Arizona Department of Agriculture
AILRC Grants Program – Final Report for 2012
April 2013

Project title: **Evaluation of New Insecticides in Desert Head Lettuce**

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Location of Research: Yuma Valley Agricultural Center

Rationale:

The number of new insecticides available for insect control in head lettuce has increased considerably in the past few years. This is extremely important given the recent losses in a number of important insecticide uses (e.g., diazinon, dimethoate), and the impending loss of the endosulfan registration scheduled for 2012. Many in the industry, expect restrictions in the uses of pyrethroids and other older products to follow in the future. Although most of the newly developed products that growers use are very effective against hey lettuce pests, they tend to be very expensive. Thus, it is critical that growers continue to explore how to use these products more cost-effectively. In addition, there are several new, unregistered insecticides that are under development that will likely provide activity against on many of the key pests that infest lettuce.

The continual occurrence of several key insect pests further justifies the need to explore new insecticides and their cost-effective use patterns for local growers and PCAs. A complex of aphid species are well established in desert lettuce, and thrips have become increasingly difficult and expensive to control in spring and fall lettuce. Many of the compounds currently used for controlling thrips (Lannate, Orthene, Endosulfan) are directly threatened by FQPA. Finally, worm pests such as beet armyworm and cabbage looper remain the most economically important pest in fall lettuce and typically require 3-4 foliar sprays throughout the season to prevent losses.

Newer insecticides are currently available for control of key insect pests. They offer many favorable attributes to lettuce growers because they are very selective, environmentally friendly, and very effective against certain insect pests. Products such as Radiant and Proclaim have been the standards for worm control the past few years, but the recent registration of a Coragen, Voliam Xpress , Synpase and Vetica have recently provided more options. Similarly, Movento is clearly the most commonly used product for aphid control, and other foliar alternative products are available. Use of Admire and generic imidacloprid products as soil insecticides remains about the same, but their cost to the grower has dropped significantly. Finally, a number of new compounds with different modes of action are presently being developed that provide a wide spectrum of activity against many key insect pests**.** To date, we have only limited research experience with them to determine how they might best fit in desert lettuce management programs.

Objective

To compare the knockdown and residual efficacy of several new insecticides for worm, whitefly, aphid and thrips control relative to the industry standards currently used in desert head lettuce production.

I. Efficacy against Worms/Leafminer/Whitefly

Foliar Trial

The objective of the study was to evaluate the efficacy of new foliar applied insecticides against lepidopterous larvae on lettuce under desert growing conditions. Lettuce was direct seeded on 8 Sep 2011 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 45 ft long and bordered by a single untreated bed. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each treatment compound are provided in the tables. Two foliar sprays were applied on 5 Oct and21 Oct with a CO_2 operated boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 21.5 GPA. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% v/v with all treatments. Evaluation of efficacy was based on the number of live larvae per plant. Ten plants per replicate were destructively sampled on each sample date. The sample unit consisted of examination of whole plants for presence of small (neonate and 2nd instar larve) and large (3rd or > instar) CL and DBM. Treatment means were analyzed using a 1-way ANOVA and means separated by a protected LSD $_{(P<0.05)}$.

Worm pressure was light –moderate during the study. Treatment differences among the spray treatments for CL and BAW control were consistent following each application. CL efficacy was comparable among the treatments where significant post-treatment reduction of large CL was similar for all treatments applied compared to the untreated check. Trends were similar for BAW where the all treatments significantly reduced large BAW larvae compared to the untreated. The lack of significant differences in small CL and DBM among the spray treatments and the UTC following some applications did not reflect a lack of control because many of the small larvae were neonates that had hatched 1-2 days following application. The results of this trial suggest that the new compound Exirel (cyazypyr) applied as a foliar spray can effectively control BAW and DBM comparable to the industry standards presently used in desert lettuce production.

