Evaluation of Admire Soil Treatments on Colonization of Green Peach Aphid and Marketability of Lettuce

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Abstract

Admire (imidacloprid), applied as a soil treatment, protected lettuce plants from developing infestations of green peach aphid, Myzus persicae (Sulzer), for 60-100 d after planting based on two small plot and two commercial field trials. Admire applied 7.6 cm sub-seed furrow provided longer and more consistent protection from green peach aphid than treatments applied to the soil surface, as a side-dress, or 15.2 cm sub-seed furrow. Surface band applications of Admire provided inconsistent control probably because of inadequate hydrological incorporation into the soil. In small plot trials, effective control of aphids by Admire applied 7.6 cm sub-seed furrow resulted in greater than 90.0% marketable heads while the untreated plots contained 20.0% marketable heads. When used in a commercial setting, Admire applied 7.6 cm sub-seed furrow on leaf lettuce prevented aphid colonization (<3 aphids per plant) for approximately 100 d after planting, while the untreated and commercial standard treated areas contained 30.7 and 26.8 aphids per plant respectively at 100 d after planting. In addition, marketability of lettuce was greater in Admire treated plots. As a sub-seed furrow treatment, Admire provides a more suitable approach to aphid control than is currently available with foliar insecticides.

Introduction

Green peach aphid, *Myzus persicae* (Sulzer), is a common pest of iceberg lettuce, *Lactuca sativa*, in the western United States. This polyphagous aphid species causes economic damage to lettuce through direct injury, virus transmission, and contamination of heads (Blackman and Eastop 1984, Reid and Cuthbert 1977, Hinsch et al. 1991). Because most Western iceberg lettuce is packed in the field at harvest, it must be relatively free of contamination by aphids and other pests. Consequently, lettuce is routinely treated with insecticides throughout the season to prevent aphid colonization.

Green peach aphids are presently controlled in lettuce with foliar applications of contact insecticides such as acephate, endosulfan and mevinphos (Minkenberg et al. 1993). Plant growth characteristics, insect behavior, and insecticide chemistry largely determine whether an insecticide application can effectively contact the target pest (van Emden et al. 1969, Reid and Cuthbert 1977). Iceburg lettuce grows as a rosette, and much of the lower foliage of the plant is sheltered from above by upper leaves. Green peach aphids prefer to feed on the underside of lower lettuce leaves and are protected from many foliar applied insecticides (Anonymous 1987). Consequently, once green peach aphid has successfully colonized the lower leaves, it is difficult to achieve adequate control. An effective systemic insecticide would alleviate many of the coverage problems associated with aphid control on lettuce.

Imidacloprid (Admire 2F), a new chloronicotynal insecticide, has a wide range of activity against many economically important insect pests such as aphids, whiteflies and thrips (Dewar and Read 1990, Elbert et al. 1990, Mullins 1993, Pike et al. 1993). Because it has considerable systemic activity in the plant, Admire may be appropriate for soil application in some crops. However, unlike other systemics, Admire is relatively immobile in the soil and should be placed precisely where root uptake can occur (Mullins 1993). Therefore, performance of the compound may vary depending on the crop and method of application (Oetting and Anderson 1990). As a seed

treatment, Admire protected growing plants of wheat and barley from developing infestations of Russian wheat aphid, *Diuraphis noxia*, for several weeks after planting (Pike et al. 1993). However, no information is available concerning the effectiveness of Admire as a soil treatment for protecting lettuce from colonization by green peach aphid. Thus, our objective was to compare the effects of Admire placement at different levels in the seedbed on green peach aphid populations and marketability of iceberg lettuce in commercial and experimental plots in the Yuma Valley of Arizona.

