Arizona Department of Agriculture

AILRC Grants Program – Final Report for 2006

December 2006

Insect Management For Desert Lettuce Production

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Introduction

Desert lettuce production remains highly dependant on the availability of effective and economical insecticides. The implementation of FQPA has begun and will likely result in the reduced availability of many important compounds. Consequently, development of new IPM alternatives for insect management has become especially important. Recent product registrations have resulted in important IPM tools for desert lettuce growers that provide excellent control of worms, *leafminers*, and whiteflies. There are several additional chemistries currently under development that will be available for insect management in the next few years. Research to evaluate and develop these products for desert lettuce IPM programs has been supported through funding provided by AILRC and the Agrochemical industry over the past several years.

However, thrips and aphids still remain key pests of spring lettuce in the desert and represent the most important insect problems currently facing the industry. Several new promising insecticides that are in early stages of development are being evaluated for their control. However, the presence of a new aphid species, the currant-lettuce aphid, *Nasonovia ribisnigri*, and the foxglove aphid, *Aulacorthum solani*, presents some new challenges. We are still uncertain how this new species will behave under desert growing conditions. Research to learn more about its damage potential and control in the desert needs to continue. Furthermore, western flower thrips remain a very difficult pest to control and no compounds are being developed specifically for its management. Many of the compounds currently used for controlling thrips (Lannate, Orthene, Dimethoate) are directly threatened by FQPA. The intention of this proposal is to continue evaluation of new chemistries and management approaches under local growing conditions and generate new information that will allow Arizona growers to cost-effectively manage these pests.

Aphids are one of the most important insect problems in head lettuce grown in Arizona. A new aphid species, the foxglove aphid, *Aulacorthum solani*, was found infesting commercial lettuce fields in the Yuma area for the first time this past growing season. It has been known to occur in California since at least 1940, and along with the lettuce aphid, *Nosanovia ribis-nigri*, has caused problems for lettuce growers in Salinas area for the past several years. Although, the lettuce aphid is the more important of the two in Salinas, studies last spring suggest that foxglove aphid may be a more important pest in the desert. Foxglove aphids are thought to occur throughout the U.S and Canada, but its effect is generally greatest in the eastern regions of the continent. It is also found worldwide, but is probably of European origin.

The foxglove aphid appears to be similar to the lettuce aphid in that the alates (winged forms) are difficult to differentiate, both aphids have short life cycles that allow populations to build up rapidly, and both tend to prefer to colonize the youngest tissue near the terminal growing point of the plant. Apterae (wingless forms) foxglove aphid are also often confused with the green peach aphid, *Myzus persicae*. Both aphids are usually yellow-green to all green but the green peach aphid may also be somewhat pink or red, as is the lettuce aphid. The foxglove aphid is slightly larger (maximum length is 3.0 mm) than the green peach aphid (max. length is 2.3 mm). One way to distinguish these two aphids is by the dark joints found on legs and antennae of the foxglove aphid, and the dark tips of the cornicles. The green peach aphid also has pale-colored legs and antennae but without dark joints. Foxglove aphids are also unique in that they have a bright green or dark colored spot at the base of each cornicle. Alates have a pattern of transverse dark bars on the dorsal abdomen.

The foxglove aphid was not previously thought to occur in Arizona. It is principally considered a serious pest of potatoes and is also found on ornamental and greenhouse plants. It is considered an occasional pest of lettuce and leafy vegetables grown in Canada. Unlike the lettuce aphid which was first found in Yuma five years ago, the foxglove aphid is known to colonize a much broader range of plant hosts, including a wide variety of weeds, ornamentals and crops. This large availability of hosts and apparent adaptation to our winter and spring growing conditions suggests that foxglove aphids might present growers with some new challenges.

There is much uncertainty surrounding this new species, and its ability to thrive within our desert growing conditions. We are not sure how or when the foxglove aphid moved into the Yuma area, but it seems likely that it may have arrived via transplants or harvest equipment, much like we suspect with the lettuce aphid. Because this species is polyphagus and utilizes a number of known host plants grown in the desert, we are concerned that foxglove aphids may become an established pest on our winter/spring crops. In terms of management, control with foliar aphicides appears to be more difficult because the aphids preference for the protected terminal growth. We have had the opportunity to conduct a considerable amount of field research over the past two growing seasons to learn more about this pest. Because of the importance of the foxglove as a contaminant of lettuce and other leafy vegetables, we designed several studies to its examine its population growth, distribution, and damage potential.

<u>Objective 1.</u> To continue monitoring for a 14th consecutive year the commercial field performance of Admire soil treatments for control of whiteflies in the Yuma area.

Methods and Materials : Several commercial lettuce fields planted in the Dome Valley, Gila Valley and Yuma Valley were used for these studies from 1993-2006. A total of 6-9 monitoring sites were established for each season (7 in 2006). (Table 1). Lettuce fields were planted within a week in early September (Sep 9-17) in each year. Admire was evaluated on 'empire' type lettuce varieties each year. Two treatments were evaluated in each growers field: (1) growers standard application of Admire throughout the field, and (2) an untreated check plot where Admire was not applied in a randomly selected area in the field measuring 4 beds * 100 ft. The commercial standard field received 16 oz of Admire (or 7 oz of Admire Pro in 2006) at planting in a total volume of 20 gallons/acre. Admire was injected at a depth of ~ 2" below the seed line just prior to seeding.

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. Since 1998, studies similar to above were initiated 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. Admire was applied similar to the lettuce trials. Leaf samples were collected from basal leaves at 20 , 40 and 60 days after planting and immature densities were assessed as above..

Results : Evaluations of Admire field efficacy in lettuce for the 2006 growing season are found in Figure 1. Over the past 14 years, silverleaf whitefly densities in lettuce fields have declined dramatically. Numbers were greatest in 1993 and 1994 when Admire was first introduced (Fig 1). We observed a small outbreak in 2005, but numbers declined to low levels again the past season. Untreated lettuce plots had significantly greater whitefly densities throughout the season than the Admire treated field plots . During the past 10 years, 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. A trend of low whitefly abundance and immigration during September in Yuma growing regions has been observed in particular the past 3 years, and can be seen more directly from trap catches in our trap network . 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 continues to provide exceptional field efficacy over the past 14 years. Thus, as of the fall 2006 our initial conclusion is that Admire remains efficacious. However, the fact that densities on lettuce have been very low ($\leq$2 nymphs/cm^2) in most years since 1995, and lettuce is a marginal host for whitefly development and colonization, suggests that these data may not truly reflect Admire efficacy against whitefly populations in Yuma. Because of this concern, untreated test sites were established in commercial broccoli fields beginning in the fall 1998 to measure differences in whitefly colonization in these highly preferred host crops. Results from the broccoli trials clearly show that Admire provided excellent efficacy of whitefly adults and small nymphs (Figure 2) . No significant colonization was observed in any of the Admire treated fields. In contrast, several of untreated plots experienced stunted growth, and chlorosis of leaf and stem tissue. Result in the melon plots showed a similar response . Field plots left untreated, resulted in significantly higher whitefly densities at each sampling interval. These results are consistent with results from our 1998 studies, suggesting that growers could expect ~ 45days of residual efficacy following soil application of Admire on fall vegetables.

Figure 1.

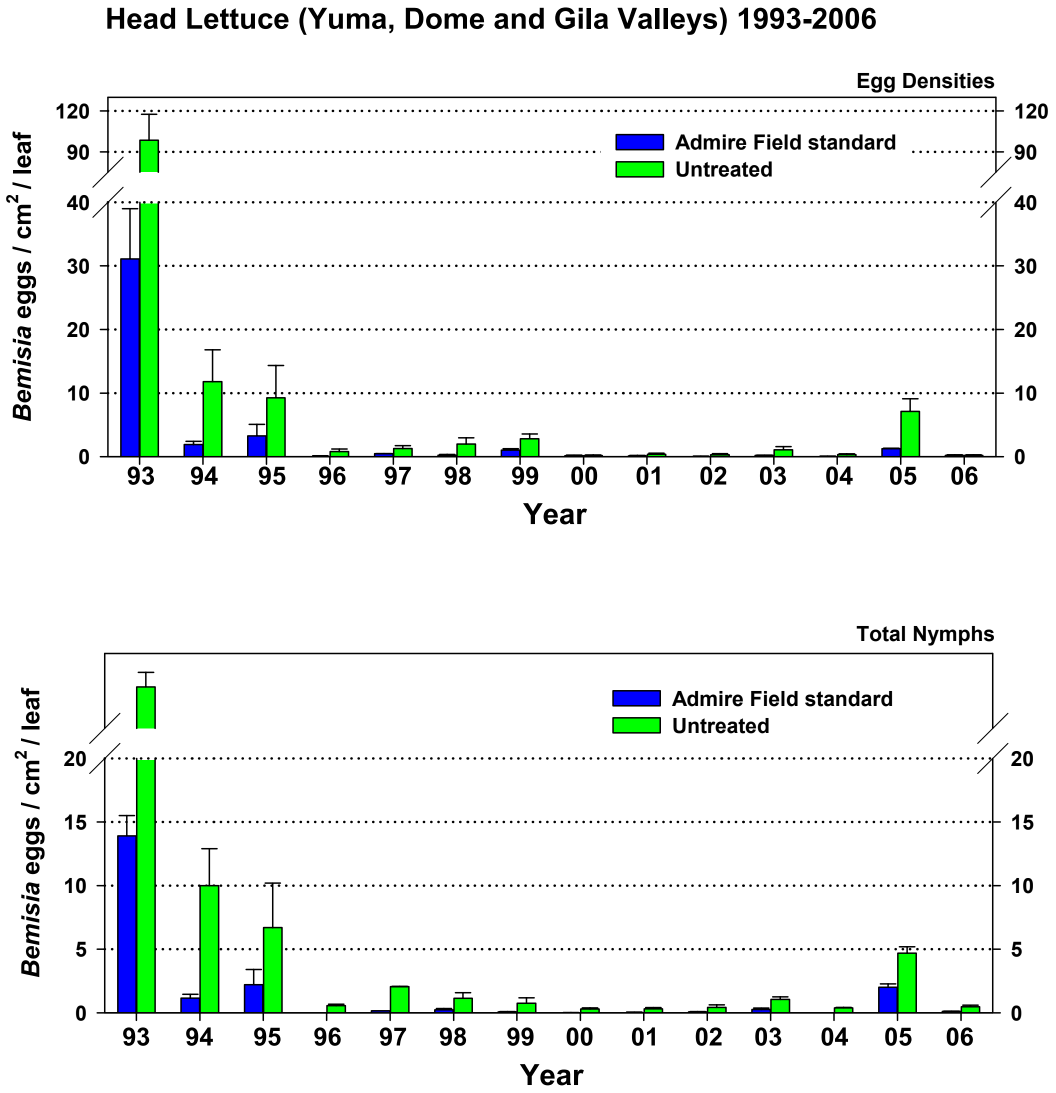
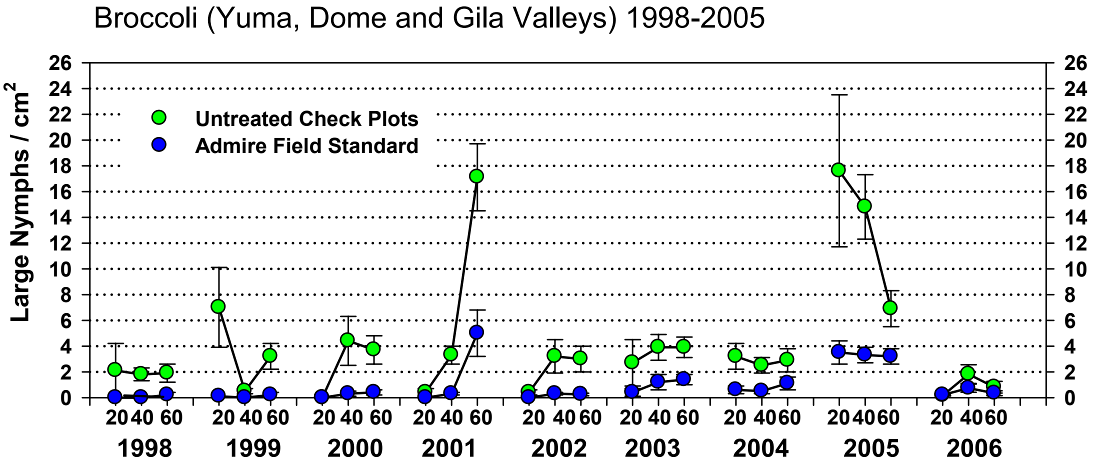


