Foliar Activity of Assail, Fulfill and Flonicamid on Aphids in Leafy Vegetables

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Abstract

Several small-plot studies were conducted in the spring of 2004 to compare the residual efficacy of several new reduced risk insecticides against aphids infesting desert head lettuce. In 4 head lettuce trials and one broccoli trial, economic aphid control was consistently achieved following foliar applications with flonicamid and Assail. These compounds provided good knockdown of aphids when applied relatively early in lettuce plant development and aphid population growth. Fulfill was less consistent and performance was reliant on correct spray timing. Collectively, the chemical attributes and biological activities of Fulfill, Assail and flonicamid make them extremely attractive for implementation into an aphid management program.

Introduction

As key pests of desert lettuce, aphids represent one of the most important insect problems currently facing the industry. 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 present in California since at least 1940, and has caused problems for lettuce growers in Salinas for the past 5 years. The foxglove aphid was first discovered infesting head lettuce at low levels the Yuma Agricultural Center in the spring of 2001, and reached high population levels at YAC on spring plantings in 2002. Foxglove aphid populations were first found in commercial fields in 2003 and built up to large populations throughout the Yuma Valley. Although we are uncertain how this new species will behave under desert growing conditions in the long-term, infestations in the spring of 2004 again reached high levels in experimental plots and in some commercial fields. Green peach aphids, traditionally our most common aphid species in lettuce, were unusually abundant on commercial lettuce during the spring 2004 growing season as well. Because of the importance of these aphids as contaminants of lettuce and other leafy vegetables, their control is very important. Given the complexities of the desert lettuce cropping systems, it is apparent that newly developed, reduced- and low-risk insecticides need to be evaluated for their efficacy against aphids.

Many of the new insecticides being developed today are selective compounds with more environmentally friendly, safer attributes. These compounds possess very safe toxicological profiles through the development of new mechanisms of toxicity and routes of activity. We have identified three new compounds that are either currently registered for use in lettuce, or should be in the near future. Fulfill® (pyemetrozine) belongs to a new, novel chemistry known as the pyridine azomethines. A highly selective, anti-feeding compound, it has a unique mode of action that acts specifically on the salivary pump of sucking insects causing rapid cessation of feeding. It is slow acting, but has both contact and systemic activity on aphids and, to a lesser extent on whiteflies. Assail® (acetamiprid is another reduced-risk/OP replacement insecticide that is a second-generation neonicotinoid with contact and systemic activity via foliar applications. It has excellent activity against sucking pests such as aphids and whitefly, but unlike other compounds in this chemistry it is less efficacious when applied to the soil. The third candidate for implementation in lettuce pest management programs is the flonicamid. It is a systemic insecticide that is a quick acting compound that immediately suppresses the feeding of aphids and other sucking insects. In an effort to learn more about these new compounds we designed several insecticide trials this past season to determine how effective they are against aphids under local growing conditions.

Materials and Methods

Small-plot field studies were conducted in several head lettuce and broccoli plantings at the University of Arizona, Yuma Agricultural Center in the spring 2004 growing seasons. The objectives of these studies were to evaluate the efficacy of several new reduced risk insecticides for control of aphids. In each trial, lettuce or broccoli 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, 45-60' long with a two bed buffers between the plots. Plots were arranged in a randomized complete block design with 4 replications. Treatments and rates for each crop are presented in the data tables. Specific information for each trial is listed below:

Table 1. Experimental parameters for several aphid studies conducted in 2003/2004 at YAC.

