crops further support this conclusion. Factors responsible for this sustained efficacy of Admire are discussed.

Introduction

Imidacloprid has been used for the past 6 years in iceberg lettuce production in Arizona. During this time, whitefly populations have dropped to manageable levels and aphids on lettuce crops are almost non-existent. These declines in pest populations can be largely attributed to the use of a soil applied formulation of imidacloprid (Admire). This chemical has provided excellent control of whiteflies on fall lettuce and aphids in spring plantings. However, there has been discussion concerning how effective Admire will remain in the coming years. Some scientists believe that because of the product's long-residual and intensive use, it is only a matter of time before field failures are observed in the Yuma area. Whitefly and aphid populations are potentially exposed to residual levels of imidacloprid from August through June.

Because Admire in lettuce is greatly influenced by depth of placement in the seedbed and amount of product applied, application errors may result in lack of adequate performance of the product. Unless field plots are set up to verify actual placement and rate, the cause of field failures may be difficult to determine. Without such monitoring, it will be difficult to determine whether poor field activity is due to application errors, or whitefly tolerance. Placement of "untreated check " plots in several areas may serve as an early warning system should the product begin to fail. Field performance of data collected from lettuce fields in the Dome, Gila, and Yuma valleys in the past 6 years provide a historical trend of performance, as well as a "baseline" with which to compare performance in future years. The objective of this study was to consistently monitor the field efficacy of Admire against silverleaf whitefly populations in commercial fields during the fall. Ultimately, we believe these field evaluations will help growers determine how Admire can be continually used in a cost/effective and sustainable manner.

Methods and Materials

Several commercial lettuce fields planted in the Dome Valley, Gila Valley and Yuma Valley were used for these studies from 1993-1998. A total of 8 monitoring sites were initially established for each season, but due to weather and other problems associated with stand establishment the actual number of fields varied each year (Table 1). Lettuce was evaluated on 'empire' type lettuce varieties planted within a week in early September (Sep 9-17) in

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each year. Three treatments were evaluated in each growers field: (1) growers standard application of Admire throughout the field, (2) a surface banded application of Admire applied over each seedline immediately following planting and before sprinklers were set , and (3) an untreated check plot. The surface banded treatment and untreated check plot were placed adjacent to each other within untreated areas of each lettuce field. All plots were 4 beds wide by 75- 150 ft long with 1-3 replications per field. The commercial standard fields and surface band treatments received 16 oz of Admire at planting in a total volume of 10 gallons/acre. Admire was injected at a depth of 1.5 - 2" below the seed line just prior to seeding. The surface band was 3" wide and applied directly over the seedline.

Lettuce plants were sampled for immature whitefly densities three times each season, based on crop phenology. Twenty basal leaves from the center rows of each plot were collected randomly from ten lettuce plants at: thinning stage (4-leaf stage; 21 days after planting), heading or "rosette" stage (leaves begin to cup inward to form heads; 50 days after planting), and harvest (mature heads; 69-77 days after planting). Samples were taken to the laboratory where two 1-cm^2 areas were selected randomly on each leaf, and the numbers of all immature stages of whiteflies were counted using a stereo microscope and recorded. Lettuce yields were taken from three m of one bed of each plot just prior to commercial harvest operations. Weight (kg) and diameter (cm) were measured for each head and averaged for each plot.

In the fall of 1998, similar studies to above were conducted in commercial broccoli and melon fields in the Yuma and Gila valleys. Broccoli plots were established in early September similar to the lettuce trials described above. Four of the experimental field sites were in the Yuma valley and one was in the Gila Valley. Admire was applied similar to the lettuce trials. Leaf samples were collected from basal leaves at 30 and 50 days after planting and immature densities were assessed as above. Melons plots were established in mid-August and conducted in drip irrigated commercial fields located in the Yuma Valley. Untreated plots consisted of a single row within each field, 300-600 ft in length. Admire was applied to the field after seedling emergence (1-2 true leaves) by injecting a 16 oz/acre rate through the sub-surface, drip irrigation lines located 8" below the seed line. Untreated beds were established by closing off the drip line during the injection period, then allowing water to flush the system for several hours. The drip line was reattached the next day and irrigation commenced in both treatments. Leaf samples were collected from crown (nymph estimates) and terminal (egg estimates) leaves at 20, 40 and 60 days after planting and immature densities were assessed as above.