Figure 2



<u>Objective 2.</u> Action Thresholds for Aphid Management with Reduced-Risk and Conventional Insecticides in Desert Head Lettuce

Introduction

For lettuce growers to successfully compete in today's marketplace, they must be able to produce high quality, insect-free crops. Contamination by aphids in heads is one of the primary constraints to economic production of winter lettuce. Furthermore, aphids have become one of the most difficult pests to manage in desert lettuce as pest management programs used to control them have become outdated. An aphid complex consisting of the green peach aphid, the potato aphid, and *Acyrthosiphon lactucae* has caused problems for Arizona lettuce growers since the early 1950's. This has recently changed as two new species have emerged that now pose serious concerns to the lettuce industry. A new exotic aphid species, the lettuce aphid and another aphid species, the foxglove aphid, were found infesting commercial lettuce fields in the Yuma area for the first time in 2001. It is not uncommon to find all five aphid species simultaneously infesting lettuce fields and if not controlled, populations can quickly build up to very high densities in mature heads. The standard aphid management approach in head lettuce since 1993 involves the prophylactic soil application of the systemic, neonicotinoid insecticide imidacloprid (Admire 2F). However, neonicotinoids have been inconsistent in controlling foxglove and lettuce aphids. Lettuce not planted with Admire often requires foliar insecticide applications on a routine basis to control all aphid species and prevent crop losses.

Given the complexities of the desert lettuce cropping systems, new reduced-risk insecticides may offer the most immediate hope as replacements for prophylactic Admire applications for control of foxglove aphids. Many of the new insecticides being developed today are selective compounds and environmentally safe. Fulfill, Assail and Beleaf have shown varying levels of control in lettuce depending on the aphid species targeted and spray timing. We know that initiating applications at low aphid densities can provide protection to marketable heads. Unfortunately, what we don't know is at what population density is *re-treatment* needed to sustain an acceptable level of protection from aphids? Can spray intervals be stretched to 14 days or longer and still achieve protection? What is needed is a management-based approach that will prevent PCAs from under or over applying these new insecticides, while producing a contaminant–free crop. The objective of this study was to empirically test pre-determined action thresholds to see if they can be used to prevent economic contamination of aphids on head lettuce using conventional and newly-developed, reduced-risk insecticides.

Methods and Materials

The action thresholds that were tested in this project are shown in the table below. The first action threshold selected was a 10% infestation level (10 % of plants infested with 5 or > apterae aphids). The rationale for selecting this threshold is based on the U.S. Fancy No. 1 Grading Standards for head lettuce. The standard basically states that a carton of lettuce (composed of 24 heads) is deemed unacceptable if more than 3 heads (12%) contain insect defects, where an insect defect can be defined any head containing 5 or more aphids. This is a very low infestation of aphids (<1.0 aphid / plant). We calculated an Aesthetic Injury Level (AIL) based on the above described standards of 12% damaged heads. Thus, we set our Action Threshold below this level at a 10% plant infestation (5 or > aphids) in an attempt to prevent the grading standard AIL from being exceeded at harvest. We hypothesized that this threshold would prevent economic contamination given the insecticides available for use. However, because the compounds may actually exceed our expectations under some growing conditions (ie. long residual control) we established an additional threshold at a 3-fold higher infestation level that is comparable to levels we have initiated treatments at before. We also included a standard foliar approach, which is to spray-at-colonization (SAC); we essentially made the 1st spray application when plants had 5 or more immature aphids, and continued on a 7-10 d interval until new aphid colonies were not found. A prophylactic soil application of imidacloprid, Admire 2F at 16 oz / acre, applied at-planting was used as a standard soil management practice.

Action Threshold	**IPM Chemistry**	
	Reduced-risk	**Conventional**
10% infested with > 4 apterae	●	●
30% infested with > 4 apterae	●	●
Spray–at–Colonization (SAC)	●	●
Prophylactic (Admire)		

This experiment was replicated 6 times under large-block field conditions at the Yuma Agricultural Center in 2005 and 2006. Lettuce plots were planted on October 19 (‘Grizzley’), November 16 (‘Bubba’), and December 13 (‘Teluride’) in 2005; and on October 25 (“Del Oro’), November 16 (‘Synegene 352’) and December 13 (‘Desert Spring’) in 2006. In each trial, lettuce was direct seeded into double row beds on 42 inch centers and sprinkled beginning the following day. Plots for each trial consisted of 4 beds, 80' long with a two bed buffer between the plots. Plots were arranged in a randomized complete block design with 4 replications. The soil application of Admire (16 oz/acre) was applied as a at-planting injection at a depth of 2" below the seed line at bed shaping in 20 GPA final dilution. In all trials, foliar spray applications were applied at 60 psi and 27 GPA. A directed spray (~75% band, with rate adjusted for band; nozzles directed inward toward the plants) was delivered through 3 nozzles (TX-10) per bed. An adjuvant was applied to all foliar treatments; DyneAmic at 0.125%v/v. The insecticides used and the dates they were applied for each treatment is shown in Tables 1 and 2. The action thresholds evaluated are shown in the table above. Spray applications were made when the designated threshold had been exceeded. Action thresholds were compared under two IPM chemical approaches. The first was a *Reduced Risk* approach that included alternating Fulfill, Assail, and Beleaf in a rotation throughout the test. A similar rotation was used with conventional insecticides including endosulfan, MSR, dimethoate, Orthene, and Capture (Table 1 and 2).

Aphid population abundance used for triggering thresholds was determined by estimating the percentage of plants in each replicate that had greater than 5 apterous aphids infesting leaves. In addition, the total number of both apterae and alatae aphids per plant were estimated for each replicate. This was accomplished by randomly selecting 10 plants per replicate at 6-7 day intervals. Each plant was individually sampled by visually examining all plant foliage and counting the number of live alatae (winged) and apterous (non-winged) aphids present on the plant. Aphid numbers were recorded by species, which included the following: Green peach aphid (GPA), Potato aphid and *Acyrthosiphon lactucae* (PA), Foxglove aphid (FGA) and Lettuce aphid (LA). Lettuce marketability data was collected from the middle 2 beds from each plot. Contamination levels for each treatment were estimated at harvest by sampling 12 contiguous plants within a single bed in 2 randomly selected locations within each plot (24 plants / replicate). Each plant was then evaluated for the presence and abundance of aphids on wrappers leaves, cap leaves and within heads. Mean seasonal aphid densities were tested for heterogeneity of variances prior to statistical analysis and means transformed when necessary. A two-way analysis of variance was conducted on the aphid data with means compared when appropriate using a protected LSD.

Results and Discussion

The foxglove aphid was the predominant species in these studies, but population and species abundance varied considerably between planting and years. Aphid abundance was lowest in the two studies planted in October. In both years, numbers in the untreated check never averaged more than 4 aphids / plant and infested plants with 5 or > aphids never increased to greater than 20% (Figures 1 and 2). Colonization in the SAC treatments was observed in late November (2005) and early December (2006) and were treated 3 times in each year. The 10% infested action threshold was exceeded only once near harvest in 2006 study. The 30% infested action threshold was not exceeded in either year and number of aphids in the standard Admire treatment remained low throughout the studies. At harvest, contamination of lettuce heads was light in all treatments (Table 3 and 4). In 2005 no one species was dominant and the number of aphids per head were not significantly different among treatments. Similarly, the percentage of a infested heads, irregardless of numbers present in heads, did not differ among treatments. In 2006, FGA and GPA were the most numerous species, but numbers per head were low and were not significantly different among treatments. As the only treatments not to receive sprays, the 30% infested action threshold treatments had significantly greater % of heads infested with 1-4 aphids. Differences among treatments were not significant for the other infestation levels (>5, >

10, or >20 aphids/head). Consequently, all of the action thresholds used prevented populations from exceeding the AIL of 12% infested heads with > 5 aphids /head. This is consistent with our observations that mid-winter lettuce that is planted in October is generally at low-risk form economic aphid infestations.