	Head Lettuce I	**Head Lettuce II**	**Head Lettuce III**	**Head Lettuce IV**	**Broccoli**
Variety	Coach Supreme	Coach Supreme	Diamond	Diamond	General
Planting date	Nov 19	Nov 19	Dec 5	Dec 12	Dec 12
Harvest date	Mar 11	*NA*	Mar 22	*NA*	*NA*
Spray dates	1/13, 1/27, 2/19, 3/4	1/16, 1/23, 2/6	2/14, 2/28, 3/15	3/9, 3/16	2/9, 2/23, 3/8
Pre-spray aphid densities	8.0/plant – GPA 0.0/plant - FGA	0.7/plant –GPA 0.0/plant - FGA	5.2/plant GPA 0.7/plant - FGA	22.3/plant GPA 4.7/plant - FGA	59.4/plant GPA

In the Lettuce I and II trials, and the Broccoli trial, at-planting soil applications of Admire were applied as a preplant injection at a depth of 1.5" below the seed line at bed shaping in 15 GPA final dilution. In all trials, foliar spray applications were hand applied with a CO_2 operated boom sprayer operated at 60 psi and 25 GPA. A directed spray (~75% band, with rate adjusted for band; nozzles directed inward toward the plants) was delivered through 3 nozzles (TX-12) per bed. An adjuvant was applied to all foliar treatments; DyneAmic at 0.065% or 0.10% v/v.

Aphid populations were assessed by estimating the number of aphids /plant in whole plant, destructive samples. Three aphid species were present on plants: Foxglove aphid (FGA), Green peach aphid (GPA) and *Acyrthosiphon lactucae* (no common name). On each sampling date, 5-8 plants were randomly selected from each plot and placed individually into large 5-gallon tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous (non-winged) aphids present. In the Lettuce I trial, infestation levels of apterous aphids at harvest were estimated by randomly selecting 10 plants within each replicate, visually counting the number of aphids on frame/wrap per leaves and heads separately. The percentage of plants with greater than 5 aphids/head was also reported. Data for aphid abundance in all trials was analyzed using ANOVA (Proc GLM) and mean differences were estimated using a protected $LSD_{(0.05)}$.

Results and Discussion

Head Lettuce I:
Aphid pressure was relatively heavy in this trial and peaked at harvest during early March. GPA was the dominant aphid species, particularly early, but FGA populations emerged at comparable levels at harvest. Foliar sprays were initiated at relatively high aphid densities (>5 aphids/plant). However, both Assail and flonicamid provided excellent control following each application and maintained populations of both aphid species to low levels at harvest (Figure 1, Table 2). Fulfill provided good control of FGA, but did not provide comparable protection of head contamination. Stretching the 2^{nd} application for 21 days allowed the populations of GPA to build up to higher numbers than the other treatments. Both dimethoate and endosulfan did not provide comparable control following each application, and aphid contamination in the dimethoate treatment was inconsistent at harvest. The Provado and Admire treatment did not provide adequate protection form the FGA, but heads in the Admire treatments were free from GPA contamination at harvest (Table 2). Overall the Assail and flonicamid treatments provided the most consistent control.

Head Lettuce II:
In this short trial, GPA was the primary aphid species peaking at 20 aphids/plant in mid-February. FGA numbers were not significant (Table 3). Assail provided quick knockdown and sustained GPA at very low levels throughout the trial. Similarly Admire maintained GPA to negligible numbers. GPA numbers in the Capture+Dimethoate treatment were significantly lower than the untreated check following each spray, but were higher than both Admire and Assail. The neonicotinoids provided the best control in this study.

Head Lettuce III:
GPA was the dominant aphid species in the late spring lettuce trial**,** peaking at >45 aphids/plant in early March. The populations crashed thereafter to very low number at harvest as a result of unusually high temperatures (Figure 2). Similar to the first trial, aphid densities were allowed to build up to higher numbers prior to the first application (Table 1). As a consequence, the Fulfill treatments did not provide consistent control at 14 day spray intervals (Table 3, Figure 3). Following the first application, the addition of Mustang with Fulfill significantly improved aphid control (Figure 2), but overall, the tank mix did not improve efficacy of GPA (Figure 3). In contrast, Flonicamid and Assail provided exceptional control for the duration of the trial, regardless of the addition of the pyrethroid or dimethoate. These two compounds provided the most consistent control (Figure 2, Table 4) and had significantly lower aphid numbers than all other treatments (Figure 3).