Materials and Methods

Small Plot Studies. Field studies were conducted in two trials in 1993 at the University of Arizona Yuma Agricultural Center. The soil type of the research site consisted of a Gasden clay (< 0.05% organic matter). In Trial 1, 'Winterhaven' lettuce was direct seeded 26 October into double row beds on 1.02 m centers; germination occurred 28 October with overhead sprinkler irrigation. Plots consisted of 4 beds, 30.5 m long with a two bed buffer between the plots. Plot preparation and seasonal maintenance followed local practices with the exception that no other pesticides were applied. Plots were arranged in a randomized complete block design with four replications. Treatments consisted of Admire 2F (Miles Corp., Kansas City, MO) applied at 0.34 kg ai/ha to the soil as follows: 1) 7.6 cm directly below the seed line depth prior to planting, 2) 15.2 cm directly below the seed line prior to planting, 3) on the soil surface, banded directly above the seedline, 4) sidedress injection and 20-0-0 liquid fertilizer, approximately 7.6 cm below the soil surface 75 days after planting, and 5) an untreated plot. Trial 2 was conducted using the same experimental design as in Trial 1 but was direct seeded with 'Van Max' lettuce on 2 December, and did not include a sidedress injection treatment. No sprinkler irrigation was used in Trial 2.

All Admire treatments were applied with water and delivered at 140.29 l/ha total volume. The Admire treatments placed below the surface at 7.6 and 15.2 cm were applied by injecting the material into the beds with long, narrow shanks before seeding. The soil surface application was applied as a 5.0-cm band using 8003 flat-fan nozzles centered on the seedline immediately following planting and preceding irrigation. Insect and marketability data were collected only from the inner two beds of each plot. Aphid densities were estimated weekly by sampling ten plants per replicate. The plants were randomly selected in each plot and carefully placed inside 33.0-l collection cans made of galvanized steel. Wire mesh was placed near the bottom of the can to suspend the plants above a steel funnel which emptied into 0.5-l cardboard containers. Several large cotton wicks were saturated with methyl ethyl ketone and placed inside each can. After 10 to 15 min., all leaves were shaken to dislodge aphids into the cans and collected in the cardboard containers. Leaves were further examined to record any aphids which had not been dislodged. Aphids were then transported to the laboratory and placed at -10 C° for 24 hours. Numbers of alate and apterous aphids were counted with the aid of a stereo microscope.

Contamination levels were estimated at harvest by randomly selecting ten plants within each replicate and recording the percentage of plants infested with >0 and >10 aphids on wrapper leaves and heads. Lettuce that contains no aphid contamination is considered most desirable, while lettuce that contains 1-10 aphids per head is considered marginal in quality. High aphid infestations on heads (>10) are often not harvested (Anonymous 1987). Counts from wrapper leaves consisted of visually examining 3-4 leaves immediately surrounding the head. Sampling lettuce heads consisted of examining the cap leaf and 2-3 leaves on the head for the numbers of apterous aphids.

Commercial Field Validation. Two commercial field trials were conducted on lettuce fields near Somerton, AZ. The first field contained a 2.5-ha block of 'Gene green' leaf lettuce that was planted on 26 November in a Rositas sandy loam soil. The field was separated into five plots of equal size (0.5 ha) and each treatment was assigned to a plot. Treatments consisted of three rates of Admire applied 7.6 cm below the seedline before planting (0.22, 0.33, and 0.44 kg ai/ha), a standard application of disulfoton (Di-syston 8, Miles Corp., Kansas City, MO) at a rate of 1.11 kg ai/ha injected into the soil at 7.6 cm as a sidedress and followed by foliar insecticides as needed, and an untreated plot. The Admire treatments were applied with water and delivered at 35.1 l/ha total volume. Disulfoton was sidedressed in 341.9 l/ha total volume and watered in 4 February 1994. In addition, this treatment received foliar applications of mevinphos (Phosdrin 4EC, Amvac Chem. Corp., Los Angeles, CA) at a rate of 1.11 kg ai/ha and endosulfan (Gowan Endosulfan 3EC, Yuma, AZ) at a rate of 0.9 kg ai/ha on 22 February and 3

March. Untreated plots were eventually treated by the grower with foliar applications of mevinphos (1.11 kg ai/ha) and endosulfan (0.9 kg ai/ha) by air at 46.7 l/ha total volume on 16, 22 February, and 3 March.

The second field contained a 5.3-ha block of 'Vango' head lettuce planted on 27 November in a Gasden Clay soil. The field was separated into three plots of equal size (1.8 ha) with each treatment assigned to a plot. The treatments consisted of a single Admire application applied 7.6 cm below the seedline before planting (0.44 kg ai/ha), a standard application of disulfoton at a rate of 1.11 kg ai/ha injected into the soil at 7.6 cm as a sidedress, and an untreated plot. The Admire and disulfoton treatments were applied as above. No foliar insecticides were applied to any of the treatments.

