

Action Thresholds for Aphid Management with Reduced-Risk and Conventional Insecticides in Desert Head Lettuce

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Abstract

Action thresholds, based on the percentage of plants infested, for the aphid pest complex found in head lettuce were evaluated in October, November and December plantings in 2005 and 2006 at the Yuma Agricultural Center. Action thresholds were also evaluated for their compatibility with newly developed reduced-risk and conventional insecticides. Although all five common aphid species were present in both years of the study, foxglove aphids provided most of the pest pressure. Compared with the SAC threshold treatment (sprayed-at colonization; essentially sprayed weekly until new aphid colonies were not found), action thresholds of 10% and 30% plants infested with 5 or more aphids resulted in fewer insecticide applications, while maintaining varying levels of head contamination at harvest. Despite variable pest pressure between years and planting dates, the threshold based on 10% infested plants performed as well as the SAC but with half as many sprays and no significant head contamination. However, significant head contamination was experienced when the 10% action threshold was used exclusively with reduced-risk insecticides.

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of the most difficult pests to manage in desert lettuce as pest management programs used to control them have become outdated.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 *Acyrtosiphon 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 *Acyrtosiphon 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 from 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+Fulfill) to effectively control FGA using the 10% action threshold. We presently have studies planned for the 2007 spring season to validate this approach.

Acknowledgements

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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	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			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	

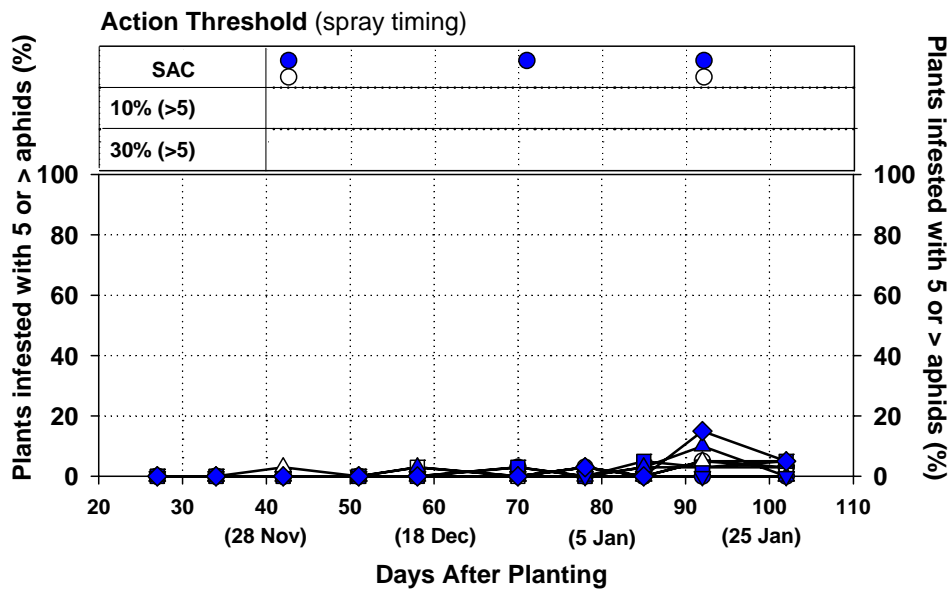
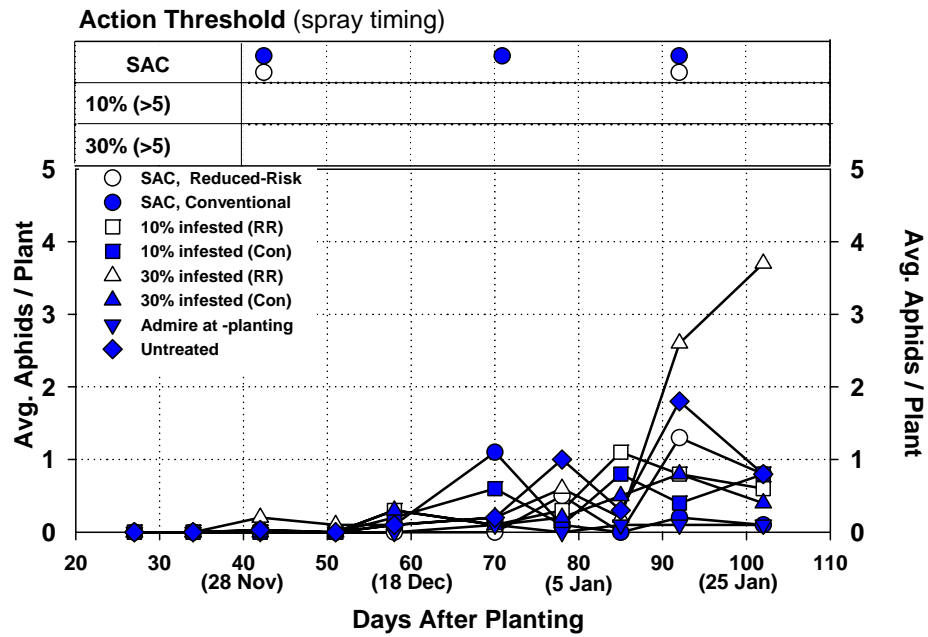