Results

Whitefly densities for the surface band application are not shown because they were not significantly different from the growers at-plant Admire application during these studies. The purpose for using the surface band application of a precise rate of Admire was to detect if the growers standard was misapplied or if Admire was actually losing efficacy. Based on our observations, neither event occurred. Similarly, whitefly estimates at harvest are not presented because significant densities were undetectable at harvest and did not differ between treatments. This was due primarily to the lack of adult migration in October and the incidence of bottom rot, *Rhyzoctonia* in the fields.

Silverleaf whitefly densities in lettuce fields was greatest in 1993 and 1994 (Fig 1). Untreated lettuce plots had significantly greater whitefly densities throughout the season and lower yields than the Admire treated field plots (Table 2). During the past 4 years(1995-1998), whitefly densities have overall been considerably lower. Although, in most years, whitefly numbers were significantly greater in the untreated plots, immature densities at thinning and heading were not great enough to cause differences in yield (Table 2). This trend of low whitefly abundance and immigration during September in Yuma growing regions has been observed in particular the past 3 years. In my estimation, this is largely a reflection of the area-wide use of Admire on fall and spring vegetable crops and the suppressive effects it has had on whitefly populations. In addition , the implementation of the IGR's, Knack and Applaud, in cotton and the additional impact that natural mortality has had whitefly populations has undoubtedly had an impact on regional whitefly activity, particularly as it relates to adult movement form cotton to fall lettuce crops.

In general, our data suggests that Admire has provided exceptional field efficacy over the past 6 years. Figure 2 shows whitefly densities and associated yields averaged across the six year experimental period. The large variability (±SE) associated with the estimated means for untreated lettuce plots can largely be attributed to variation among sites and among years. Nonetheless, Admire provided significant control of whitefly nymphs during this period. Thus, as of the fall 1998, our initial conclusion is that Admire remains highly efficacious. However, the fact that densities on lettuce have been very low (≤ 2 nymphs/cm^2) since 1995, and lettuce is a marginal host for whitefly development and colonization, suggests that data derived the past two years may not truly reflect Admire efficacy against whitefly populations in Yuma. Because of this concern, untreated test sites were established in commercial broccoli and melon fields in 1998 to measure differences in whitefly colonization in these two highly preferred host crops.

Results from the broccoli and melon trials clearly show that Admire provided excellent efficacy of whitefly adults and small nymphs. Large numbers of eggs and nymphs were measured in 3 of the 5 broccoli fields at 30 DAP (Table 3). As high as 30-fold differences in density of nymphs was recorded. Averaged across all five experimental sites, nymph densities in Admire treatments were significantly lower (< 2 nymphs/cm^2)than the untreated plots. No significant colonization was observed in any of the Admire treated fields. In contrast, in two of the experimental sites, untreated plants experienced stunted growth, and chlorosis of leaf and stem tissue. These plots were not harvested by the grower. Result in the melon plots showed a similar response (Table 4). Field plots left untreated, resulted in significantly higher whitefly densities at each sampling interval. In particular, Ranch 32 maintained high densities of nymphs in the untreated melons, with of 25, 19 and 12 fold differences between the treatments at 20, 40 and 60 DAT, respectively. At 60 DAT, a sharp increase in nymph numbers was observed in the Admire plots. However, this is consistent with 1994 field studies that indicated growers could expect, at best, 45-60 days of residual efficacy following soil application of Admire on fall vegetables. Furthermore, whitefly populations in Admire treated fields required no additional foliar treatments for whitefly control at or during harvest, whereas, plants in 2 of the 4 check untreated plots (Ranch 32 and 7) experienced vine collapse, sooty mold contaminated melons and reduced fruit size.

Finally, similar studies have been conducted for aphids (green peach and potato aphids) in the Yuma Valley. Studies were established similar to the above on 3-4 fields planted in mid-late November. Efficacy was rated by simply measuring the level of aphid contamination (if heads contained >5 aphids, they were considered contaminated) in untreated lettuce plants at harvest. The efficacy of Admire against aphids is even more striking. In the past five years, no aphid contamination was measured on any of the Admire treated lettuce that we observed. This is relative to 40, 55, 20, 10, 20 % contaminated heads measured from untreated lettuce plots from 1994 -1998 respectively. This data further supports our contention that Admire is highly efficacious against aphid species found on lettuce.