Densities and contamination levels were estimated with the same methods used in the small plots. Within each plot, five subsamples of ten plants (50 plants/treatment) were collected and examined for numbers of aphids using collection cans. At harvest, five subsamples of five plants were examined for aphids on wrapper leaves and heads.

Data Analysis. Upon completion of the study, aphid counts from collection cans were transformed ($\log_{10}+1$) prior to analysis of variance to stabilize variances which were found to be heterogenous (Gomez and Gomez 1984). Counts of numbers of infested plants were converted to percentages with an arc sine transformation before further analyses (Gomez and Gomez 1984). Treatment differences were estimated with analysis of variance (ANOVA) and mean separation with a protected $LSD_{0.05}$ [PROC GLM, SAS Institute (1988)].

Results and Discussion

Small Plot Studies. In Trial 1, aphid populations in the untreated plots quickly colonized the plants and began rapid growth about 70-80 d after planting. Thereafter, population densities continued to increase until harvest. Aphids in the plots treated with Admire did not begin rapid population growth until 101 d after treatment. At harvest, numbers of aphids in the untreated plots were significantly higher than all Admire treatments (Fig. 1A). During Trial 2, aphid populations in the untreated and surface-applied Admire plots began rapid growth 60 d after planting and peaked about 30 d later (Fig. 1B). Aphid populations remained relatively low throughout the season in the sub-seed furrow Admire treatments and contained significantly lower numbers of aphids at harvest.

Seasonal mean numbers of alate aphids per plant were consistently low across all treatments throughout the season (Table 1). The lack of treatment differences in the number of alate aphids in Trial 1 may suggest that Admire was not effective on this morph. Dewar and Read (1990) reported that Admire seed treatments had no effect on alate green peach aphids colonizing sugarbeets. However, it is possible that the low densities of alates continually moving into the experimental plots may have diluted treatment effects. In Trial 2, where aphid migration did not appear to be as continuous, greater numbers of alate aphids were observed in the untreated plots.

The seasonal mean numbers of apterous aphids were significantly lower in the Admire treated plots than in the untreated plots, regardless of placement in the seedbed (Table 1). In Trial 1, Admire applied at planting to the soil surface or 7.6 cm sub-seed furrow provided the most seasonal protection. However, during Trial 2, the soil surface application of Admire contained significantly more aphids than the sub-seed furrow applications. The inconsistency of the surface band application in Trial 2 was likely in response to poor incorporation of Admire into the soil. The plants were germinated using furrow, sub-surface irrigation which likely failed to move the compound downward into the effective root zone. Admire in aqueous solution is rapidly degraded by sunlight (Mullins 1993). In contrast, the lettuce in Trial 1 was germinated using impact-sprinkler irrigation which facilitated hydrological incorporation of Admire into the root zone.

Differences in head size and weight were not observed among the treatments in either trial. However, effective levels of green peach aphid control by Admire resulted in significantly less contamination of wrapper leaves and heads than the untreated plots. In Trial 1, all Admire-treated plots contained large percentages of marketable lettuce, while greater than 80% of the lettuce heads and wrapper leaves were unmarketable in the untreated plots (Table 2). However, only the lettuce treated with the surface band application of Admire contained a significantly lower percentage of wrapper leaves completely free of aphid infestation. During Trial 2, aphid densities were lower

at harvest (Fig 1 and 2), and only 10% of the lettuce heads were unmarketable in the untreated plots. In lettuce treated with Admire at 7.6 or 15.2 cm sub-seed furrow, 85% of the wrapper leaves were completely free of aphid infestation (Table 3). Only 10% of lettuce harvested in the untreated plots and plots treated with a surface band application of Admire were free of aphid infestations (Table 3). Because iceberg lettuce can be harvested with (naked packed) or without (film-packed) wrapper leaves, preventing aphids from colonizing the outer leaves at harvest can be economically important. Harvest companies may refuse to pack a lettuce plant that contains ten or more aphids. Naked packed lettuce usually contains greater numbers of aphids at harvest because of the inclusion of wrapper leaves, but green peach aphids are present in both types of lettuce (Hincsh et al. 1991). Consequently, based on the percentage of contaminated wrapper leaves and heads found in our studies, Admire applied below the seed furrow at 7.6 cm provided the most consistent and desirable protection from aphid colonization and contamination of marketable heads.