Figure 1. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 October planting.

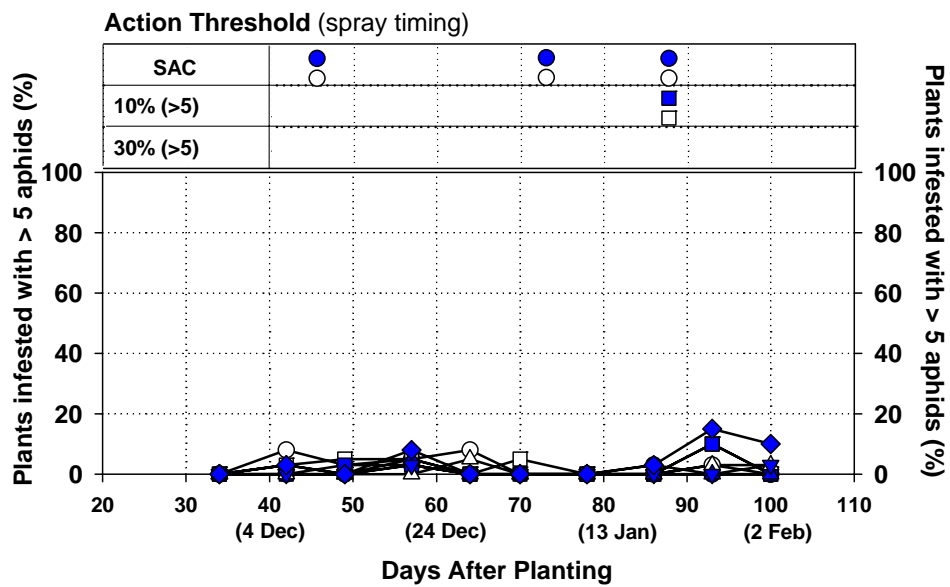
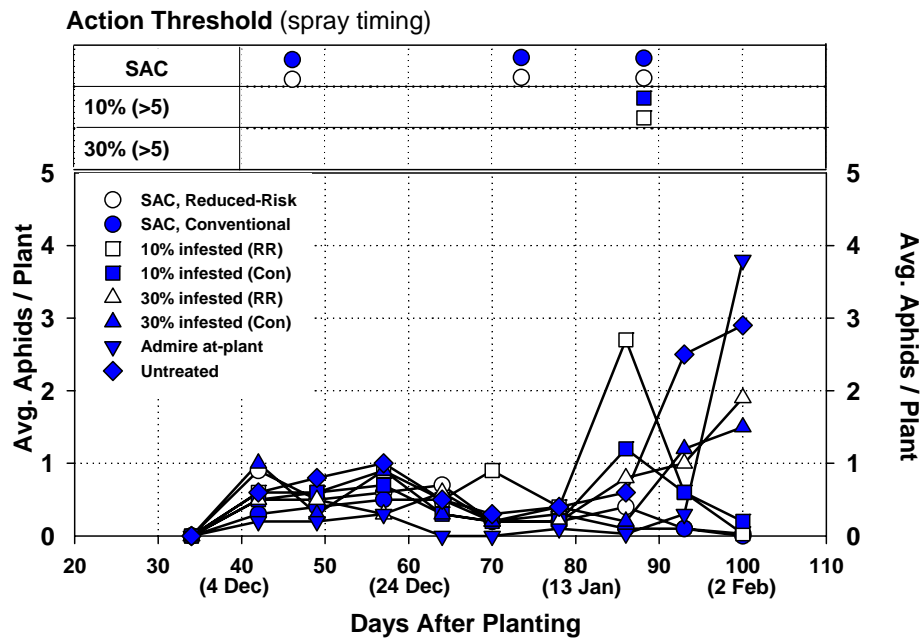