In contrast, our experiences have been that spring lettuce planted during the November planting window is consistently the most prone to be infested with aphids. As expected, aphid pressure was much heavier in our November plantings, particularly in 2005 where aphid numbers peaked at nearly 200 aphids / plant. All of the thresholds maintained aphids at significantly lower numbers compared to the untreated check, and were also significantly lower than the Admire standard (Figure 3). This was not surprising considering that FGA was the most abundant species present and Admire has shown inconsistent activity against FGA over the past few years. Aphid population levels in the sprayed plots were similar throughout the season, irrespective of action threshold used and number of applications made. At harvest, differences in the number of aphids / head did not differ among the action threshold treatments, but were all significantly lower than both the Admire and untreated check (Table 5). However, not all the threshold treatments significant maintained head contamination below the AIL. The 10% threshold for the RR chemistry and the 30% infested action threshold for both RR and Con compounds exceeded the AIL of 12% infested heads (>5 aphids) at harvest (Table 5). The 10% Con action threshold treatment provided significant protection comparable to the SAC treatments, but with 3 fewer spray applications. In the 2006 November planting aphid populations were lighter, but pressure was more consistent throughout the trials resulting in a higher number of applications for the 10% infested threshold treatments. Similarly, FGA was the predominant species and all action threshold treatments maintained aphids at significantly lower numbers compared to the untreated check and the Admire standard (Figure 4). Spray treatments were concentrated almost weekly in the 4-5 weeks prior to harvest. Contamination of lettuce heads at harvest was lighter than the previous year, and all thresholds except the 30% RR treatment had fewer total aphids numbers per head than the check or Admire (Table 6). Similarly, only the 30% RR threshold treatment had exceeded the AIL.

Aphid infestations on head lettuce planted in December can be unpredictable, and this is generally when FGA and LA are most abundant. Aphid pressure was highest in the 2005 planting where aphid populations exceeded more than 300 aphids / plant in early March (Figure 5). Consequently, during the last week prior to harvest only the SAC and 10% infested threshold treatments sprayed with conventional insecticides had lower aphid numbers and % infested plants than the untreated check. At harvest, head contamination with FGA was heavy in the Admire and untreated plots. Only the SAC and 10% infested threshold treatments sprayed with conventional insecticides had maintained aphid number below the AIL (Table 7). Aphid pressure was much lower in the December 2006 planting, but we observed a similar trend in population development (Figure 6). FGA was the primary species present, but did not exceed more than 10 aphids / head at harvest (Table 8). Nonetheless, only the action threshold treatments sprayed with conventional insecticides prevented aphids from significantly contaminating heads.

In summary, the use of action thresholds based on the percentage of plants infested with 5 or > aphids is an effective method of assessing the current infestation level and making an informed pest management decision. Compared with the SAC threshold treatment, the action thresholds of 10% and 30% infested plants resulted in fewer insecticide applications. Mean reduction in insecticide usage for both years ranged from 34-58% for RR insecticides and 50-65 % for Con insecticides. However, inconsistencies in preventing lettuce contamination at harvest were observed among the action thresholds depending on the chemistry used. Despite the variable aphid pressure between years and planting dates, the threshold based on 10% infested plants performed as well as the SAC with half as many sprays and no significant head contamination in any of the trials. However, this was the case only when rotations of conventional insecticide combinations were applied. When rotations of reduced- risk insecticides were used, the 10% infested action threshold was less consistent in maintaining aphids below the AIL This is not a complete surprise considering that FGA was the primary species in these studies and the neonicotinoid Assail provides marginal activity against this aphid, particularly under heavy pressure in late February and March. Fulfill has marginal activity against all aphids species when population densities are high. In contrast, conventional products such as dimethoate, orthene, endosulfan and Capture have provided excellent contact activity of FGA. The 30% infested action threshold was similarly inconsistent in preventing head contamination, regardless of chemistry used. This suggests that initiation of spray treatments at this level of plant infestation is likely too high.

In conclusion, the 10% infested threshold appears to be an ideal action threshold for head lettuce production under desert lettuce growing conditions. Given the shortcomings of using this action threshold exclusively with the new, “softer” reduced-risk compounds, selection of chemistries will be important for effective aphid management. The fact that spray combinations containing Provado (neonicotinoid, see Tables 1 and 2) were used successfully with the conventional rotations suggests that in practice PCA’s can use tank-mixtures of conventional and reduced-risk insecticides (i.e., Capture+Assail, or Endosulfan+Fuflfill) to effectively control FGA using the 10% action threshold. We presently have studies planned for the 2007 spring season to validate this approach.

Table 1. Application dates and products applied for each action threshold during the three 2005 head lettuce experiments.

2005 – October 19 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**2 Dec**	**28 Dec**	**19 Jan**			
SAC , spray at colonization	Reduced-risk	Fulfill – 2.75 oz		Beleaf-2.3 oz			
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	Provado-3.7 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz			
10% infested plants with 5 or > aphids	Reduced-risk						
	Conventional						
30% infested plants with 5 or > aphids	Reduced-risk						
	Conventional						

2005 – November 16 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**7 Jan**	**14 Jan**	**21 Jan**	**29 Jan**	**8 Feb**	**16 Feb**
SAC , spray at colonization	Reduced-risk	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	Provado-3.7 oz Endosulfan -1qt	Dimethoate-12 oz MSR-2 pts	Provado-3.7 oz Endosulfan -1qt	Dimethoat-12 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz
10% infested plants with 5 or > aphids	Reduced-risk		Assail-4 oz	Beleaf-2.3 oz			Beleaf-2.3 oz
	Conventional		Dimethoate-12 oz Orthene-0.5 lb	Provado-3.7 oz Endosulfan -1qt		Capture-6 oz Endosulfan -1qt	
30% infested plants with 5 or > aphids	Reduced-risk			Beleaf-2.3 oz	Assail-4 oz		
	Conventional			Provado-3.7 oz Endosulfan -1qt		Capture-6 oz Endosulfan -1qt	

2005-December 13 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**24 Jan**	**5 Feb**	**13 Feb**	**22 Feb**	**3 Mar**	**10 Mar**
SAC , spray at colonization	Reduced-risk	Assail-4 oz	Beleaf-2.3 oz	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz	Assail-4 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	Provado-3.7 oz Endosulfan -1qt	MSR-2 pts Capture-6 oz	Capture-6 oz Endosulfan -1qt	Dimethoate-12 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz
10% infested plants with 5 or > aphids	Reduced-risk	Assail-4 oz	Beleaf-2.3 oz	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz	Assail-4 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	Provado-3.7 oz Endosulfan -1qt		MSR-2 pts Capture-6 oz		Provado-3.7 oz Capture-6 oz
30% infested plants with 5 or > aphids	Reduced-risk	Assail-4 oz		Beleaf-2.3 oz	Fulfill 2.7 oz	Beleaf-2.3 oz	Assail-4 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb		Provado-3.7 oz Endosulfan -1qt		Dimethoate-12 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz

Table 2. Application dates and products applied for each action threshold during the three 2006 head lettuce experiments.

2006 – October 25 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**9 Dec**	**7 Jan**	**22 Jan**			
SAC , spray at colonization	Reduced-risk	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz			
	Conventional	Orthene-0.5 lb	Dimethoate-12 oz Provado-3.7 oz	Capture-6 oz Endosulfan -1qt			
10% infested plants with 5 or > aphids	Reduced-risk			Beleaf-2.3 oz			
	Conventional			Capture-6 oz Endosulfan -1qt			
30% infested plants with 5 or > aphids	Reduced-risk						
	Conventional						
2006 – November 16 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**19 Jan**	**26 Jan**	**3 Feb**	**9 Feb**	**17 Feb**	**22 Feb**
SAC , spray at colonization	Reduced-risk	Beleaf-2.3 oz	Assail-4 oz	Beleaf-2.3 oz	Fulfill 2.7 oz	Assail-4 oz	Beleaf-2.3 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	MSR-2 pts Capture-6 oz	Provado-3.7 oz Endosulfan -1qt	Capture-6 oz Dimethoate-12 oz	Provado-3.7 oz Endosulfan -1qt	Capture-6 oz Endosulfan -1qt
10% infested plants with 5 or > aphids	Reduced-risk	Beleaf-2.3 oz	Assail-4 oz			Fulfill 2.7 oz	Beleaf-2.3 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb		MSR-2 pts Capture-6 oz	Provado-3.7 oz Endosulfan -1qt		Capture-6 oz Endosulfan -1qt
30% infested plants with 5 or > aphids	Reduced-risk			Beleaf-2.3 oz		Assail-4 oz	
	Conventional			MSR-2 pts Capture-6 oz		Provado-3.7 oz Endosulfan -1qt	
2006-December 13 Planting		**Application Dates and Products Applied**					
Action Threshold	**Chemistry**	**24 Jan**	**3 Feb**	**10 Feb**	**17 Feb**	**27 Mar**	**6 Mar**
SAC , spray at colonization	Reduced-risk	Assail-4 oz	Beleaf-2.3 oz	Fulfill 2.7 oz		Beleaf-2.3 oz	Assail-4 oz
	Conventional	Dimethoate-12 oz Orthene-0.5 lb	MSR-2 pts Capture-6 oz	Provado-3.7 oz Endosulfan -1qt	Dimethoate-12 oz Orthene-0.5 lb	Capture-6 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz
10% infested plants with 5 or > aphids	Reduced-risk		Assail-4 oz	Beleaf-2.3 oz		Assail-4 oz	Fulfill 2.7 oz
	Conventional		Provado-3.7 oz Orthene-0.5 lb			Capture-6 oz Endosulfan -1qt	Provado-3.7 oz Capture-6 oz
30% infested plants with 5 or > aphids	Reduced-risk		Assail-4 oz			Beleaf-2.3 oz	Fulfill 2.7 oz
	Conventional		Provado-3.7 oz Orthene-0.5 lb			Dimethoate-12 oz Endosulfan -1qt	