Commercial Field Validation. When used in a commercial setting, Admire applied 7.6 cm below the seed furrow prevented aphid colonization of lettuce for approximately 100 d, while lettuce left untreated or grown with the commercial standards were steadily colonized throughout the season (Fig. 2). In the leaf lettuce field, green peach aphid populations in both the standard and untreated plots exceeded 25 aphids per plant at harvest (Fig. 2A). Consequently, about 10% of the plants were unmarketable. In contrast, leaf lettuce treated with Admire soil treatments contained relatively low aphid numbers at harvest and all plants were marketable, regardless of rate of Admire. In the head lettuce field, populations in the untreated lettuce exceeded 60 aphids per plant at harvest and contained about 15% unmarketable heads (Fig. 2B). Both the standard and the Admire soil treatments maintained aphid numbers at relatively low densities and contained no contaminated heads or wrapper leaves.

Conclusion. Our results demonstrate that soil treatments of Admire can effectively protect lettuce plants from colonization by green peach aphids and prevent contamination of marketable portions of the plant. Placement of the compound in the soil appears to be important for efficient root uptake and systemic activity within the plant. As a sub-seed furrow application, Admire may provide a more suitable and practical approach to aphid management on lettuce than is currently available with foliar insecticides.

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TABLE 1. Effect of Admire Soil Treatments on Seasonal Population Densities of Alate and Apterous Green Peach Aphids in Iceberg Lettuce, Yuma, AZ, 1993-1994.

	Seasonal mean ± SEM[a]			
	Trial 1		Trial 2	
Soil treatment	Alate	Apterous	Alate	Apterous
Untreated	1.5 ± 0.2a	196.1 ± 13.0a	3.8 ± 0.2a	223.1 ± 28.5a
Side dress	1.2 ± 0.1a	32.0 ± 13.6b	-	-
Surface band	1.3 ± 0.2a	9.6 ± 1.7c	2.8 ± 0.1b	72.8 ± 11.6b
Sub-seed furrow[b]	1.2 ± 0.2a	17.8 ± 1.5bc	2.9 ± 0.3b	10.7 ± 0.8c
Sub-seed furrow[c]	1.2 ± 0.2a	36.6 ± 18.1b	2.3 ± 0.3b	10.5 ± 1.5c

[a]Means followed by the same letter are not significantly different [Proc GLM, protected $LSD_{0.05}$ (SAS Institute 1988)].
[b]Admire placed 7.6 cm sub-seed furrow.
[c]Admire placed 15.2 cm sub-seed furrow.

TABLE 2. Influence of Admire Soil Treatments on Green Peach Aphid Infestations on Iceberg Lettuce at Harvest, Trial 1, Yuma AZ, 1993-1994.

	Mean % plants infested[a]			
	Wrapper leaves		Heads	
Soil treatment	> 0 aphids	> 10 aphids	> 0 aphids	> 10 aphids
Untreated	100.0 a	95.0 a	97.5 a	80.0 a
Side dress	52.2 b	12.5 bc	40.0 bc	20.0 b
Surface band	7.5 c	0.0 c	15.0 c	2.5 b
Sub seed furrow, 7.6 cm	57.5 b	5.0 bc	32.5 c	2.5 b
Sub-seed furrow, 15.2 cm	90.0 a	22.5 b	80.0 ab	15.0 b

[a]Means followed by the same letter are not significantly different [Proc GLM, protected $LSD_{0.05}$ (SAS Institute 1988)].

TABLE 3. Influence of Admire Soil Treatments on Green Peach Aphid Infestations on Iceberg Lettuce at Harvest, Trial 2, Yuma AZ, 1993-1994.

	Mean % plants infested[a]			
	Wrapper leaves		Heads	
Soil treatment	> 0 aphids	> 10 aphids	> 0 aphids	> 10 aphids
Untreated	90.0 a	30.0 a	72.5 a	10.0 a
Surface band	90.0 a	0.0 b	40.0 b	0.0 b
Sub seed furrow, 7.6 cm	15.0 b	0.0 b	0.0 c	0.0 b
Sub-seed furrow, 15.2 cm	15.0 b	0.0 b	0.0 c	0.0 b

[a]Means followed by the same letter are not significantly different [Proc GLM, protected $LSD_{0.05}$ (SAS Institute 1988)].