Figure 2. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 October planting.

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

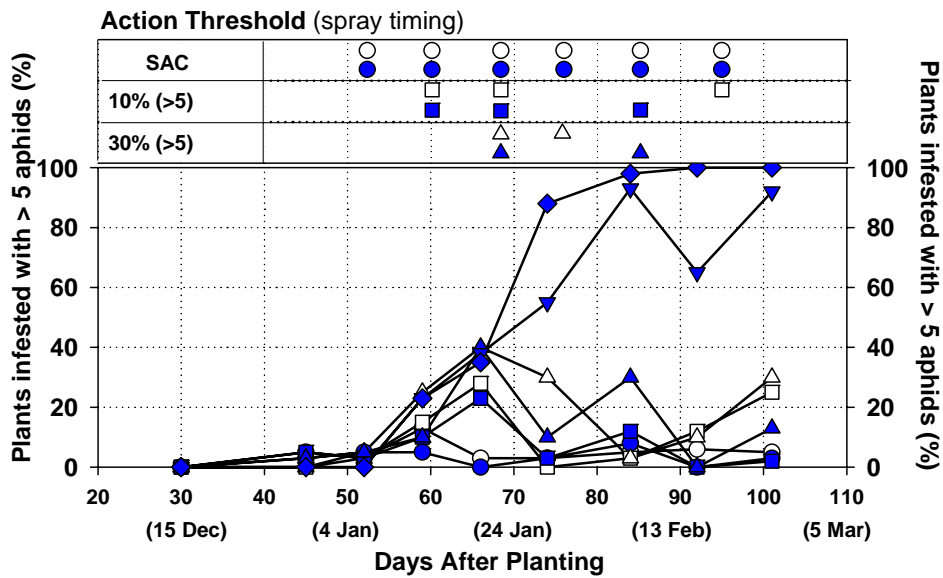
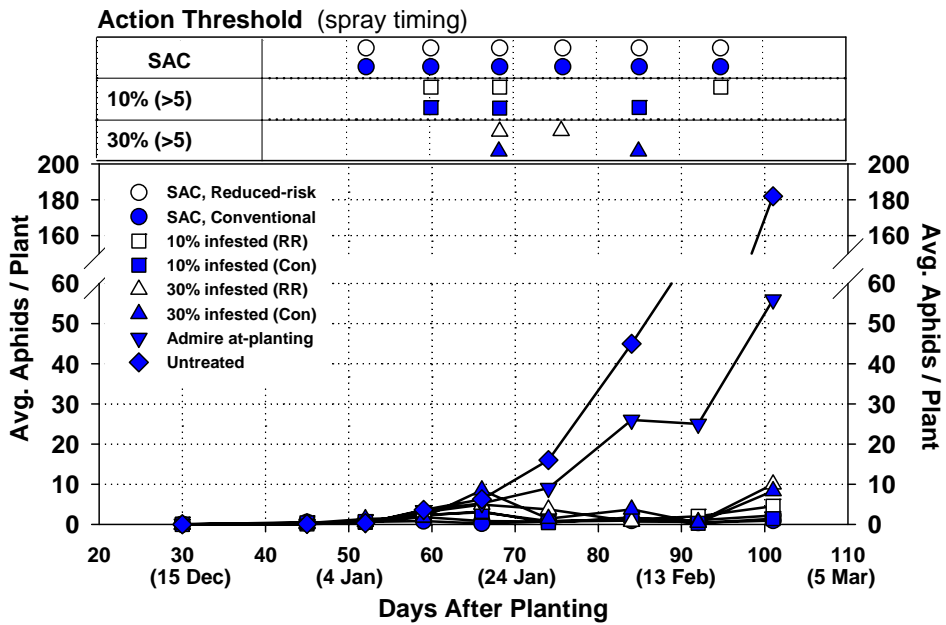


Figure 3. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 November planting.