Discussion

Over the past several years, whitefly and aphid populations in the Yuma area have been effectively managed. Relative to our observations in 1993 and 1994, whitefly and aphid populations during the past four growing seasons have remained at sub-economic levels. Data from our studies suggests that these declines in pest populations can be largely attributed to the use of Admire 2F (imidacloprid) soil treatments. After 6 years of evaluating Admire in commercial lettuce fields, there has been no measurable decline in the commercial field performance of Admire in lettuce and the product appears to remain highly efficacious. This is further corroborated with data in 1998 showing expected residual efficacy on melon and broccoli. Because Admire has been very successful in controlling whiteflies and aphids, the product has been used on the majority of vegetable and melon acres in Yuma over the past six years.

Sustaining long-term Admire efficacy is of great concern. Although hydroponic bioassays conducted at EARML have recently measured declines in adult whitefly mortality to imidacloprid, and despite the fact that whiteflies populations in the Yuma area are potentially exposed to Admire most of the year (Table 5), the product continues to provide good control of whiteflies. Why? There are several possible factors, which may in part explain why we have not seen declines in Admire performance in the field. Discussed below are factors which may be responsible for the product's sustained efficacy in the Yuma cropping system.

- *Management of Polyphagus pest in multiple cropping system.* Growers are faced with managing a number of pests other than whitefly in several different crops in distinctly different, but overlapping growing conditions. There are four distinct alternative classes of chemistry with different modes of action, that act differently on whitefly adults. Distinct whitefly populations within a large area are consistently being exposed to different modes of action throughout the year. Consequently, if individuals are developing tolerance to Admire, it may be that they are periodically being selected out or eliminated from the population as a result of alternative chemical use.

- *Ag/Urban Interface*. Another factor that may be responsible for the sustained efficacy in this area may be the movement of whiteflies between agricultural and urban areas. Many of the landscape ornamental and weeds found in urban areas are excellent hosts for whitefly. Generally, these host plants and the whiteflies that inhabit them are not exposed to Admire or very few other active ingredients . This may serve as a refuge for susceptible individuals that move back into vegetable and melon fields.

- *Alfalfa /Vegetable Seed Crops*. Similarly, Admire is not registered for use on alfalfa, or *Brassica* seed crops. However, whiteflies readily colonize and reproduce on these crops at different times of the year. Although the acreage is not large for these crops relative to vegetables and melons, they are spread across the valley and mixed among the other crops. These crops do receive insecticide sprays for other pests during the year. Thus, these crops may serve as a refuge and expose whiteflies to alternate chemistries as well.

- *Management of Whiteflies on Cotton.* This may be the one of the most important contributors to the sustainability of Admire. The use of imidacloprid (Provado foliar sprays) for control of whiteflies and Lygus bug in cotton is minimal. Whiteflies are managed successfully with alternative chemistries, including insect growth regulators. There are several active ingredients that may be selecting out Admire-tolerant individuals over several generations, including Applaud, Knack, pyrethroids, organophosphates, carbamates, and formamidines. The addition of the regulated use of the IGRs will probably be very beneficial because of their excellent efficacy during the time of year when whiteflies can potentially increase most rapidly. This may possibly explain why whitefly abundance on lettuce was the lowest in 4 years in the Yuma Area in 1996.

- *Inherent Toxicity of Imidacloprid and its Metabolites*. Imidacloprid is a novel mode of action which possesses a high level of systemic toxicity activity against sucking insects, particularly via root uptake. Local whitefly populations were not exposed to this type of neurotoxin previous to it's registration in 1993. Furthermore, recent laboratory studies have shown that imidacloprid administered to plants by soil application is metabolized by the plant into several metabolites with varying levels of insecticidal activity. Essentially, two of the plant metabolites were more active against aphids than the parent compound imidacloprid itself. Although, these findings cannot be directly correlated to Admire efficacy against whiteflies on lettuce/melons plants, it may provide some insight into why Admire continues to provide excellent residual control following soil application.

Acknowledgments

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Table 1. Location of commercial lettuce fields used for monitoring efficacy of Admire against silverleaf whitefly

	Number of monitoring sites		
Year	Yuma Valley	Gila Valley	Dome Valley/Roll
1993	0	1	4
1994	2	1	4
1995	1	0	6
1996	2	2	2
1997	2	2	1
1998	2	2	4

Table 2. Admire Field Performance Against Silverleaf Whitefly on Commercial Lettuce average across all sites in each growing season in Yuma 1993-1998.