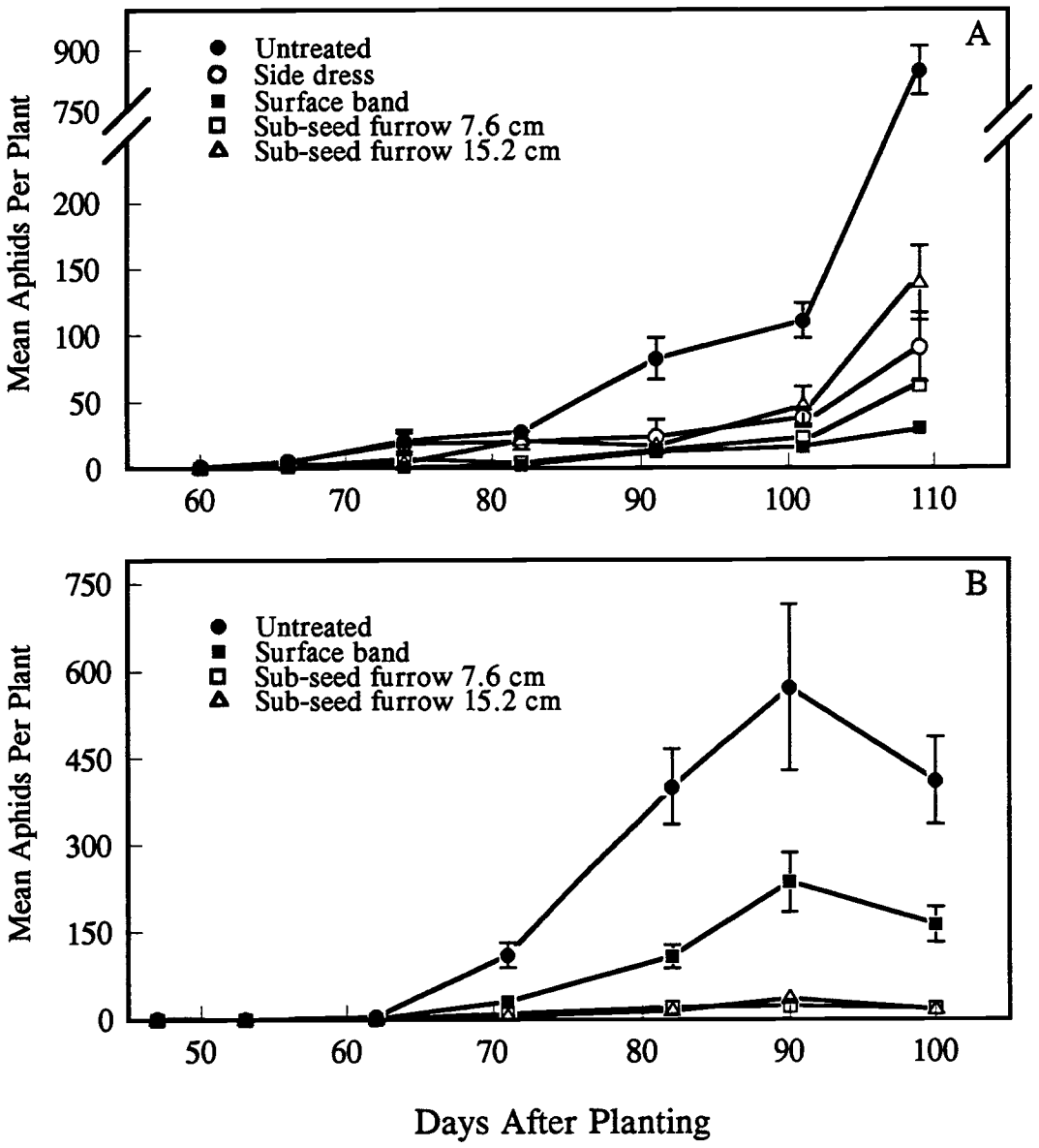

Fig. 1. Effect of Admire soil treatment on colonization of green peach aphids in iceberg lettuce in Trial 1 (A) and Trial 2 (B).