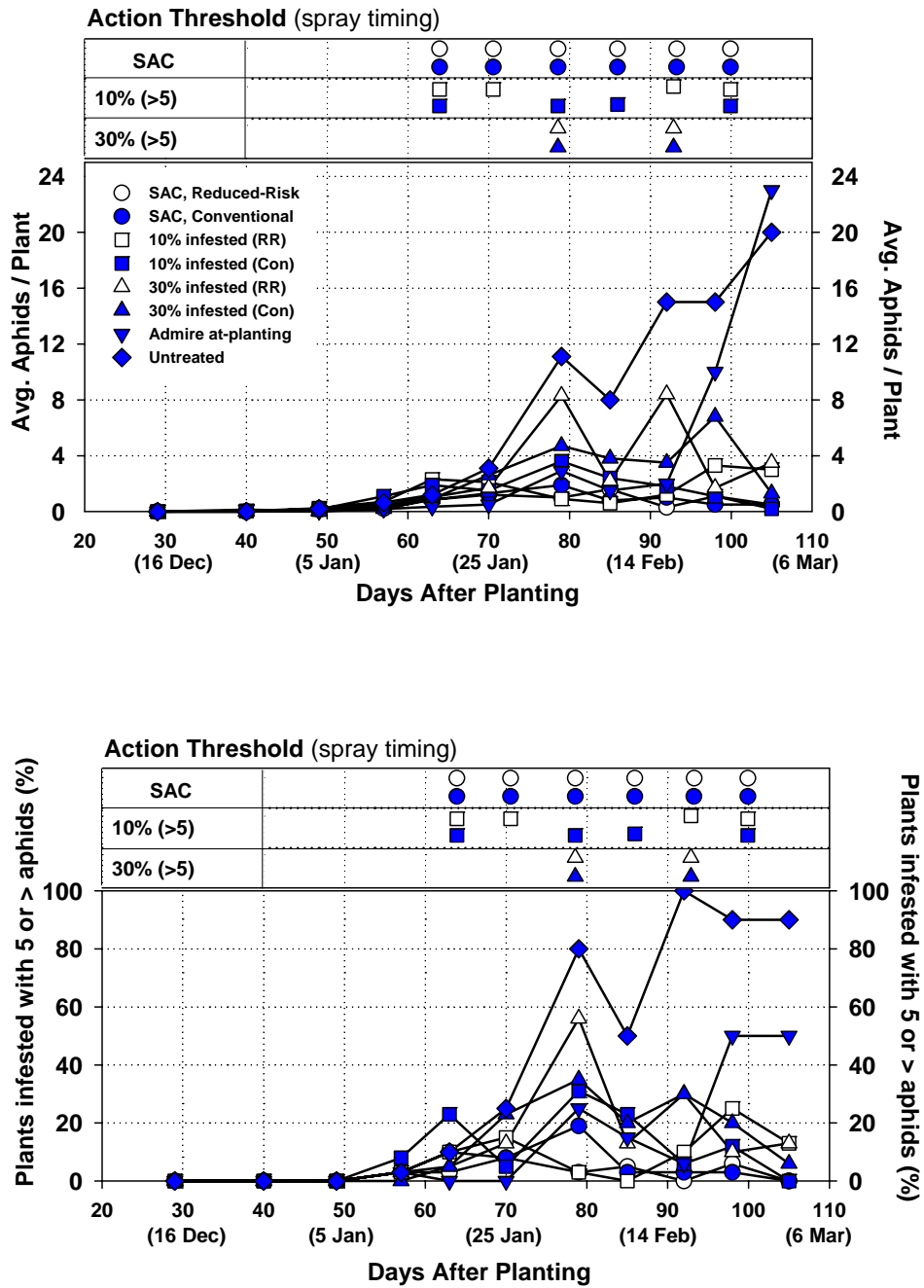


Figure 4. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 November planting.