		Whitefly densities ($\bar{x}$ / cm^2)					
		Thinning (21 DAP)		Heading (50 DAP)		Yields ($\bar{x}$/head)	
Year	Treatment	eggs	nymphs	eggs	nymphs	Wt (lbs)	Diam. (in)
1993	Admire	44.8	11.1	17.6	16.7	1.7	6.7
	Untreated	132.1	51.9	65.0	49.6	1.4	5.6
	t value	*2.3 **	*6.1 ***	*0.8*	*2.2 **	*2.8 **	*6.2 ***
1994	Admire	2.7	0.6	1.1	1.7	1.9	6.9
	Untreated	20.7	5.5	2.9	15.1	1.3	5.8
	t value	5.8 **	6.4 **	3.3 *	6.4 **	14.0 **	8.6 **
1995	Admire	6.4	4.2	0.1	0.2	2.0	7.0
	Untreated	18.1	12.8	0.4	0.6	1.8	6.8
	t value	1.5	2.2 *	1.0	1.7	2.0	1.8
1996	Admire	0.2	0.1	0.0	0.1	2.0	7.0
	Untreated	1.5	0.5	0.1	0.7	1.9	7.0
	t value	2.0	1.5	2.0	2.4 *	0.5	0.3
1997	Admire	0.5	0.2	0.4	0.2	1.9	6.9
	Untreated	2.0	2.0	0.4	2.1	1.9	6.8
	t value	1.3	2.2 *	0.1	2.6 *	0.3	0.4
1998	Admire	0.4	0.4	0.1	0.1	2.0	6.9
	Untreated	3.7	1.9	0.1	0.4	1.9	6.9
	t value	1.1	3.1 *	1.0	1.1	0.7	0.1

*, ** , indicates significant *t* value at $P < 0.05$ and $P < 0.01$, respectively; paired t-test.

Table 3. Admire Field Performance Against Silverleaf Whitefly on Commercial Broccoli Fields in the Yuma Valley, Fall 1998.

		Whitefly densities ($\bar{x}$ / cm^2)			
		30 DAP		50 DAP	
Site	Treatment	eggs	nymphs	eggs	nymphs
Ranch 19	Admire	26.1	6.5	0	0.6
	Untreated	177.0	36.2	2.0	16.8
Ranch 47	Admire	0.4	0.1	0.3	0.0
	Untreated	5.9	10.5	0.5	2.8
Ranch 62	Admire	0.8	0.3	0.1	2.8
	Untreated	37.6	33.3	1.3	20.4
Ranch 8	Admire	0.2	0.1	0.0	0.0
	Untreated	0.4	1.1	0.0	1.4
Ranch 93	Admire	0.8	0.1	0.0	0.0
	Untreated	11.1	0.3	0.2	10.2
Average (n=5)	Admire	5.9	1.4	0.3	0.9
	Untreated	57.9	17.9	1.7	15.2
	t value	1.6	2.3 *	1.2	2.5 *

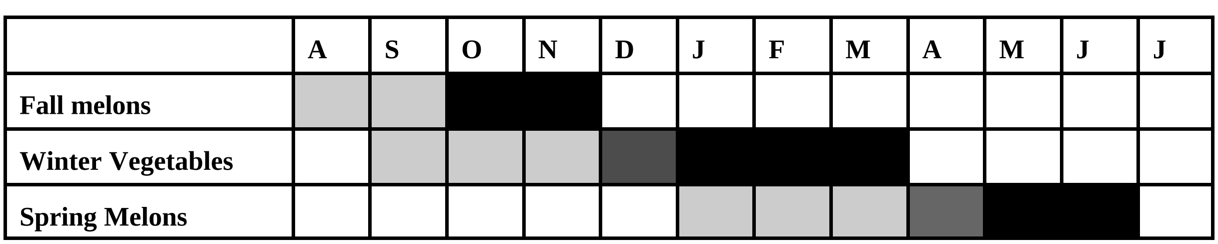
*, ** , indicates significant *t* value at $P < 0.05$ and $P < 0.01$, respectively; paired t-test.

Table 4. Admire Field Performance Against Silverleaf Whitefly on Commercial Drip Irrigated Cantaloupe Fields in the Yuma Valley, Fall 1998.