			Avg. Larvae (>1st instar)/ 10 plants		
Treatment	**Rate/ac**	**% plants w/ fresh feeding**	**Cabbage looper**	**Beet armyworm**	**Total**
Radiant	5 oz	3.3 cd	0.1 c	0.1 b	0.2 b
Voliam Xpress	9 oz	1.9 d	0.1 c	0.3 b	0.4 b
Exirel	13.5 oz	6.6 bcd	0.04 c	0.4 b	0.5 b
Coragen	5 oz	4.7 cd	0.2 c	0.4 b	0.5 b
Proclaim	3.6 oz	13.2 bc	0.6 b	0.1 b	0.7 b
Vetica	17 oz	7.2 bcd	0.1 c	0.8 b	0.9 b
Intrepid+Warrior	10 + 1.8 oz	9.5 bc	0 c	1.4 b	1.4 b
Untreated	-	63.6 a	1.2 a	6.8 a	8.0 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD)

Soil Trial

The objective of this trial was to evaluate the efficacy of a new experimental compound for cross-spectrum (sucking and chewing insect pests) control of major insects in head lettuce under fall growing conditions. Head lettuce 'Diamondback' was direct seeded into double row beds on 42 inch centers on 8 Sep, 2011. Plots were two beds wide by 75 ft long and bordered by two untreated beds. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Sub-surface, soil injection treatments were applied by placing the insecticides 1.5 in. directly below line each seedline with a modified fertilizer shank just prior to planting in a total water volume of 20.5 GPA. No other insecticide application were applied during the trial. At various intervals after planting (DAP), 10 plants were randomly selected from each replicate and destructively sampled for the presence of each insect species. Evaluation of LM control was conducted by examining all leaves on each plant and counting the number of mines on each leaf. BAW and CL control was based on the examination of whole plants for presence of large (2^{nd} or > instar) larvae. SWF immature densities were estimated by examining 10 leaves per replicate (collected near the base of the plant) on each sample date. Leaves were taken into the laboratory where the total number small nymphs were counted on two, 2-cm^2 leaf discs of each leaf using a dissecting microscope. Data were subjected to ANOVA and means were separated using an *F*-protected LSD ($P \leq 0.05$).

LM population pressure was moderate and the Verimark soil applications provided significant control of LM compared to the untreated check throughout the trial (Table 1.) When averaged across all sample dates, no differences in the numbers of *Liriomyza* leaf mines were observed among the three Verimark treatments and all these treatments provided significantly better control than the Durivo standard. All the soil treatments provided significant suppression of SWF nymphs during the trial with the exception of the 33 DAP sample date when differences were not observed among the soil treatments and the untreated check (Table 2). Overall, the high rate of Verimark provided the most consistent control of SWF nymphs . BAW pressure was high during this trial but large larvae were not observed on plants prior to 18 DAP. The Verimark and Durivo treatments significantly reduced BAW larvae numbers compared to the untreated control for up to 48 DAP. CL pressure was moderate and did not significantly infest plots until 40 DAP. However, at 40 and 48 DAP, plants in the Verimark and Durivo treatments contained significantly fewer CL larvae than the untreated check. As anticipated, BAW and CL larvae numbers did not differ between the Admire Pro and untreated check on any of the sample dates. These results are encouraging and suggest that the acropetal systemic activity provided by soil application of Verimark can provide excellent levels of cross-spectrum activity in head lettuce that is commonly expected from pyrethroids and organophosphates.

		Mean *Liriomyza* leaf mines / 10 Plants							
Treatment	**Rate/ac**	**12 DAP 20-Sep**	**18 DAP 26-Sep**	**23 DAP 1-Oct**	**27 DAP 5-Oct**	**33 DAP 10-Oct**	**40 DAP 17-Oct**	**48 DAP 25-Oct**	**Trial Avg.**
Verimark	8.5 oz	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	8.0 c	1.1 c
Verimark	10.2 oz	0.0b	0.3b	0.0b	0.0b	0.0a	0.0b	6.0 c	0.9 c
Verimark	13.5 oz	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	3.5 c	0.5 c
Admire Pro	10 oz	0.0b	0.3b	0.3b	3.3a	1.0a	13.5b	29.5 bc	6.9 b
Durivo	12 oz	0.0b	0.0b	0.0b	0.0b	0.0a	7.0b	38.0 b	6.4 b
Untreated	-	1.5a	2.8a	2.0a	2.9a	2.5a	53.0a	78.0 a	20.8 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD)