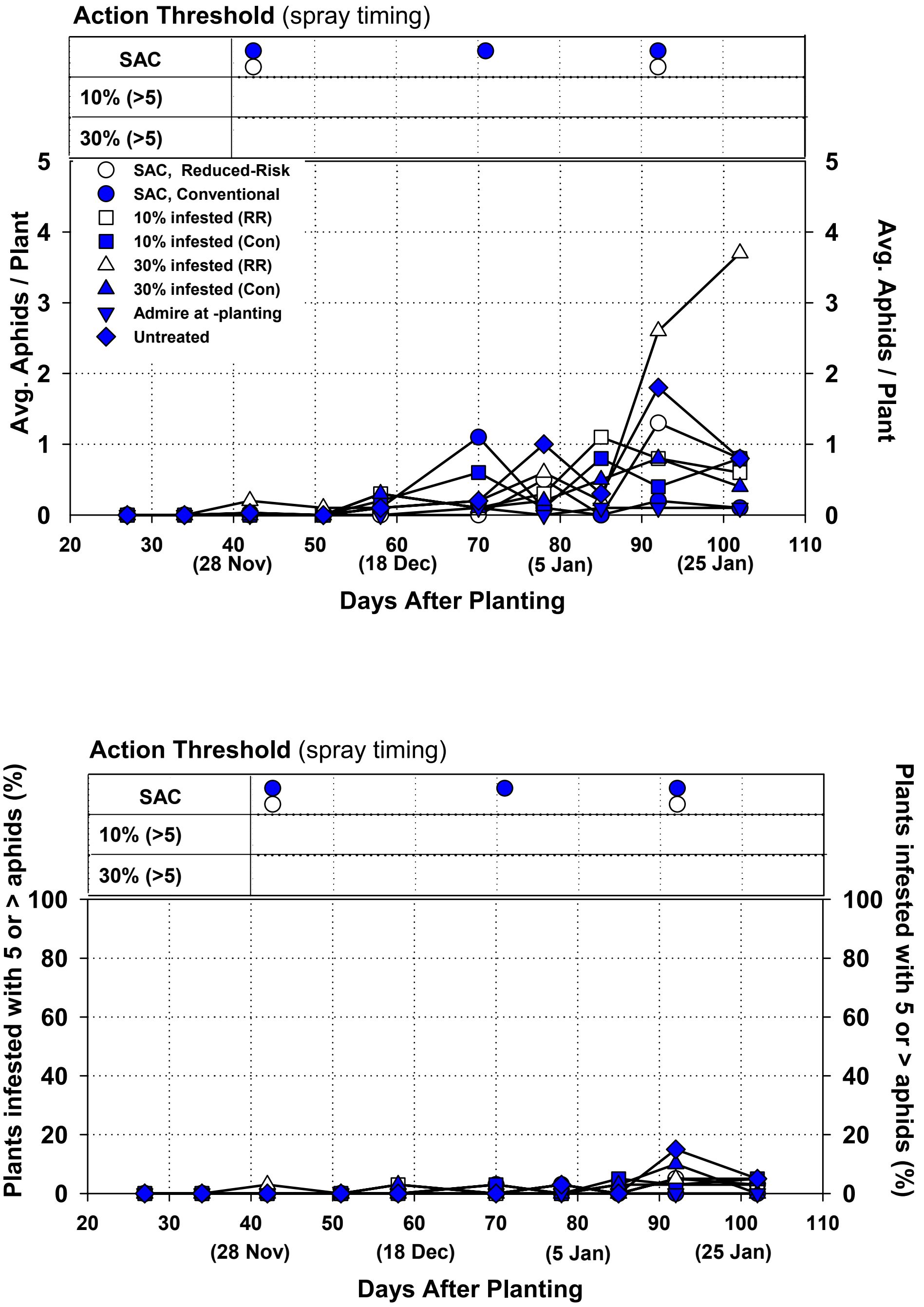


Figure 1. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 October planting.

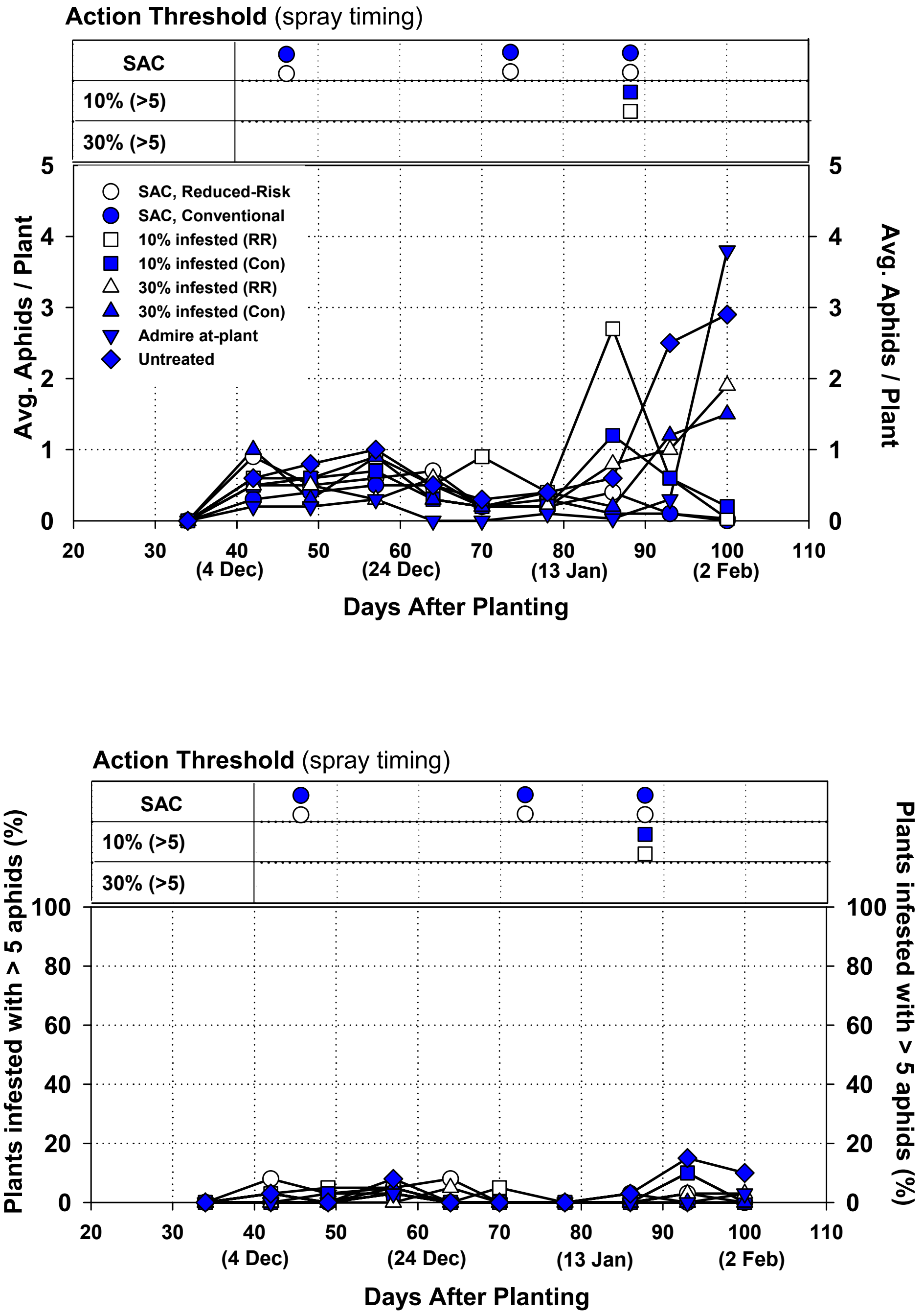


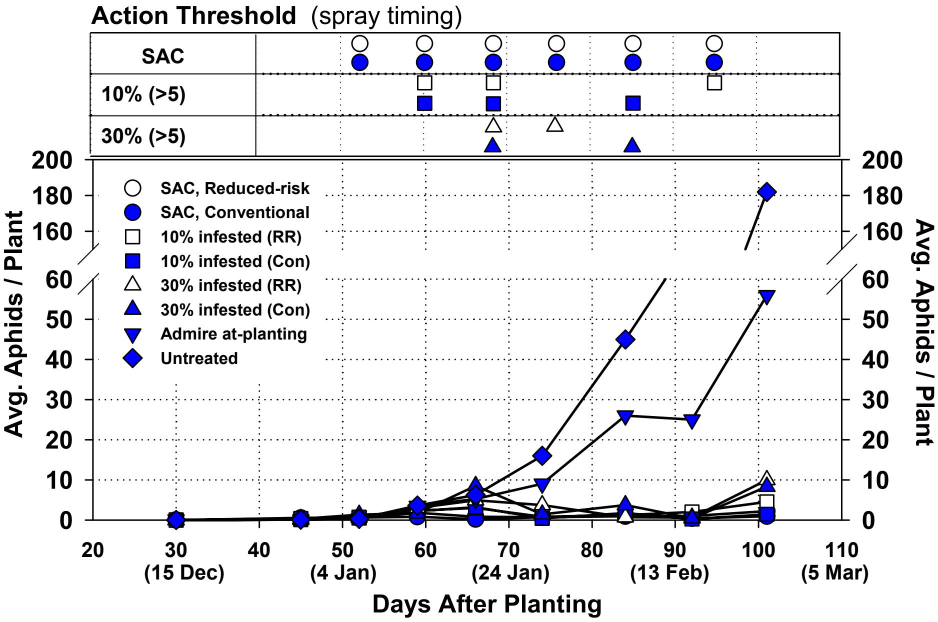
Figure 2. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 October planting.