Head Lettuce IV:
FGA and GPA was the primary aphid species peaking at >30 aphids/plant at the beginning of the study (Table 5). Following the first application, flonicamid provided the most consistent knockdown of aphids, reducing GPA to significantly lower levels than either Assail or the Orthene+Capture treatment. All three treatments reduced FGA numbers to significantly comparable numbers. After the 2^{nd} application numbers declined in all treatments and treatment differences were not observed among treatments for each species (Table 5). Flonicamid appeared to provide the most consistent knockdown activity of GPA and FGA.

Broccoli:
GPA was the only aphid measured during this study and peaked following the 3^{rd} application in late March. GPA levels were very high when the first application was made, but nonetheless, both Assail and flonicamid significantly reduced infestations comparable to those found in the Admire treated plots (Figure 4). None of the other foliar treatments, including Fulfill, were capable of significantly reducing aphid infestations following any of the treatments. However, the seasonal average number of GPA in both Fulfill and the OP rotation treatments were significantly lower than the untreated check (Figure 5). Flonicamid was the only foliar treatment that provided aphid control equitable to the standard Admire soil application.

Conclusions:
Collectively, the chemical attributes and biological activities of Fulfill, Assail and flonicamid make them extremely attractive for implementation into an aphid management program. The past performance of these insecticides under experimental settings has shown that efficacy was highly dependant on spray timing. We know that initiating applications at low aphid densities (threshold of ~1 apterae/plant), particularly for Fulfill, has provided consistent protection to marketable heads. Fulfill did not perform well in the trials where sprays were applied above threshold levels. However, Flonicamid, and in most cases Assail, provided good economic control of FGA and GPA when sprays were initiated at densities above our nominal threshold. This is encouraging considering that most PCAs typically initiate sprays at or near threshold levels. Unfortunately, what we don't know is at what population density is *re-treatment* needed to sustain this level of protection from aphids? Can spray intervals be stretched to greater than 14 days and still achieve protection? Based on these studies, this might be possible for flonicamid and Assail, but not likely for Fulfill. Ultimately what PCAs need is a simple action threshold that can be used in conjunction with a reliable sampling plan that will assist them in making cost-effective management decisions. In other words, they need a management-based approach that will prevent them from under-or-over applying these new insecticides, while producing a contaminant–free crop. Studies will be underway this next season to evaluate predetermined action thresholds for these aphid species which will allow us to provide cost-effective guidelines for the use of these products in the future.

Acknowledgments

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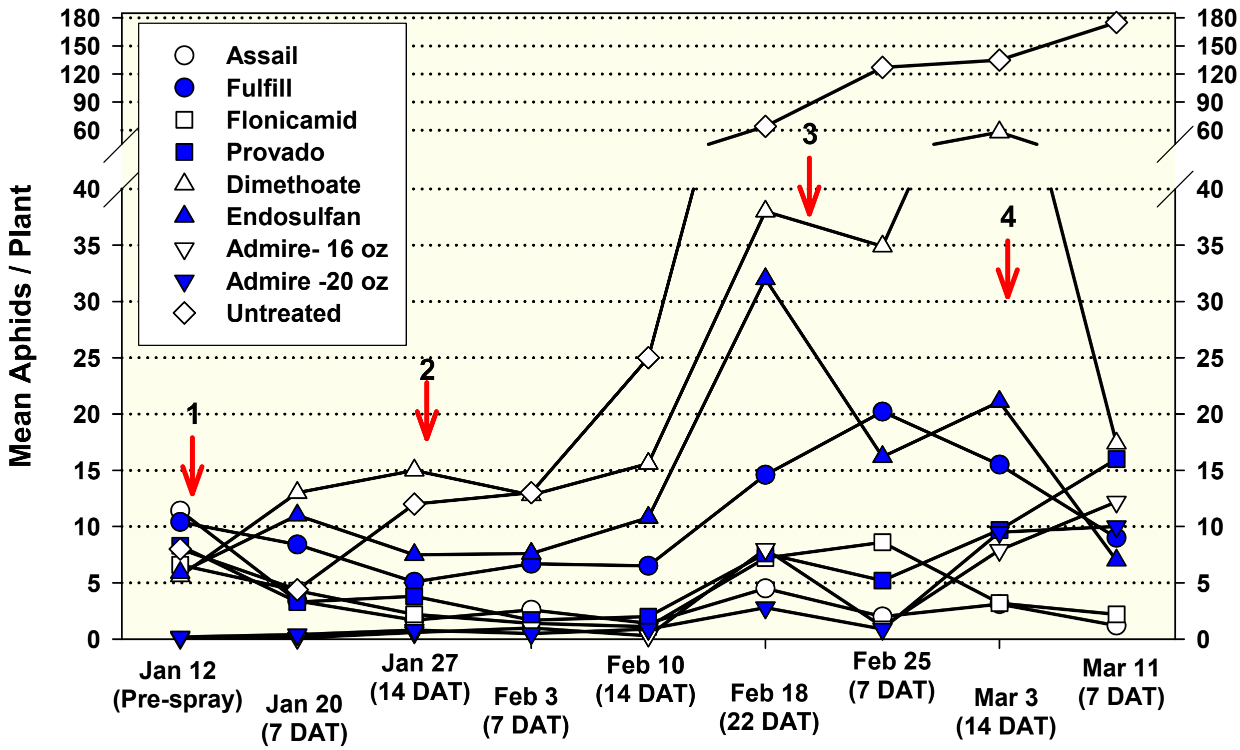