		Mean SWF nymphs / cm^2 / leaf						
Treatment	Rate/ac	18 DAP 26-Sep	23 DAP 1-Oct	27 DAP 5-Oct	33 DAP 10-Oct	40 DAP 17-Oct	48 DAP 25-Oct	Trial Avg.
Verimark	8.5 oz	0.2 b	0.3 c	0.2 cd	0.1 a	0.4 bc	0.2 c	0.2 b
Verimark	10.2 oz	0.1 b	0.3 c	0.1 cd	0.2 a	0.2 c	0.1 c	0.2 b
Verimark	13.5 oz	0.1 b	0.2 c	0.0 d	0.0 a	0.1 c	0.1 c	0.1 b
Admire Pro	10 oz	0.1 b	1.0 bc	1.1 bc	0.8 a	0.5 bc	0.1 c	0.6 b
Durivo	12 oz	0.2 b	3.4 ab	1.4 b	1.2 a	0.9 ab	0.6 b	1.3 a
Untreated	-	0.6 a	4.4 a	2.5 a	1.5 a	1.3 a	0.9 a	1.9 a

		Mean BAW larvae / 10 plants						
Treatment	Rate/ac	18 DAP 26-Sep	23 DAP 1-Oct	27 DAP 5-Oct	33 DAP 10-Oct	40 DAP 17-Oct	48 DAP 25-Oct	Trial Avg.
Verimark	8.5 oz	0.0 c	0.0 b	0.8 b	0.0 b	0.5 b	0.5 b	0.3 b
Verimark	10.2 oz	0.0 c	0.0 b	0.4 b	0.4 b	0.5 b	0.0 b	0.1 b
Verimark	13.5 oz	0.0 c	0.3 b	0.4 b	0.0 b	0.5 b	0.0 b	0.2 b
Admire Pro	10 oz	5.5 a	16.3 a	15.8 a	2.5 a	8.5 a	3.0 ab	8.6 a
Durivo	12 oz	0.0 c	0.0 b	0.4 b	0.0 a	0.5 b	0.5 b	0.2 b
Untreated	-	3.0 b	12.5 a	15.0 a	3.8 a	9.0 a	5.5 a	8.3 a

		Mean CL larvae / 10 plants						
Treatment	Rate/ac	18 DAP 26-Sep	23 DAP 1-Oct	27 DAP 5-Oct	33 DAP 10-Oct	40 DAP 17-Oct	48 DAP 25-Oct	Trial Avg.
Verimark	8.5 oz	0.0a	0.0a	0.0 a	0.0 a	0.5 b	1.5 bc	0.3 bc
Verimark	10.2 oz	0.0a	0.0a	0.0 a	0.4 a	0.5 b	0.0 c	0.2 c
Verimark	13.5 oz	0.0a	0.0a	0.0 a	0.4 a	1.0 b	2.0 bc	0.6 bc
Admire Pro	10 oz	0.0a	0.0a	0.4 a	0.4 a	1.8 ab	4.0 ab	1.1 ab
Durivo	12 oz	0.0a	0.0a	0.0 a	0.0 a	0.0 b	0.0 b	0.0 c
Untreated	-	0.0a	0.0a	0.4 a	0.0 a	4.0 a	5.0 a	1.6 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD)

II. Efficacy against Aphids

Foliar Trial I

The objective of this study was to evaluate the residual efficacy of a new active ingredient, Closer (sulfoxaflor), as a foliar spray for control of aphids on spring head lettuce under desert growing conditions. Head lettuce 'Navajo' was direct seeded into double row beds on 42 inch centers on 7 Dec, 2010. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 12 and 28 Feb with a CO_2 operated boom sprayer at 40 psi and 28 gpa. A broadcast application was delivered through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all treatments. Aphid populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sampling date, 5 plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous aphids present. Data were log transform (mean+1) and subjected to ANOVA; means were separated using an *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