Table 3. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2005 October planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					% Heads infested (all species)			
Action threshold	Chemistry	No. of sprays	FGA	LA	PA	GPA	Total	1-4 aphids	>5 aphids	>10 aphids	>20 aphids
Spray–at–colonization	Reduced-risk	2	0.2a	0.0	0.0	0.4a	0.6a	15.0a	2.5a	2.5a	0.0a
Spray–at–colonization	Conventional	3	0.0a	0.1a	0.0	0.0a	0.1a	5.0a	0.0a	0.0a	0.0a
10% infested (>5 aphids)	Reduced-risk	0	0.3a	0.0a	0.0	0.1a	0.4a	15.0a	2.5a	0.0a	0.0a
10% infested (>5 aphids)	Conventional	0	0.5a	0.0a	0.0	0.1a	0.6a	15.0a	5.0a	2.5a	0.0a
30% infested (>5 aphids)	Reduced-risk	0	0.0a	3.5a	0.0	0.1a	3.7a	10.0a	5.0a	5.0a	5.0a
30% infested (>5 aphids)	Conventional	0	0.2a	0.0a	0.0	0.0a	0.2a	15.0a	0.0a	0.0a	0.0a
Preventative (Admire)	--	0	0.1a	0.0a	0.0	0.0a	0.1a	2.5a	0.0a	0.0a	0.0a
Untreated	--	0	0.4a	0.0a	0.0	0.1a	0.5a	12.5a	5.0a	2.5a	0.0a
		Pr > F	0.39	0.46	0.46	0.44	0.56	0.52	0.55	0.73	0.45
		LSD	0.49	3.7	0.03	0.04	3.8	15.5	7.5	7.0	5.2

Table 4. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2006 October planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					**% Heads infested (all species)**			
Action threshold	**Chemistry**	**No. of sprays**	**FGA**	**LA**	**PA**	**GPA**	**Total**	**1-4 aphids**	**>5 aphids**	**>10 aphids**	**>20 aphids**
Spray–at–colonization	Reduced-risk	3	0.0a	0.0	0.0	0.0a	0.0a	0.0b	0.0a	0.0a	0.0a
Spray–at–colonization	Conventional	3	0.0a	0.0	0.0	0.0a	0.0a	0.0b	0.0a	0.0a	0.0a
10% infested (>5 aphids)	Reduced-risk	1	0.0a	0.0	0.0	0.0a	0.0a	5.0b	0.0a	0.0a	0.0a
10% infested (>5 aphids)	Conventional	1	0.0a	0.0	0.0	0.1a	0.1a	2.5b	0.0a	0.0a	0.0a
30% infested (>5 aphids)	Reduced-risk	0	1.4a	0.0	0.0	0.4a	1.8a	22.5a	2.5a	2.5a	2.5a
30% infested (>5 aphids)	Conventional	0	0.1a	0.0	0.0	0.2a	0.3a	17.5a	0.0a	0.0a	0.0a
Preventative (Admire)	--	0	3.3a	0.0	0.0	0.1a	3.3a	2.5b	2.5a	2.5a	2.5a
Untreated	--	0	0.0a	0.0	0.0	0.2a	0.2a	10.0a	0.0a	0.0a	0.0a
		Pr > F	0.46	-	-	0.23	0.44	0.03	0.45	0.45	0.45
		LSD	3.5	-	-	0.35	3.5	14.5	3.4	3.4	3.4



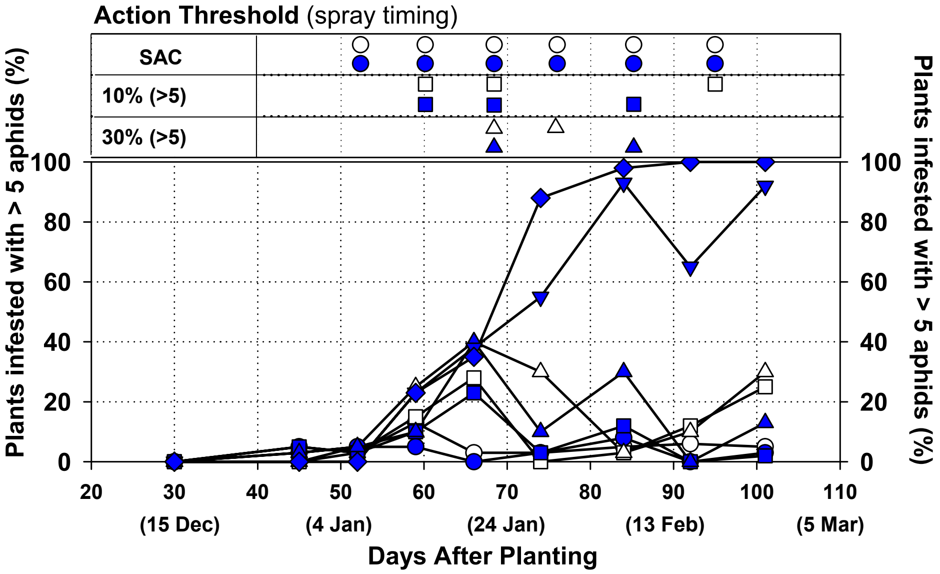
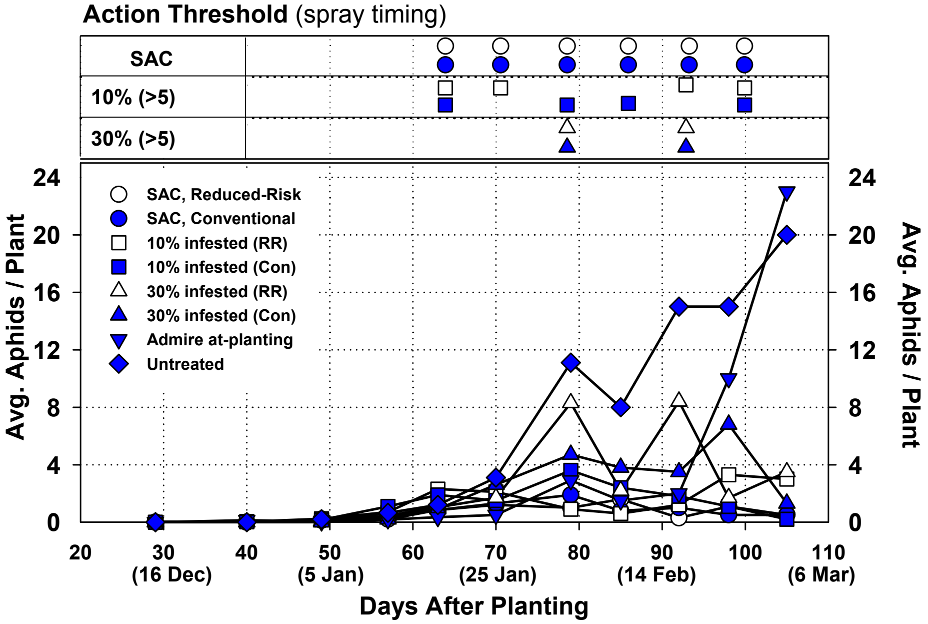


Figure 3. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 November planting.



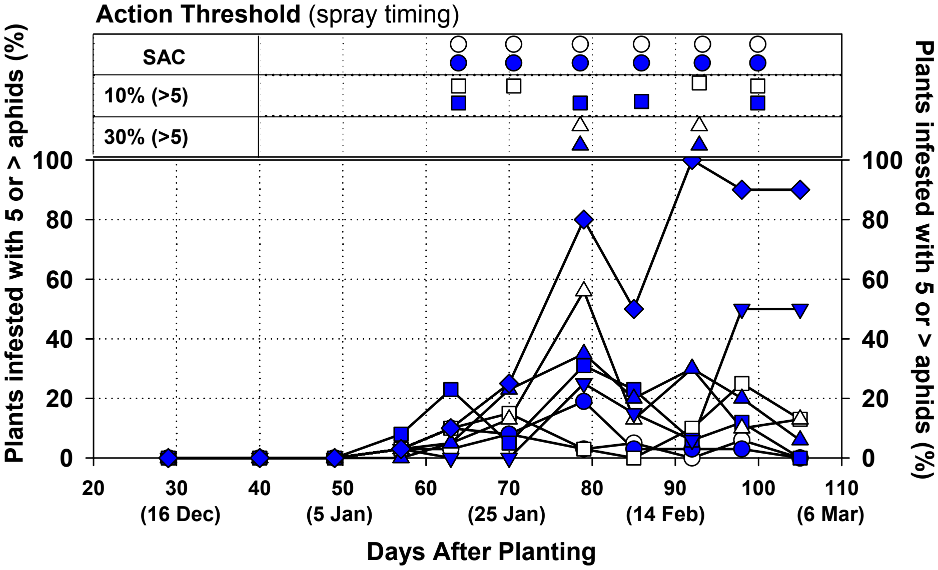


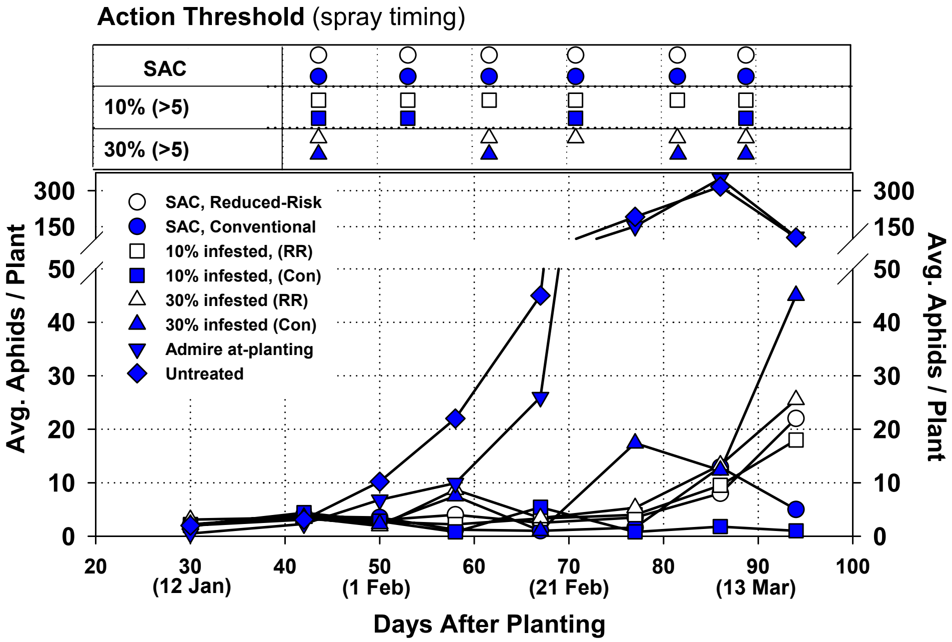
Figure 4. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 November planting.