Figure 1. Aphid abundance on lettuce plants treated with various insecticides, YAC, spring 2004 – Head Lettuce I

Table 2. Aphid abundance and contamination on treated lettuce plants at harvest, YAC, spring 2004 – Head Lettuce I

		Avg. No. Aphids / Head			% Contaminated Heads (> 5 aphids)		
Treatment	**Rate**	**GPA**	**FG**	**Total**	**GPA**	**FG**	**Total**
Assail	1.7 oz	0.2 b	0.2 b	0.4 b	0.0 c	0.0 d	0.0 d
Fulfill	2.75 oz	2.0 b	0.0 b	1.9 b	14.8 b	0.0 d	9.5 cd
Flonicamid	2.3 oz	0.7 b	0.0 b	0.7 b	0.0 c	0.0 d	0.0 d
Provado	3.75 oz	1.4 b	4.0 b	5.4 b	9.5 b	29.5 b	33.3 b
Dimethoate	8 oz	2.2 b	0.5 b	2.7 b	14.8 b	4.8 cd	19.1 bcd
Endosulfan	32 oz	1.7 b	0.1 b	1.7 b	4.8 bc	0.0 d	4.8 cd
Admire	16 oz	0.1 b	7.1 b	7.2 b	0.0 c	24.1 b	28.6 bc
Admire	20 oz	0.3 b	3.0 b	3.3 b	0.0 c	28.9 b	28.6 bc
Untreated		23.0 a	34.1 a	57.1 a	80.2 a	52.4 a	100 a

Data was transformed log (x+1) before ANOVA; untransformed means are presented in table. Means followed by the same letter are not significantly different, ANOVA, $LSD_{(p>0.05)}$.

Table 3. Aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce II

Treatment	Rate/ac	Mean GPA / Plant Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	1.5 c	0.5 c	0.4 c	1.0 bc	1.4 c	1.2 c
Capture+Dimethoate	5oz + 12 oz	6.2 b	3.8 b	2.3 b	2.7 b	5.0 b	4.0 b
Admire	16 oz	0.0 c	0.2 c	0.6 c	0.1 c	1.1c	0.4 c
Untreated		9.9 a	16.3 a	9.3 a	14.6 a	20.0 a	13.9 a

Treatment	Rate/ac	Mean FG / Plant Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	0.0 a	0.0 a	0.0 a	0.1 b	0.1 a	0.1 a
Capture+Dimethoate	5oz + 12 oz	0.0 a	0.0 a	0.0 a	0.1 b	1.1 ab	0.2 a
Admire	16 oz	0.0 a	0.4 a	0.4 a	0.2 b	5.2 a	1.2 a
Untreated		0.0 a	1.1 a	0.7 a	1.8 a	1.1 ab	0.9 a