Green peach aphid (GPA) pressure was light during the trial. Following the first application, all Closer treatments provided significant suppression of GPA comparable to the industry standards (Movento, Assail and Beleaf) (Table 1). A similar trend was observed at 7 DAT 2, but by 15-DAT 2 the GPA population had declined to insignificant levels in all treatments. In contrast, *Acerthosiphon lactucae* pressure was moderate during the trial (Table 2). No differences in *A. lactucae* numbers were observed among all treatments at 7 DAT-1, but thereafter all the Closer treatments significantly reduced *A. lactucae* numbers relative to the untreated check. Among the industry standards, Assail failed to provide significant control of *A. lactucae* following the second application. These results suggest that Closer may be a viable rotational alternative for aphid control in desert head lettuce.

		GPA/ plant					
		19-Feb	26-Feb	7-Mar	15-Mar	22-Mar	Avg.
Treatment	Rate/ac	7-DAT1	14-DAT1	7-DAT2	15-DAT2	22-DAT2	
Closer	1.43 oz	0.4 b	0.6 b	0.1 b	0.1 a	0.0 a	0.2 b
Closer	2.14 oz	0.2 b	0.4 bc	0.0 b	0.0 a	0.0 a	0.1 b
Closer	2.85 oz	0.1 b	0.3 bc	0.2 b	0.4 a	0.0 a	0.2 b
Movento	5 oz	0.3 b	0.7 b	0.1 b	0.3 a	0.0 a	0.3 b
Assail	4 oz	0.3 b	0.6 b	0.4 b	0.4 a	0.0 a	0.3 b
Beleaf	2.8 oz	0.3 b	0.0 c	0.3 b	0.3 a	0.0 a	0.2 b
Untreated	-	2.8 a	5.7 a	2.9 a	1.2 a	0.1 a	2.5 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

		A. lactucae / plant					
		19-Feb	26-Feb	7-Mar	15-Mar	22-Mar	Avg.
Treatment	**Rate/ac**	**7-DAT1**	**14-DAT1**	**7-DAT2**	**15-DAT2**	**22-DAT2**	
Closer	1.43 oz	0.3 a	2.0 b	0.4 cd	2.8 b	0.6 cd	1.3 b
Closer	2.14 oz	0.5 a	2.3 b	0.1 d	2.1 b	1.0 cd	1.2 b
Closer	2.85 oz	0.1 a	1.5 b	0.1 d	2.3 b	0.9 cd	1.0 b
Movento	5 oz	4.7 a	2.9 b	1.0 c	1.9 b	0.2 d	2.2 b
Assail	4 oz	3.8 a	3.8 b	4.1 b	19.5 a	6.4 a	8.1 a
Beleaf	2.8 oz	1.1 a	2.6 b	0.7 c	4.7 b	2.0 bc	2.2 b
Untreated	-	6.8 a	16.5 a	46.3 a	56.9 a	4.8 ab	26.2 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Foliar Trial II

The objective of this study was to evaluate the residual efficacy of a new active ingredient, Sivanto (flupyradifurone), as a foliar spray for control of aphids on spring head lettuce under desert growing conditions. Romaine lettuce 'Desert Spring' was direct seeded into double row beds on 42 inch centers on 7 Jan, 2011. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 22 Mar and 13 Apr with a CO_2 operated boom sprayer at 40 psi and 21.5 gpa. A broadcast application was delivered through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all treatments. Aphid populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples following each application. On each sampling date, 5 plants were randomly selected from each plot and placed individually into large 5-gal tubs. At harvest (27 Apr; 14-DAT2), 10 plants were randomly selected from each plot and sampled by visually examining all foliage within a harvested heart and recording the number of live aphids present in each individual heart. Mean aphids per heart (species combined) and the percentage of hearts contaminated with greater than 1 and 5 live aphids were calculated at harvest. Aphid data were log transform (mean+1) and percent contaminated hearts were acrsine transformed prior to the ANOVA and an *F*-protected LSD ($P \leq 0.05$) to distinguish treatment mean differences. Actual non-transformed means are presented in the tables.