		Whitefly densities ($\bar{x}$ / cm^2)					
		20 DAT		40 DAT		60 DAT	
Site	Treatment	eggs	nymphs	eggs	nymphs	eggs	nymphs
Ranch 7	Admire	3.0	0.2	0.3	0.4	0.2	0.5
	Untreated	9.8	10.2	2.6	5.0	0.5	4.7
Ranch 9	Admire	2.1	1.0	0.5	0.0	0.1	0.0
	Untreated	12.9	20.5	2.7	1.3	0.1	0.6
Ranch 12	Admire	0.7	1.8	1.0	0.4	0.0	0.0.
	Untreated	9.6	71.9	27.6	2.1	0.8	5.0
Ranch 32	Admire	3.8	1.4	5.3	1.0	0.1	5.8
	Untreated	11.4	35.7	330.7	19.2	2.7	72.2
Average (n=4)	Admire	2.4	0.8	1.9	0.4	0.1	1.6
	Untreated	10.9	20.7	93.7	6.6	0.3	20.7
	t value	*8.2* **	3.2 **	1.2	2.3 *	1.5	2.6 *

*, ** , indicates significant *t* value at $P < 0.05$ and $P < 0.01$, respectively; paired t-test.

Table 5. Conceptualized Windows of Admire Residual in Vegetable and Melon Crops in Yuma Valley.



Grey bars: Optimal plant residual;
Black bars: suspected sub-lethal plant residual.

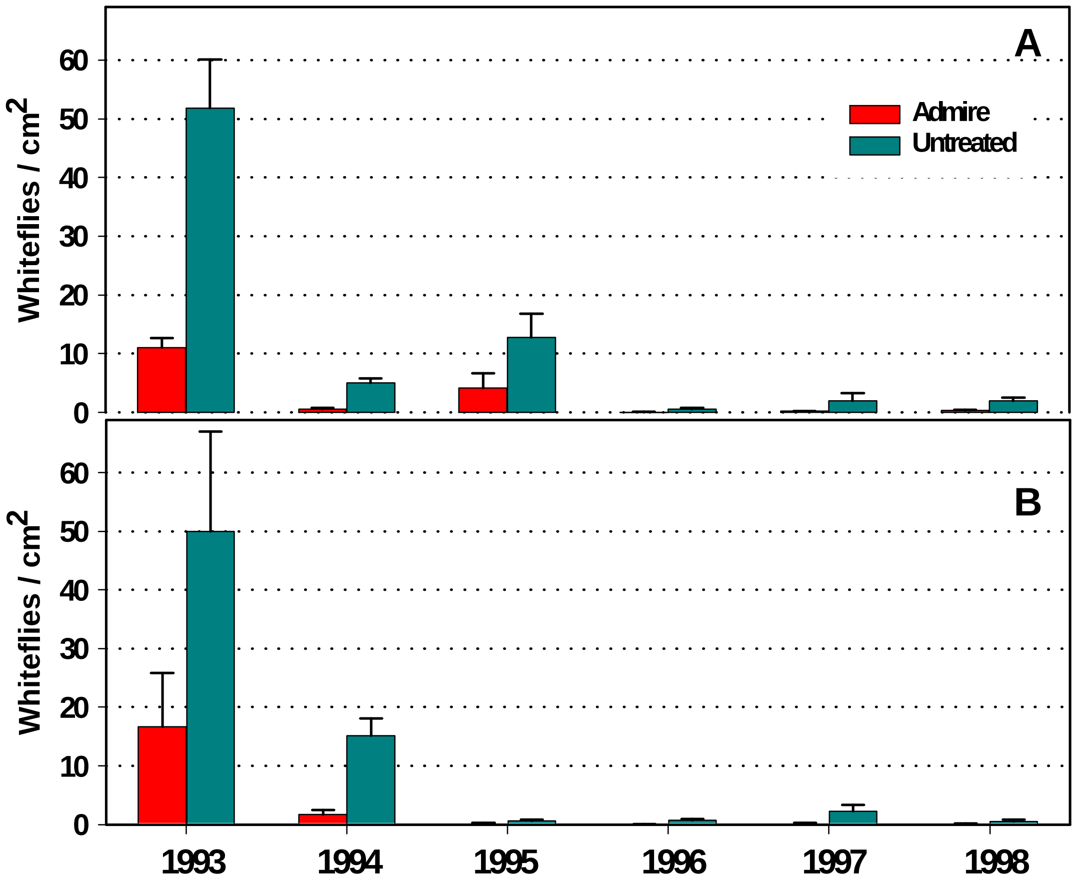
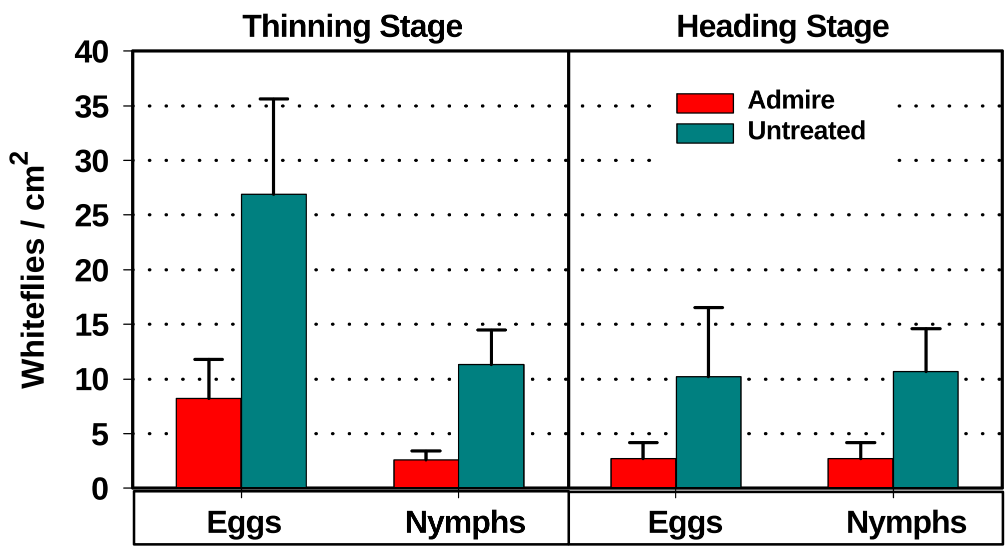