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								
Action threshold	Chemistry	No. of sprays	Avg. aphids / head					% Heads infested (all species)			
			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

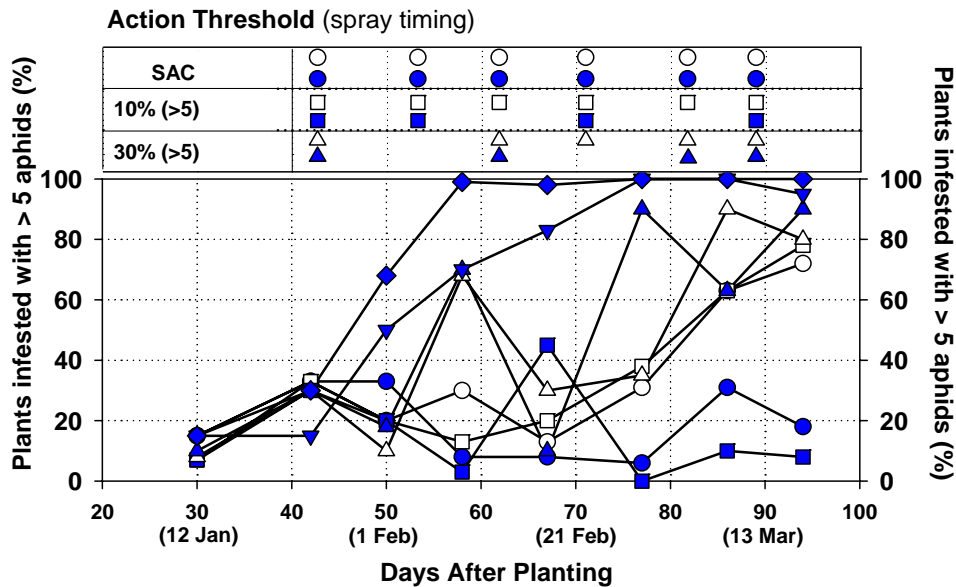
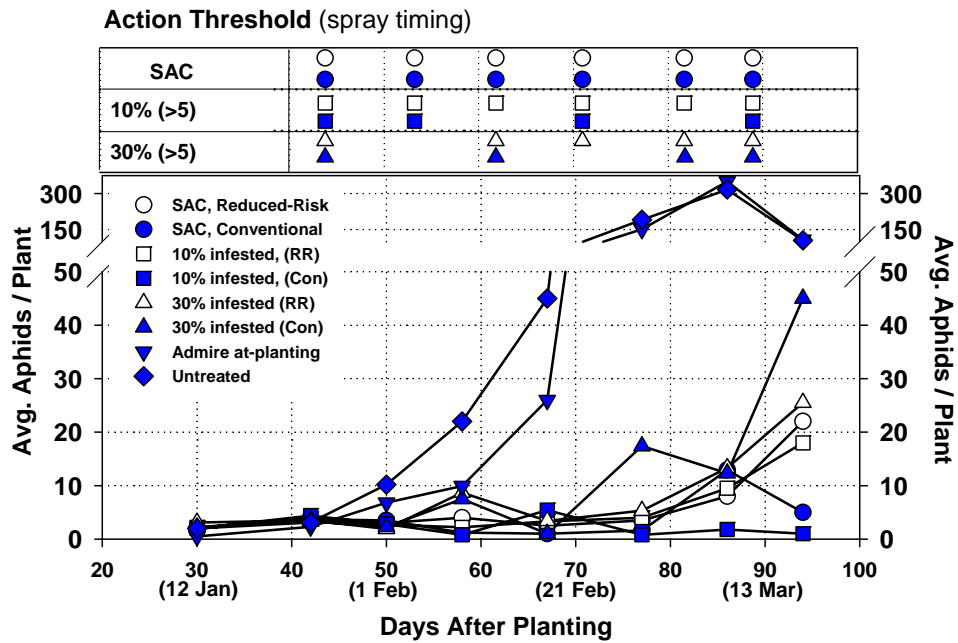


Figure 5. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2005 December planting.