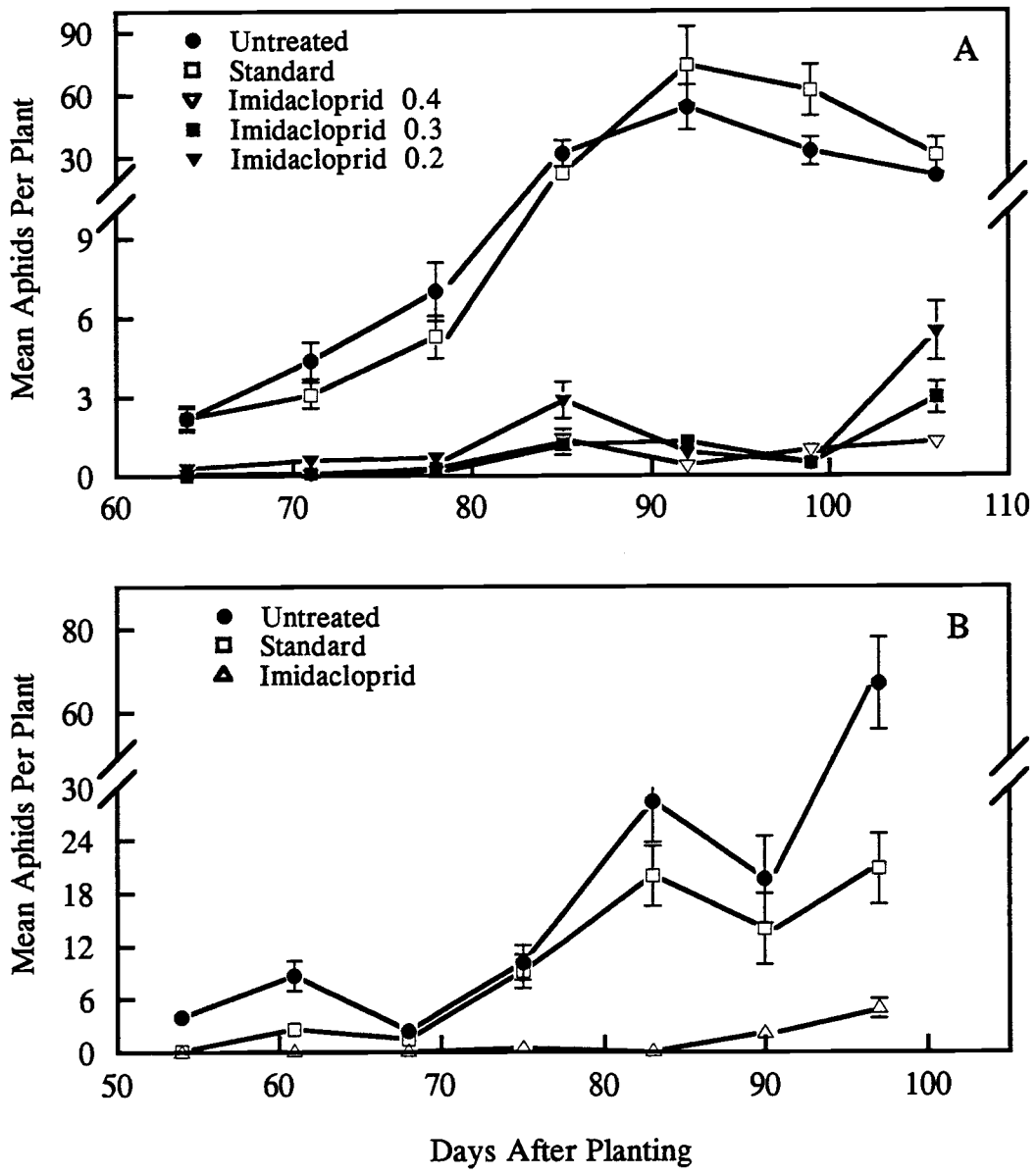

Fig 2. Influence of Admire on aphid colonization in commercial leaf lettuce (A) and head lettuce (B) near Somerton, AZ, 1993-1994.