Treatment	Rate/ac	Mean Total Aphids / Plant Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	1.5 c	0.5 b	0.4 b	1.1 b	1.5 b	1.0 c
Capture+Dimethoate	5oz + 12 oz	6.2 b	3.8 b	2.3 b	2.8 b	6.1 ab	4.2 b
Admire	16 oz	0.0 c	0.6 b	1.0 b	0.3 b	6.3 ab	1.6 c
Untreated		9.9 a	17.4 a	1.0 a	16.4 a	21.1 a	13.2 a

Data was transformed log (x+1) before ANOVA; untransformed means are presented in table. Mean followed by the same letter are not significantly different, $LSD_{(p>0.05)}$.

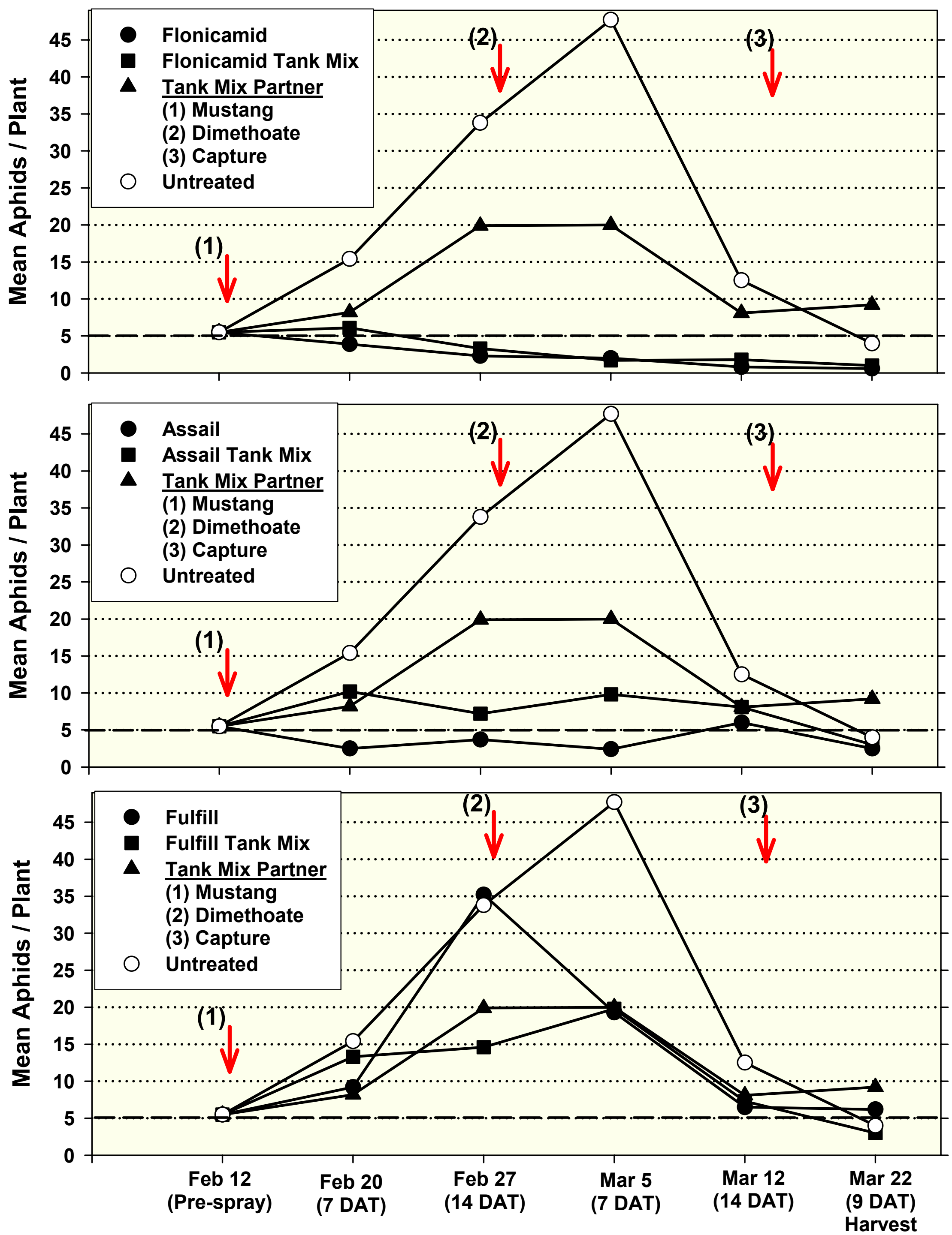

Figure 2. Aphid abundance on lettuce plants treated with various insecticides, YAC, spring 2004 – Head Lettuce III

Table 4. Green peach (GPA) and foxglove aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce III

	Avg no. GPA / Plant				
Treatment	**20-Feb**	**27-Feb**	**5-Mar**	**15-Mar**	**22-Mar**