Table 5. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2005 November planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					**% Heads infested (all species)**			
Action threshold	**Chemistry**	**No. of sprays**	**FGA**	**LA**	**PA**	**GPA**	**Total**	**1-4 aphids**	**>5 aphids**	**>10 aphids**	**>20 aphids**
Spray–at–colonization	Reduced-risk	6	0.6c	1.1a	0.2b	0.0b	1.9 c	20.0d	5.0c	2.5c	2.5c
Spray–at–colonization	Conventional	6	0.2c	0.2a	0.0b	0.2b	0.6 c	22.5d	2.5c	0.0c	0.0c
10% infested (>5 aphids)	Reduced-risk	3	3.5c	0.1a	0.1b	0.5b	4.2 c	55.0bc	25.0b	15.0b	5.0c
10% infested (>5 aphids)	Conventional	3	0.8c	0.0a	0.1b	0.1b	1.0 c	42.5d	2.5c	0.0c	0.0c
30% infested (>5 aphids)	Reduced-risk	2	5.0c	1.2a	0.0b	0.1b	6.3 c	75.0b	30.0b	17.5b	7.5c
30% infested (>5 aphids)	Conventional	2	7.6c	0.0a	0.0b	0.2b	7.8 c	30.0d	12.5bc	7.5bc	7.5c
Preventative (Admire)	--	0	42.4b	8.6a	0.3b	0.7b	52.0 b	97.5a	92.5a	87.5a	60.0b
Untreated	--	0	108.4a	5.7a	8.1a	13.1a	135.3 a	100.0a	100.0a	100.0a	95.0a
		Pr > F	0.008	0.08	0.0001	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001
		LSD	19.5	6.4	0.7	5.9	19.8	22.9	17.6	13.5	15.1

Table 6. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2006 November planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					% Heads infested (all species)			
Action threshold	**Chemistry**	**No. of sprays**	**FGA**	**LA**	**PA**	**GPA**	**Total**	**1-4 aphids**	**>5 aphids**	**>10 aphids**	**>20 aphids**
Spray–at–colonization	Reduced-risk	6	0.6a	1.1a	0.0	0.0b	1.5b	25.0c	3.1c	3.1b	3.1b
Spray–at–colonization	Conventional	6	0.4a	0.0a	0.0	0.1b	0.5b	12.5c	3.1c	3.1b	0.0b
10% infested (>5 aphids)	Reduced-risk	5	0.8a	0.1a	0.0	0.0b	1.0b	25.0c	6.3bc	0.0b	0.0b
10% infested (>5 aphids)	Conventional	4	0.2a	0.0a	0.0	0.2b	0.4b	21.9b	0.0c	0.0b	0.0b
30% infested (>5 aphids)	Reduced-risk	2	4.1a	2.8a	0.0	0.1b	6.9ab	53.1b	25.0ab	15.6a	9.4ab
30% infested (>5 aphids)	Conventional	2	0.4a	0.1a	0.0	0.2b	0.6b	31.3bc	0.0c	0.0b	0.0b
Preventative (Admire)	--	0	14.9a	0.3a	0.0	0.1b	15.4a	75.0a	37.5a	22.0a	9.4ab
Untreated	--	0	6.0a	6.1a	0.0	0.8a	12.9a	78.0a	35.0a	22.0a	18.8a
		Pr > F	0.06	0.54	-	0.002	0.05	0.0001	0.002	0.0008	0.03
		LSD	9.6	6.8	-	0.36	11.0	24.3	21.4	12.1	12.0



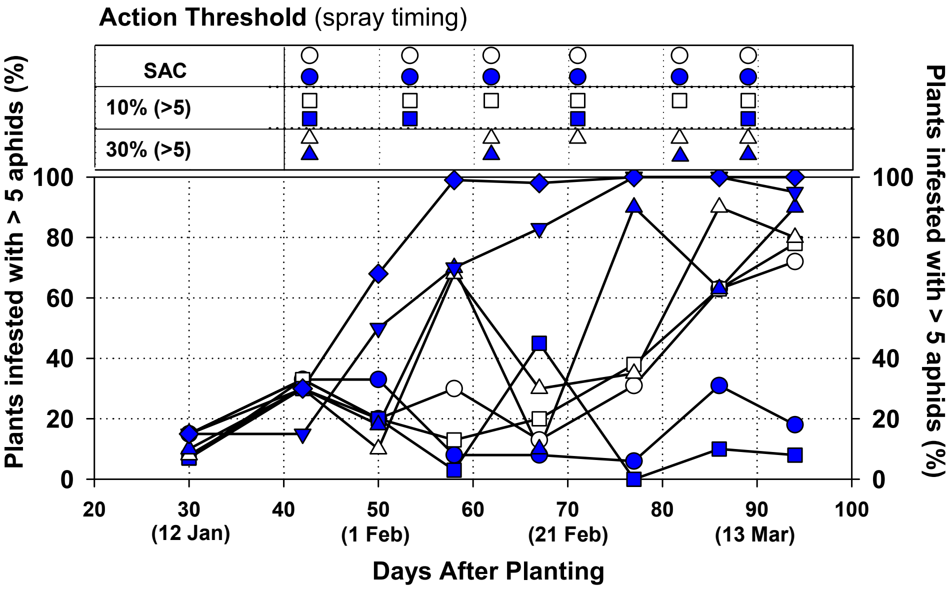
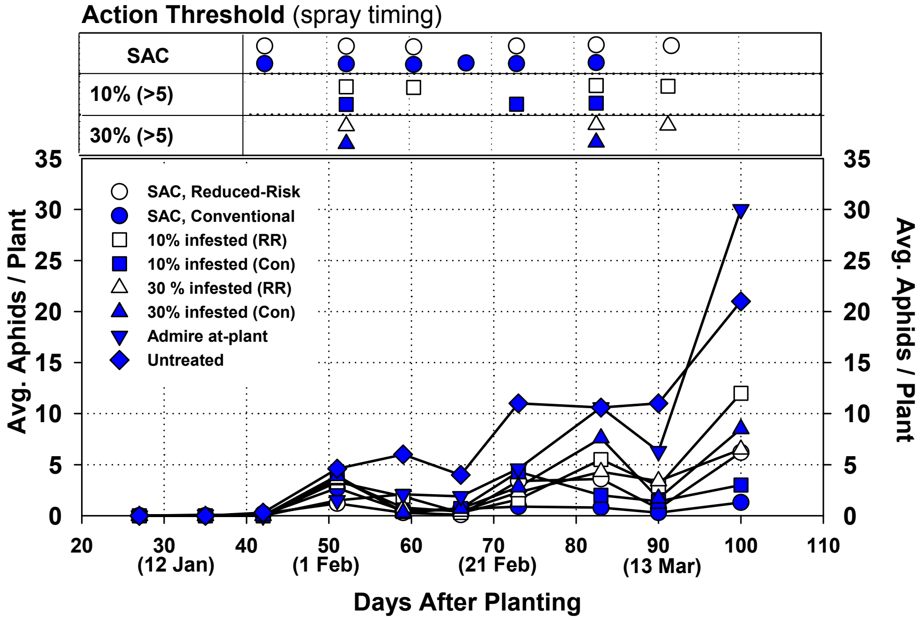


Figure 5. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 December planting.



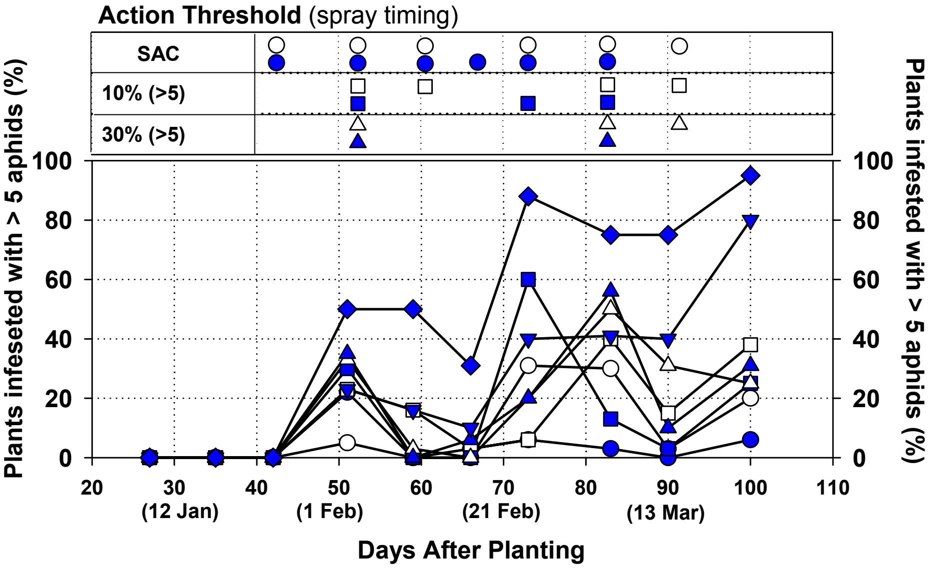


Figure 6. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 December planting.

Table 7. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2005 December planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					**% Heads infested (all species)**			
Action threshold	**Chemistry**	**No. of sprays**	**FGA**	**LA**	**PA**	**GPA**	**Total**	**1-4 aphids**	**>5 aphids**	**>10 aphids**	**>20 aphids**
Spray–at–colonization	Reduced-risk	6	14.0ab	7.6a	0.0a	0.0	21.6b	87.5a	72.5a	55.0ab	40.0a
Spray–at–colonization	Conventional	6	4.8b	0.0a	0.0a	0.0	4.8b	42.5b	10.0b	10.0c	5.0b
10% infested (>5 aphids)	Reduced-risk	6	12.5ab	5.2a	0.2a	0.0	17.8b	95.0a	77.5a	45.0b	30.0a
10% infested (>5 aphids)	Conventional	4	1.0b	0.0a	0.0a	0.0	1.0b	32.5b	7.5b	0.0c	0.0b
30% infested (>5 aphids)	Reduced-risk	5	9.7ab	14.6a	0.4a	0.0	24.7ab	97.5a	82.5a	67.5a	48.0a
30% infested (>5 aphids)	Conventional	4	39.6a	6.3a	0.0a	0.0	45.8ab	95.0a	87.5a	77.5a	60.0a
Preventative (Admire)	--	0	91.9a	3.1a	0.0a	0.0	95.0a	100.0a	95.0a	95.0a	70.0a
Untreated	--	0	71.2a	8.0a	6.5a	0.0	85.7a	95.0a	80.0a	75.0a	65.0a
		Pr > F	0.05	0.09	0.32	-	0.04	0.0001	0.0001	0.0001	0.003
		LSD	63.1	8.9	6.0	-	62.5	21.6	21.3	21.4	34.8

Table 8. Aphid contamination levels in heads lettuce plants treated with reduced-risk and conventional insecticides at various action thresholds in the 2006 December planting.