LA and *A. lactucae* population pressures were moderate during the trial. Two days prior to the beginning of the trial, pre-spray estimates for LA and *A. lactucae* were 12.5 and 5.3 aphids / plant, respectively. Following the first application, none of the spray treatments significantly reduced numbers of either aphid species at 3-DAT (Table 1 and 2). By 6-DAT1, aphid numbers in all spray treatments were significantly reduced compared to the untreated check. This trend continued for the remainder of the trial except for the Assail treatment, which did not significantly reduce LA numbers beginning 10-DAT1 and *A. lactucae* numbers after 14-DAT1.Overall, each rate of Sivanto provided control of both aphid species comparable to the industry standard, Movento. At harvest, aphid numbers and percent heart contamination were significantly lower in the Sivanto treatments relative to the untreated check. Although, heart contamination did not differ among the Movento and Sivanto treatments, contamination levels would have only been commercially unacceptable

in the Sivanto treatments under normal market conditions. These results suggest that Sivanto may be a viable early season, rotational alternative with Movento for aphid control in desert romaine lettuce.

		Lettuce aphid / plant					
		3-DAT1	6-DAT1	10- DAT1	14-DAT1	21-DAT1	7-DAT2
Treatment	Rate/ac	25-Mar	28-Mar	1-Apr	5-Apr	12-Apr	20-Apr
Sivanto	5.2 oz	2.5 a	0.6 c	1.2 bc	0.9 b	5.7 b	1.3 b
Sivanto	8.6 oz	6.2 a	0.3 c	0.2 c	0.2 c	6.0 b	1.8 b
Movento	5 oz	9.1 a	2.4 b	1.3 bc	1.3 b	3.1 b	1.5 b
Assail	3 oz	11.8 a	3.5 b	10.2 ab	20.1 a	28.5 a	22.3 a
Untreated	-	10.3 a	16.1 a	21.4 a	34.7 a	55.7 a	15.7 a

		A. lactucae / plant					
		3-DAT1	6-DAT1	10- DAT1	14-DAT1	21-DAT1	7-DAT2
Treatment	Rate/ac	25-Mar	28-Mar	1-Apr	5-Apr	12-Apr	20-Apr
Sivanto	5.2 oz	6.0 a	0.7 cd	0.7 cd	0.1 c	0.4 b	0.0 b
Sivanto	8.6 oz	9.3 a	0.2 d	0.4 d	0.1 c	1.4 b	0.1 b
Movento	5 oz	21.1 a	2.5 bc	1.3 bc	0.6 c	1.0 b	0.1 b
Assail	3 oz	8.6 a	4.6 b	3.8 b	9.2 b	13.8 a	11.0 a
Untreated	-	18.9 a	14.8 a	24.1 a	38.0 a	24.8 a	16.4 a

			% Contaminated Hearts	
Treatment	Rate/ac	Total aphids per heart	> 1 aphid	> 5 aphids
Sivanto	5.2 oz	1.9 bc	30.0 bc	15.0 bc
Sivanto	8.6 oz	2.4 bc	50.0 bc	20.0 bc
Movento	5 oz	0.3 c	10.0 c	0.0 c
Assail	3 oz	4.4 ab	65.0 ab	37.5 ab
Untreated	-	11.3 a	95.0 a	60.0 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Soil/Foliar

The objective of these studies was to evaluate control of aphids using either foliar-applied insecticides, soil-applied insecticides or a combination of both on spring head lettuce under desert growing conditions. Head Lettuce ('Winter King') was direct seeded on 3 Jan, 2012. Plots consisted of 2 beds , 45' long and were arranged in a randomized complete block design with 4 replications. Rates for each compound are provided in the tables for each study. Admire Pro (7 oz/ac) was applied at planting in 20.5 gpa final solution and inject 2" below the seedline. Foliar sprays were applied on 22 Feb (Movento-5 oz/ac, and Closer-2.0 oz/ac in non-Admire Pro treated plots) and 31 Mar (Movento-5 oz/ac, and Closer-2.0 oz/ac in both Admire Pro treated and non-treated plots) with a CO_2 operated boom sprayer at 40psi and 21.5 gpa. A broadcast application was delivered through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, DyneAmic, was applied at 0.25 % vol/vol. Harvest was conducted on 12 Apr.