Flonicamid	3.6 a	2.2 e	1.8 c	0.4 b	0.0 a
Flonicamid tank mix	5.2 a	3.3 de	1.7 c	0.5 b	0.0 a
Assail	1.9 a	3.3 de	1.7 c	1.7 b	0.0 a
Assail tank mix	6.4 a	5.9 cde	1.5 c	1.4 b	0.0 a
Fulfill	9.2 a	22.6 bcd	8.8 bc	1.9 b	0.2 a
Fulfill tank mix	10.9 a	13.0 bc	14.3 b	2.0 b	0.0 a
Tank mix partner	7.8 a	17.6 ab	18.3 b	2.7 ab	0.2 a
Untreated	13.4 a	27.7 a	35.6 a	4.3 a	0.4 a

	Avg no. FGA / Plant				
Treatment	**20-Feb**	**27-Feb**	**5-Mar**	**15-Mar**	**22-Mar**
Flonicamid	0.3 a	0.1 a	0.2 b	0.4 a	0.6 a
Flonicamid tank mix	0.9 a	0.0 a	0.0 b	1.3 a	1.0 a
Assail	0.6 a	0.4 a	0.7 b	4.3 a	2.5 a
Assail tank mix	3.8 a	1.3 a	8.3 ab	6.7 a	3.0 a
Fulfill	0.0 a	2.6 a	0.7 b	4.6 a	6.0 a
Fulfill tank mix	2.4 a	1.6 a	5.5 b	5.3 a	3.0 a
Tank mix partner	0.4 a	2.3 a	1.7 b	5.4 a	9.0 a
Untreated	2.0 a	5.1 a	11.5 a	7.8 a	3.1 a