			Head Lettuce Contamination at Harvest								
			Avg. aphids / head					**% Heads infested (all species)**			
Action threshold	**Chemistry**	**No. of sprays**	**FGA**	**LA**	**PA**	**GPA**	**Total**	**1-4 aphids**	**>5 aphids**	**>10 aphids**	**>20 aphids**
Spray–at–colonization	Reduced-risk	6	1.4b	0.6a	0.0	0.0a	2.0bc	46.9b	12.5b	6.3ab	0.0b
Spray–at–colonization	Conventional	5	0.2b	0.1a	0.0	0.1a	0.3c	25.0bc	0.0c	0.0b	0.0b
10% infested (>5 aphids)	Reduced-risk	4	2.9b	1.8a	0.0	0.0a	4.7b	56.3ab	28.1ab	12.5ab	9.4ab
10% infested (>5 aphids)	Conventional	3	0.2b	0.0a	0.0	0.0a	0.2c	9.4d	0.0c	0.0b	0.0b
30% infested (>5 aphids)	Reduced-risk	3	2.2b	0.4a	0.0	0.0a	2.6bc	34.4bc	15.6bc	12.5ab	0.0b
30% infested (>5 aphids)	Conventional	2	0.3b	0.0a	0.0	0.2a	0.5c	21.9bc	3.0c	0.0b	0.0b
Preventative (Admire)	--	0	7.3a	0.7a	0.0	0.1a	8.0a	84.4a	34.4a	25.0a	15.0a
Untreated	--	0	8.3a	0.7a	0.0	0.2a	9.1a	70.8ab	22.8a	16.0a	8.0ab
		Pr > F	0.004	0.08	-	0.13	0.0005	0.0006	0.002	0.005	0.02
		LSD	3.5	1.2	-	0.18	3.5	30.4	17.1	12.9	9.9

Objective 3. Efficacy of Radiant (XDE-175) Against Western Flower Thrips in Lettuce

Introduction

Western flower thrips (WFT) , *Frankiniella occidentalis*, have become a serious pest in romaine lettuce production. This thrips species is polyphagous and appears to have a wide host range in most vegetable producing areas. They occur on lettuce throughout the growing season and are present in damaging numbers in Oct and Nov and can build up to very serious damaging numbers again in Feb through April. Adults often migrate onto lettuce crops during the winter months as weeds and other host plants dry down or are harvested. WFT are considered a pest because of the cosmetic damage they cause romaine leaves and hearts. Grower tolerance for WFT damage and contamination has recently become very low in romaine lettuce. Consequently, PCAs rely almost exclusively on insecticide applications to prevent WFT damage and have a limited number of effective treatment options. Success, Lannate and pyrethroids are presently the most frequently used products. Radiant, a new reduced-risk insecticide from Dow AgroSciences has recently been introduced to the vegetable industry that has shown excellent activity against WFT. This macrocyclic lactone compound is considered a 2nd generation sprinosyn, similar to spinosad (Success). However, it reportedly has a broader spectrum than Success and appears to be more active at lower use rates. Registration on leafy vegetables, melons and other important desert crops is pending, but a label is anticipated in the next year or so. The objective of these studies was to evaluate the efficacy of Radiant against WFT compared with Success, Lannate and other insecticides

Materials and Methods

Spring 2005 –Trial I: The field trial was conducted at the University of Arizona Yuma Agricultural Center. Romaine lettuce 'Fresh heart' was direct seeded 1 Dec into double row beds on 42 inch centers Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Insecticide treatments and rates used in the trial are found in Tables1 and 2. The foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 20.5 GPA. A broadcast spray was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.125%v/v with all spray applications. Sprays were applied on Feb 9, 15 and 25. No other pesticides were applied.

Spring 2005 –Trial II: The field trial was conducted at the University of Arizona Yuma Agricultural Center. Romaine lettuce ‘PIC 715’was direct seeded 20 Jan into double row beds on 42 inch centers Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 30 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Insecticide treatments and rates used in the trial are found in Tables 3-5. The foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 20.5 GPA. A broadcast spray was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.125%v/v with all spray applications. Sprays were applied on Feb 25, Mar 7 and Mar 17. No other pesticides were applied.

Fall 2005 –Trial I: The field trial was conducted at the University of Arizona Yuma Agricultural Center. Romaine lettuce 'Rubicon' was direct seeded 8 Sep into double row beds on 42 inch centers Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Insecticide treatments and rates used in the trial are found in Tables 6-7. The foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 20.5 GPA. A broadcast spray was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.125%v/v with all spray applications. Sprays were applied on Oct 9, 16 and 22. No other pesticides were applied.

Fall 2005 –Trial II: The field trial was conducted at the University of Arizona Yuma Agricultural Center. Romaine lettuce 'PIC 715' was direct seeded 20 Sep into double row beds on 42 inch centers Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Insecticide treatments and rates used in the trial are found in Tables 8-9. The foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 20.5 GPA. A broadcast spray was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.125%v/v with all spray applications. Sprays were applied on Oct 31, Nov 8 and 17. No other pesticides were applied.

Spring 2006: The field trial was conducted at the University of Arizona Yuma Agricultural Center. Romaine lettuce 'PIC 715' was direct seeded 18 Jan into double row beds on 42 inch centers Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 33 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Insecticide treatments and rates used in the trial are found in Tables 10-11. The foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 20.5 GPA. A broadcast spray was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.125%v/v with all spray applications. Sprays were applied on Mar 6, 13 , 20 and 31. On the third (Mar 20) and fourth (Mar 31) applications, the rate of Lannate was increased to 0.75 lb/ac and Mustang Max was applied at 4 oz/ac instead of Renounce. Also on the fourth application, the Success–only treatment was increased to 9 oz/ac and the rate of XDE-175 was increased to 7 oz/ac. No other pesticides were applied.

Sampling and Statistical Analysis: Evaluation of WFT control in each study was based on the number of live adults and nymphs per plant sampled from the center 2 rows of each replicate at intervals following each application. Numbers of WFT adults and larvae from 5 plants per replicate were recorded on each sample. Samples were taken by removing plants and beating them vigorously against a screened pan for a predetermined duration. Inside of the pan was a sticky trap to catch the dislodged WFT. Sticky traps were then taken to the laboratory where adult and larvae were counted. WFT adult and larvae numbers were subjected to a two-way analysis of variance using the SAS statistical software. When analysis of variance was significant ($p<0.05$), the mean values were subjected to a protected LSD $_{(p<0.05)}$ F test to distinguish treatment differences.

Results and Discussion

In each study we conducted, RADIANT performed statistically comparable to or better than Success and at lower use rates. This was most evident in the spring 2005–Trial I where RADIANT applied at rates as low as 2 oz /acre provided the same level of adult and larval WFT control as Success applied at 6 oz (Table 1 and 2). This is particularly important since the RADIANT formulation used in these trials was a 1 lb ai/gal material versus the 2 lb ai/gal Success 2SC formulation. Although the spinosyn class of chemistry is inherently weaker on adult WFT, RADIANT provided adult control comparable to the Lannate +Warrior standard on several post-treatment samples. In the spring 2005–Trial II, RADIANT was compared to Lannate +Mustang and Beleaf (an aphicide with marginal WFT activity) + Mustang. Adult pressure was much heavier and RADIANT did not provide consistent knockdown of adult WFT (Tables 3-5). In some cases, WFT adult numbers were statistically higher in the RADIANT than in the untreated check. It is not uncommon to measure poor efficacy against adults in late spring trials due to the daily movement of WFT adults from field to field this time of the year, particularly in small plots. The lettuce plants treated with RADIANT may have also been more attractive to migrating adults as very little feeding damage was observed on treated plants, a result of the excellent larval control. The highly significant reduction in larvae numbers was clearly evident following the 3rd application (Table 5).

In the Fall 2005 Trial I, RADIANT provided as good or better control of WFT adult and larvae than Success, which was again applied at a higher rate (Table 6 and 7). In the Fall 2005 Trial II, RADIANT provided larval WFT control comparable to the standard Lannate+Mustang under higher population pressure (Table 8 and 9). In most cases, RADIANT provided statistically similar suppression of adults as well. Measurement of adult efficacy is generally much more accurate in fall trials as adult numbers are lower and not moving a great deal between plots.

In the final trial (Spring 2006), RADIANT again showed excellent control of WFT larvae, comparable to its sister compound Success, and statistically superior to Lannate+Renounce in many post-spray evaluations (Table 10-11). We also included a Success + Renounce treatment and it did not provide significantly better control of WFT larvae than RADIANT. The addition of the pyrethroid to both Success and Lannate did provide statistically better efficacy against WFT adults, however by the end of the trial adult numbers were high in all the treatments, even with the use of higher rates on the last application. Again, the lack of measurable adult control was probably somewhat masked by the daily inter-plot movement of adults.

In summary, application of RADIANT to romaine lettuce showed significant activity against WFT comparable to Success, but at lower use rates. This is important as many consider that Success is presently used in produce production at low rates. It appears to provide better residual activity against larvae than the standard compounds presently used, but does not appear to provide any additional adult efficacy. We plan to further evaluate RADIANT in combination with pyrethroids and other active ingredients to determine if adult activity can be significantly enhanced. RADIANT also has excellent residual activity against our lepidopterous larvae complex in lettuce (JCP, unpublished data), and will be an excellent addition to our IPM programs. Because of its enhanced residual activity at low use rates against WFT and Lep larvae, it will likely replace Success uses in produce crops. Unfortunately, because it has the same mode-of-action as Success, it will not provide an additional rotational partner for our resistance management programs.