Aphid populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sampling date, 5 plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous aphids present. Data were log transform (mean+1) and subjected to ANOVA; means were separated using a *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

Aphid pressure was heavy in this trial and the aphid complex consisted predominantly of *A. lactucae* with a few lettuce aphids present at harvest. All the treatments significantly reduced aphid contamination at harvest, but lettuce treated with Admire Pro and without additional foliar sprays had unacceptable aphid contamination. In this trial, two applications of Closer, a new insecticide with an anticipated registration date of early 2013, and Movento applied to non-Admire Pro treated lettuce reduced aphid contamination to very low levels, but the most consistent treatments were the Admire Pro at-plant treatment followed by a single foliar application of Closer 12 days before harvest. Given the current economics of imidacloprid and the cost-effective aphid control that can be achieved by using higher rates (e.g., *Alias, 16-24 oz*, *Wrangler, 10-12 oz* or *Admire Pro, 7-10.4 oz*), it is recommended that growers apply imidacloprid at-planting applications on their spring lettuce plantings (mid-November through December). If aphids move onto crops late in the crop season and begin to colonize, foliar products like Movento, Assail, Beleaf, and Closer (upon EPA registration) can be effectively applied.

		Aphids / Plant					
Soil Treatment	**Foliar Treatment**	**17-Feb**	***24-Feb***	***2-Mar***	***15-Mar***	***29-Mar***	***8-Apr***
Admire Pro	-	1.5 a	3.1 a	3.1 a	1.9 a	2.8 b	11.7 b
Admire Pro	Movento	1.4 a	4.9 a	3.2 a	2.1 a	1.9 b	1.9 cd
Admire Pro	Closer	1.6 a	5.0 a	2.9 ab	1.5 a	2.3 b	0.9 d
-	Movento	1.4 a	4.3 a	1.2 b	1.5 a	6.0 a	3.4 cd
-	Closer	1.5 a	4.4 a	1.1 b	2.7 a	5.9 a	4.6 bc
Untreated	-	1.4 a	4.3 a	5.7 a	3.4 a	11.2 a	37.9 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Soil Treatment	Foliar Treatment	*Mean Aphids per Head*	*% Heads infested with 1 or > aphids*	*% Heads infested with 5 or > aphids*	*% Heads infested with 10 or > aphids*
Admire Pro	-	11.7 b	64.3 b	60.7 b	35.7 c
Admire Pro	Movento	1.9 cd	29.3 c	21.4 c	3.6 c
Admire Pro	Closer	0.9 d	14.3 d	10.7 c	0.0 c
-	Movento	3.4 cd	64.3 b	28.6 c	3.6 c
-	Closer	4.6 bc	60.7 dc	28.6 c	10.7 c
Untreated	-	37.9 a	92.9 a	92.9 a	82.1 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

II. Efficacy against Western Flower Thrips

Trial I

The objective of the trial was to evaluate the efficacy of several insecticides for control of western flower thrips on fall head lettuce under desert growing conditions. Head lettuce 'Diamondback' was direct seeded on 15 Sep, 2011 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 24 Oct and 1 Nov with a CO_2 operated boom sprayer that delivered a broadcast application at 40 psi and 25 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all but the M-Pede and Aza-Direct treatments. Numbers of WFT from 5 plants per replicate were recorded at various sample date following each application (DAT). Relative WFT numbers were measured by removing plants and beating them vigorously against a screened pan (12 in. x 7 in. x 2 in) for a predetermined time (10 sec). A 6 in. by 6 in. sticky card was placed inside of the pan to catch the dislodged WFT. Sticky cards were then taken to the laboratory where adult and larvae were counted. Data were subjected to ANOVA and means were separated using an *F*-protected LSD ($P \leq 0.05$).