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

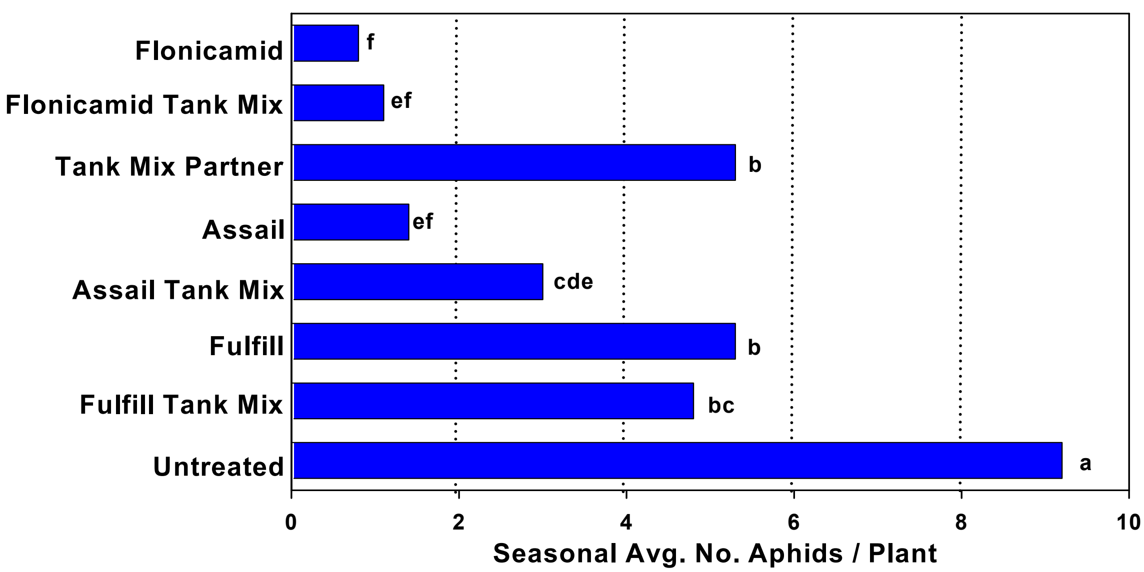

Figure 3. Seasonal aphid abundance on lettuce plants treated with various insecticides, YAC 2004, Head Lettuce III

Table 5. Green peach, foxglove aphid and *Acyrthosiphon lactucae* aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce IV

March 8 (Pre-spray counts)

Treatments	Rate/acre	Mean Aphids / Plant: Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
All treatments	-	22.4	5.9	4.5	32.9

March 16 (7 DAT#1)

Treatments	Rate/acre	Mean Aphids / Plant: Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
Assail	1.7 g	1.4 ab	7.5 b	0.0 a	8.8 b
Flonicamid	0.071 lb ai	0.0 b	3.1 b	0.0 a	3.1 b
Orthene+Capture	1 lb + 5 oz	4.1 a	3.9 b	0.0 a	8.0 b
Untreated	-	6.8 a	20.7 a	1.0 a	28.5 a

March 23 (7 DAT#2)

Treatments	Rate/acre	Mean Aphids / Plant: Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
Assail	1.7 g	0.0 a	6.3 a	0.0 a	6.3 a
Flonicamid	0.071 lb ai	0.0 a	1.3 a	0.0 a	1.3 b
Orthene+Capture	1 lb + 5 oz	0.1 a	8.3 a	0.0 a	8.4 a
Untreated	-	0.5 a	7.6 a	0.2.a	8.2 a