Figure 1. Silverleaf Whitefly Nymph Densities on Leaves at Thinning (A) and Heading (B) from 1993-1998 at Several Commercial Lettuce Fields in Yuma.



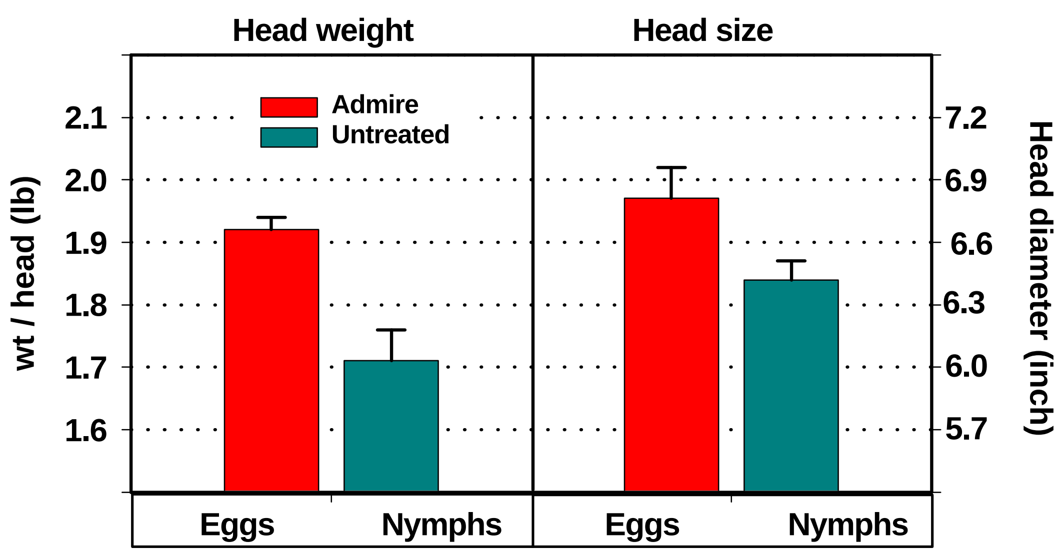


Figure 2. Silverleaf Whiteflies Densities and Associated Yields averaged over Six Years at Several Commercial Lettuce Fields in Yuma, Fall 1993-1998.