WFT population levels were light during this fall trial. Following each application, the industry standards (Lannate+Brigade and Radiant) and Lannate+Torac significantly reduced adult WFT numbers relative to the untreated check, with the exception of the 14-DAT2 sample when none of the spray treatments provided residual control of WFT adults. The Exirel, M-Pede, and M-Pede+Aza-Direct did not provide consistently significant adult control and when averaged across all sample dates, WFT adult numbers in these treatments did not differ from the untreated check. All the treatments appeared to be more active against the WFT larvae. The industry standards and Lannate+Torac provided the most consistent control of WFT larvae. When averaged across all sample dates, WFT larvae numbers in the Exirel, M-Pede, and M-Pede+Aza-Direct treatments were significantly lower than the untreated, but not as low as the industry standards.

		Avg. Adults / Plant					
Treatment	**Rate/ ac**	**3-DAT1**	**7-DAT1**	**3-DAT2**	**7-DAT2**	**14-DAT2**	**Avg.**
Lannate +Brigade	0.8 lb + 5 oz	2.1 d	6.2 cd	1.3 c	1.9 d	3.6 a	3.0 c
Lannate +Torac	0.8lb + 21 oz	2.6 cd	5.6 d	2.7 bc	3.1 cd	3.4 a	3.5 bc
Radiant	7 oz	2.9 cd	9.2 bc	4.3 b	4.0 cd	2.3 a	4.5 b
Exirel	13.5 oz	4.8 bc	13.0 a	9.2 a	5.0 bc	4.6 a	7.3 a
M-Pede	2% v/v	5.7 ab	11.3 b	7.5 a	7.0 ab	3.9 a	7.0 a
M-Pede+Aza-Direct	2% v/v + 2 pt	7.1 a	12.0 ab	7.5 a	7.8 ab	5.3 a	7.9 a
UTC	-	5.9 ab	12.3 a	8.2 a	8.1 a	4.2 a	7.4 a

		Avg. Larvae / Plant					
Treatment	**Rate/ ac**	**3-DAT1**	**7-DAT1**	**3-DAT2**	**7-DAT2**	**14-DAT2**	**Avg.**
Lannate +Brigade	0.8 lb + 5 oz	2.5 c	3.5 d	0.9 cde	0.4 a	0.7 c	1.6 d
Lannate +Torac	0.8lb + 21 oz	2.7 c	1.7 d	0.7 de	0.3 a	0.6 c	1.2 d
Radiant	7 oz	2.9 c	2.7 d	0.2 e	0.3 a	1.2 c	1.5 d
Exirel	13.5 oz	5.4 bc	8.3 c	3.5 ab	0.9 a	2.0 c	4.0 c
M-Pede	2% v/v	5.4 bc	7.8 c	2.7 bc	1.2 a	6.8 ab	4.8 bc
M-Pede+Aza-Direct	2% v/v + 2 pt	7.4 ab	12.7 ab	2.6 bcd	1.2 a	4.8 b	5.7 b
UTC	-	10.1 a	15.2 a	4.7 a	3.1 a	7.7 a	8.1 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Trial II

The objective of the trial was to evaluate the efficacy of the new insecticide Torac (tolfenpyrad) when applied alone and in a mixture with an industry standard for control of western flower thrips on spring head lettuce under desert growing conditions. Head lettuce was direct seeded on 7 Jan, 2011 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 6 and 20 Mar with a CO_2 operated boom sprayer that delivered a broadcast application at 40 psi and 21.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all treatments. Numbers of WFT from 5 plants per replicate were recorded at various sample date following each application (DAT). Relative WFT numbers were measured by removing plants and beating them vigorously against a screened pan (12 in. x 7 in. x 2 in) for a predetermined time (10 sec). A 6 in. by 6 in. sticky card was placed inside of the pan to catch the dislodged WFT. Sticky cards were then taken to the laboratory where adult and larvae were counted. Data were subjected to ANOVA and means were separated using an *F*-protected LSD ($P \leq 0.05$).