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

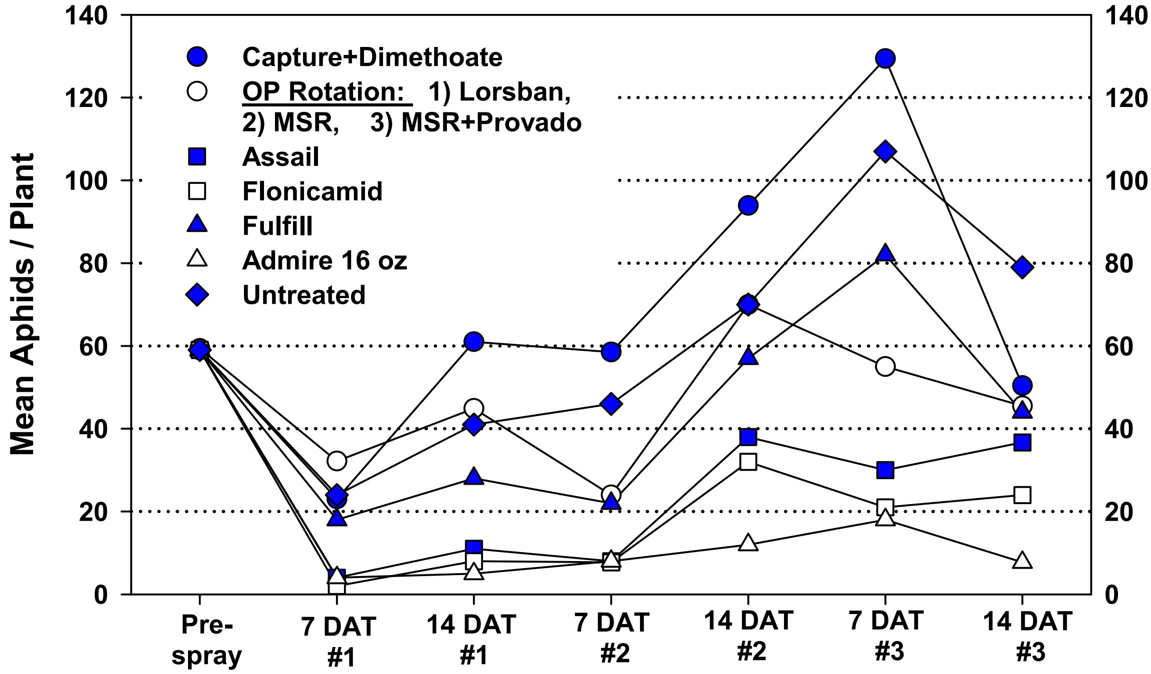

Figure 4. Aphid abundance on lettuce plants at various intervals after spray treatments, YAC, 2004 – Broccoli.

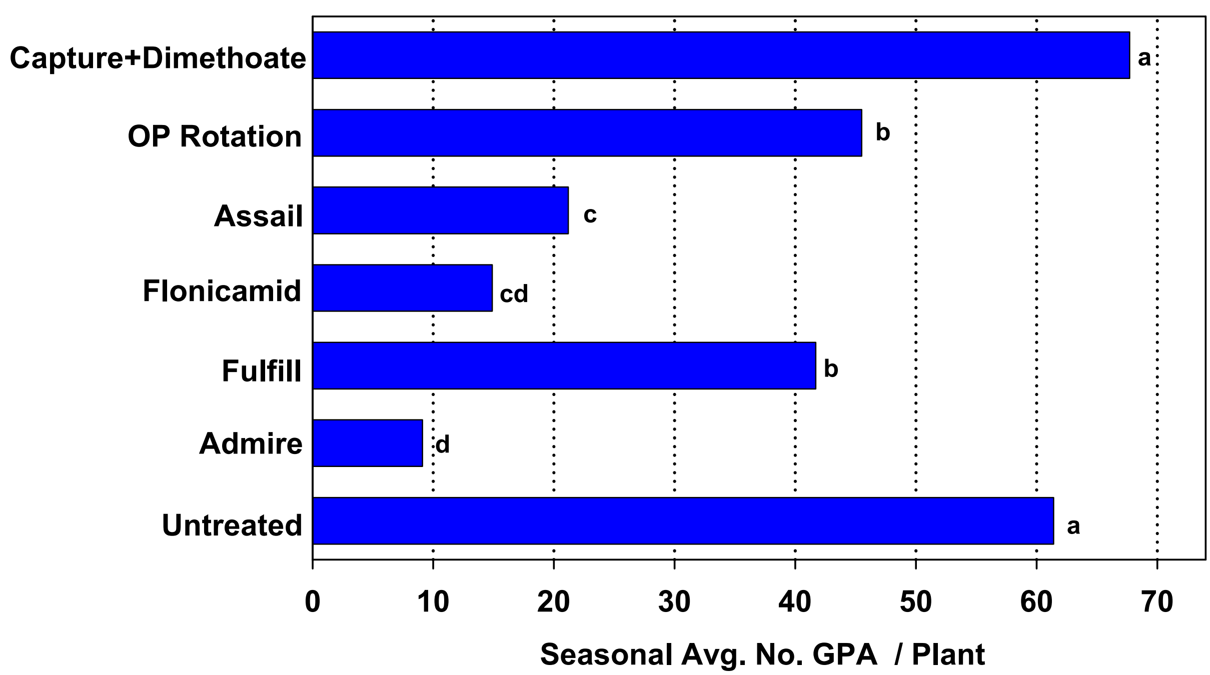

Figure 5. Seasonal aphid abundance on lettuce plants treated with various insecticides, YAC 2004, Broccoli