Table 1. Adult WFT numbers on spring romaine lettuce, 2005 – Trial I

		Mean WFT adults / Plant						
Treatment	**Rate**	**9-Feb**	**14-Feb**	**17-Feb**	**21-Feb**	**25-Feb**	**28-Feb**	**4-Mar**
Radiant	7 oz	3.0a	2.7 bc	3.6 b	2.5 bc	5.1 a	8.3 b	13.7 b
Radiant	5 oz	3.5a	3.7 bc	3.5 b	2.7 bc	6.0 a	7.6 bc	16.7 b
Radiant	3 oz	4.5a	2.9 bc	3.1 b	2.3 bc	7.0 a	8.8 b	16.5 b
Radiant	2 oz	2.5a	3.8 bc	3.5 b	3.5 bc	5.9 a	9.3 ab	19.2 b
Success 2SC	6 oz	3.1a	4.3 b	3.3 b	3.7 b	4.3 a	7.3 bc	17.1 b
Lannate+Warrior	0.8 lb+ 3.8 oz	3.1a	1.9 c	0.8 c	1.7 c	4.3 a	3.6 c	13.3 b
Untreated	--	3.0a	7.3 a	7.1 a	6.3 a	6.8 a	13.9 a	29.7 a

Means followed by the same letter are not significantly different, SAS ANOVA, protected LSD$_{(p>0.05)}$

Table 2. Larvae WFT numbers on spring romaine lettuce, 2005 – Trial I

		Mean WFT larvae/ Plant						
Treatment	**Rate**	**9-Feb**	**14-Feb**	**17-Feb**	**21-Feb**	**25-Feb**	**28-Feb**	**4-Mar**
Radiant	7 oz	10.2a	8.5 bc	6.7 bc	2.0 b	1.5 b	2.0 b	0.5 b
Radiant	5 oz	11.2a	5.8 c	7.1 bc	3.7 b	1.3 b	1.7 b	0.2 b
Radiant	3 oz	13.0a	8.0 bc	12.6 b	2.3 b	2.5 b	1.7 b	0.3 b
Radiant	2 oz	12.3a	10.8 bc	11.5 bc	3.7 b	2.7 b	2.9 b	0.4 b
Success 2SC	6 oz	12.8a	11.9 b	11.9 bc	3.5 b	2.5 b	2.0 b	0.7 b
Lannate+Warrior	0.8 lb+ 3.8 oz	13.0a	7.9 bc	5.2 c	4.1 b	2.9 b	1.6 b	0.9 b
Untreated	--	13.2a	18.9 a	25.9 a	20.8 a	23.1 a	13.7 b	4.8 a

Means followed by the same letter are not significantly different, SAS ANOVA, protected LSD$_{(p>0.05)}$

Table 3. Adult and Larvae WFT numbers following the first application on spring romaine lettuce, 2005 – Trial II.

Application # 1		**Mean WFT / Plant**					
		1-Mar		**4-Mar**		**7-Mar**	
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Adult**	**Larvae**	**Adult**	**Larvae**
Mustang+Lannate	4 oz + 0.8 lb	6.3 b	6.1 bc	13.1 b	5.1 b	19.1 cd	4.3 ab
Mustang+Beleaf	4 oz+2.3 oz	28.5 a	8.1 b	27.5 a	8.9 a	28.3 ab	7.8 a
Radiant	5 oz	13.9 b	2.7 c	16.7 b	1.3 c	23.1 bc	1.2 b
Untreated	--	23.9 a	17.5 a	19.7 b	8.8 a	18.2 d	5.4 a

Table 4. Adult and Larvae WFT numbers following the second application on spring romaine lettuce, 2005 – Trial II.

Application # 2		**Mean WFT / Plant**					
		11-Mar		**14-Mar**		**17-Mar**	
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Adult**	**Larvae**	**Adult**	**Larvae**
Mustang+Lannate	4 oz + 0.8 lb	49.4 b	6.0 b	90.7 b	33.2 b	66.6 a	59.3 b
Mustang+Beleaf	4 oz+2.3 oz	36.4 b	16.8 b	80.7 b	70.4 b	84.0 a	72.0 b
Radiant	5 oz	94.8 a	2.3 b	109.9 a	10.6 b	81.3 a	24.7 b
Untreated		53.0 b	83.6 a	82.2 b	170.7 a	70.0 a	204.0 a

Table 5. Adult and Larvae WFT numbers following the second application on spring romaine lettuce, 2005 – Trial II.

Application # 3		**Mean WFT / Plant**					
		21-Mar		**24-Mar**		**28-Mar**	
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Adult**	**Larvae**	**Adult**	**Larvae**
Mustang+Lannate	4 oz + 0.8 lb	42.6 b	30.7 b	60.0 a	100.0 a	104.0 a	60.0 c
Mustang+Beleaf	4 +2.3 oz	42.0 b	75.3 b	62.3 a	94.7 a	138.0 a	98.7 b
Radiant	5 oz	90.7 a	25.3 b	78.7 a	18.0 b	119.3 a	4.7 d
Untreated		64.7 b	255.3 a	79.3 a	165.3 a	142.7 a	210.7 a

Means followed by the same letter are not significantly different, SAS ANOVA, protected $LSD_{(p>0.05)}$

Table 6. Adult WFT numbers on fall romaine lettuce, 2005 – Trial I.

		Mean WFT adults / plant							
Treatment	Rate/ac	7-Oct	11-Oct	15-Oct	19-Oct	22-Oct	27-Oct	3-Nov	8- Nov
Success	6 oz	0.8 a	1.8 ab	5.3 a	1.8 b	3.3 c	5.2 ab	4.1 ab	6.3 a
Radiant	5 oz	0.9 a	1.0 b	5.3 a	1.9 b	2.8 b	3.4 b	3.8 b	4.5 a
UTC	.	0.7 a	3.8 a	4.9 a	4.2 a	5.3 a	5.8 a	5.7 a	7.0 a

Table 7. Larvae WFT numbers on fall romaine lettuce, 2005 – Trial I.

		Mean WFT larvae / plant							
Treatment	Rate/ac	7-Oct	11-Oct	15-Oct	19-Oct	22-Oct	27-Oct	3-Nov	8-Nov
Success	6 oz	0.9 a	2.9 a	1.1 b	0.2 b	1.0 b	0.4 b	0.9 b	2.7 b
Radiant	5 oz	1.0a	2.7 a	1.0 b	0.2 b	0.3 b	0.1 b	0.3 b	1.0 b
UTC	.	1.0 a	8.4 a	3.4 a	1.6 a	2.4 a	3.2 a	6.6 a	7.0 a

Means followed by the same letter are not significantly different, SAS ANOVA, protected LSD$_{(p>0.05)}$

Table 8. Adult WFT numbers on fall romaine lettuce, 2005 – Trial II.

		Mean WFT adults / plant					
Treatment	**Rate**	**27-Oct**	**3-Nov**	**7-Nov**	**11-Jan**	**16-Nov**	**23-Nov**
Lannate+Mustang	0.5 lb+ 4 oz	9.7a	2.6 c	3.8 b	2.2 c	3.8 c	1.5 b
Success	6 oz	9.9a	5.1 a	4.3 b	4.8 b	7.0 b	4.3 b
Radiant	5 oz	9.9a	3.9 b	5.5 ab	3.4 bc	4.2 bc	3.1 b
UTC	.	7.0a	6.2 a	7.0 a	10.7 a	11.3 a	9.3 a

Table 9. Larvae WFT numbers on fall romaine lettuce, 2005 – Trial II.

		Mean WFT larvae / plant					
Treatment	**Rate**	**27-Oct**	**3-Nov**	**7-Nov**	**11-Jan**	**16-Nov**	**23-Nov**
Lannate+Mustang	0.5 lb+ 4 oz	82.4a	26.4 bc	16.1 bc	4.1 c	0.7 c	0.9 b
Success	6 oz	75.7a	25.3 bc	12.8 c	3.6 c	2.8 b	1.7 b
Radiant	5 oz	71.7a	14.0 c	10.5 c	1.9 c	0.8 c	1.5 b
UTC	.	88.0a	46.3 a	37.9 a	18.1 a	11.2 a	10.0 a

Means followed by the same letter are not significantly different, ANOVA, protected LSD$_{(p>0.05)}$

Table 10. Adult WFT numbers on spring romaine lettuce, 2006.

		Mean WFT adults / plant									
Treatment	**Rate**	**3-Mar**	**9-Mar**	**13-Mar**	**17-Mar**	**20-Mar**	**24-Mar**	**29-Mar**	**6-Apr**	**10-Apr**	**13-Apr**
Lannate+Renounce	0.5 lb+3.5 oz	12.8a	2.0c	6.2c	5.1b	8.5a	12.7c	60.0a	28.5bc	43.5a	133.8a
Success+Renounce	5 oz + 3.5 oz	12.0a	2.0c	8.2b	6.0b	12.0a	15.5c	51.9a	21.0c	61.8a	105.6a
Success	6 oz	12.1a	3.3bc	7.3bc	10.0a	14.8a	23.4b	63.0a	33.3ab	56.1a	79.2b
Radiant	5 oz	11.8a	3.8b	5.7c	12.3a	14.2a	25.2b	56.7a	29.7b	46.8a	75.0b
UTC	-	12.0a	9.1a	14.6a	11.8a	10.2a	31.6a	40.9a	39.9a	63.0a	75.6b

Table 11. Larvae WFT numbers on spring romaine lettuce, 2006.

		Mean WFT larvae / plant									
Treatment	**Rate**	**3-Mar**	**9-Mar**	**13-Mar**	**17-Mar**	**20-Mar**	**24-Mar**	**29-Mar**	**6-Apr**	**10-Apr**	**13-Apr**
Lannate+Renounce	0.5 lb+3.5 oz	1.6a	4.2c	16.0c	18.5b	15.8b	11.1b	25.2b	24.0b	97.2a	70.5b
Success+Renounce	5 oz + 3.5 oz	3.1a	9.6b	22.5b	24.0b	16.4b	8.7b	33.6b	17.7bc	37.5bc	44.4bc
Success	6 oz	2.4a	7.4bc	12.1c	6.6c	8.7bc	5.9bc	43.8b	13.5c	41.4b	35.1cd
Radiant	5 oz	2.2a	4.3c	5.9d	3.6c	2.8c	1.4c	15.3b	8.7c	15.3c	21.6d
UTC	**-**	2.6a	16.8a	35.7a	60.7a	63.5a	77.3a	92.7a	53.1a	52.2b	166.6a

Means followed by the same letter are not significantly different, SAS ANOVA, protected LSD$_{(p>0.05)}$