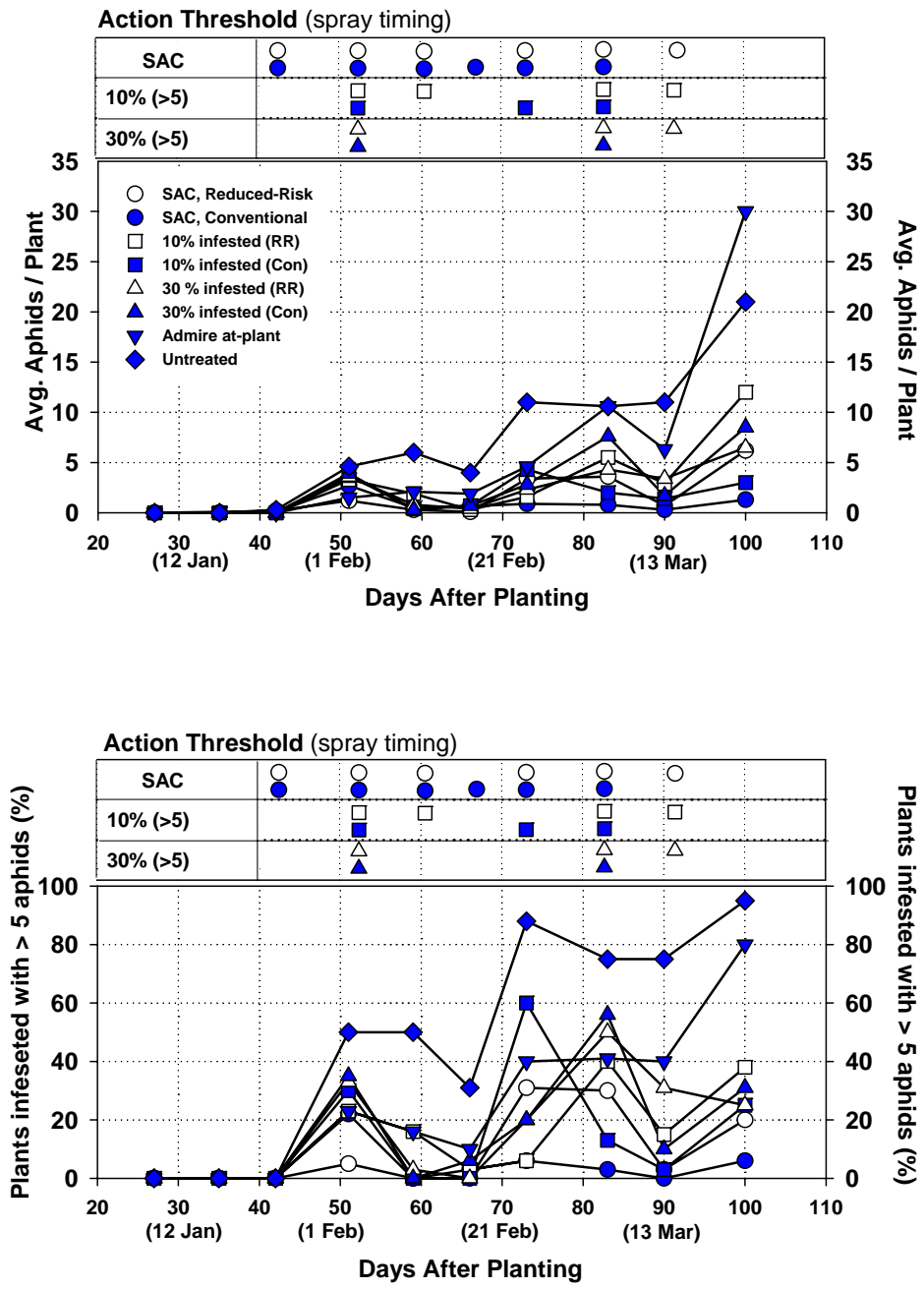


Figure 6. Aphid numbers / plant and % plants infested with > 5 aphids in head lettuce treated with reduced-risk (RR) and conventional (Con) insecticides at various action thresholds, in the 2006 December planting.

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								
Action threshold	Chemistry	No. of sprays	Avg. aphids / head					% Heads infested (all species)			
			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									
Action threshold	Chemistry	No. of sprays	Avg. aphids / head					% Heads infested (all species)			
			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