WFT population levels were moderate during this trial. Following the first application, adult WFT numbers did not differ between the Torac+Lannate and Torac alone treatments (Table 1). However, by 3 DAT2 the Torac+Lannate treatment provided significantly better control than the Torac alone. None of the spray treatments in this trial provided residual control of WFT adults beyond 5 - 6 days following application. When averaged across all sample dates, WFT adult numbers in the Torac-only treatment did not differ from Lannate, Warrior or the Torac+Lannate treatments, but were significantly higher than the Radiant and Lannate+Warrior standards. The Torac+Lannate treatment provided more consistent control of WFT larvae relative to the Torac treatment applied alone (Table 2). When averaged across all sprays and sample dates, the Torac-alone treatment had significantly higher WFT larvae numbers than all other treatments except the Warrior II treatment. As a stand-alone treatment Torac provides significant activity against adult WFT comparable to the pyrethroid. However, when used in combination with Lannate, Torac provided enhanced control of WFT larvae comparable to the standard Lannate+Warrior II mixture presently used by desert lettuce growers.

		Avg. Adults / Plant						
Treatment	**Rate/ ac**	**2-DAT1**	**5-DAT1**	**9-DAT1**	**3-DAT2**	**6-DAT2**	**10-DAT2**	**Avg.**
Lannate+Warrior	0.75 lb+1.9 oz	1.5 b	3.4 c	15.6 a	9.1 c	18.1 cd	27.1 a	12.5 cd
Lannate+ Torac	0.75 lb+21 oz	1.0 b	2.7 c	16.1 a	11.8 c	23.3 bc	42.2 a	16.2 b
Lannate	0.75 oz	1.5 b	5.1 bc	21.0 a	9.7 c	20.7 bcd	30.7 a	14.7 bc
Warrior II	1.9 oz	2.3 b	7.0 ab	16.9 a	12.9 c	24.0 b	26.9 a	15.0 b
Torac	21 oz	2.6 b	4.2 bc	18.0 a	18.4 b	24.5 b	32.3 a	16.6 b
Radian	7 oz	1.0 b	3.9 c	14.9 a	11.9 c	15.6 d	22.9 a	11.7 d
Untreated	-	6.6 b	9.7 a	15.5 a	26.9 a	32.4 a	31.3 a	20.4 a

		Avg. Larvae / Plant						
Treatment	**Rate/ ac**	**2-DAT1**	**5-DAT1**	**9-DAT1**	**3-DAT2**	**6-DAT2**	**10-DAT2**	**Avg.**
Lannate+Warrior	0.75 lb+1.9 oz	9.5 d	22.9 c	26.5 bc	5.9 c	9.1 d	34.4 cd	18.0 d
Lannate+ Torac	0.75 lb+21 oz	11.6 cd	20.5 c	19.8 cd	4.5 c	7.5 d	23.8 de	14.6 d
Lannate	0.75 oz	14.5 bcd	21.4 c	18.4 cd	7.1 c	13.2 d	41.4 bcd	19.3 d
Warrior II	1.9 oz	20.5 b	36.9 b	38.0 b	32.3 b	53.5 b	58.8 ab	39.9 b
Torac	21 oz	17.6 bc	28.3 bc	22.0 c	17.6 c	27.3 c	43.9 bc	26.1 c
Radian	7 oz	10.5 d	9.1 d	8.2 d	4.3 c	4.4 d	6.5 e	7.2 e
Untreated	-	34.9 a	46.9 a	51.1 a	79.4 a	73.0 a	73.1 a	59.7 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Trial III

The objective of the trial was to evaluate the influence of spray volumes on the efficacy of the new insecticide Torac (tolfenpyrad) relative to industry standards for control of western flower thrips on romaine lettuce under desert growing conditions. Romaine was direct seeded on 4 Jan, 2012 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 12 and 22 Mar with a tractor drawn, CO_2 operated boom sprayer that delivered various spray volumes (23.5 and 62.4 gpa) at 50 psi through 2-ConeJet nozzles per bed. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments.

Numbers of WFT from 5 plants per replicate were recorded at various sample dates following each application (DAT). Relative WFT numbers were measured by removing plants and beating them vigorously against a screened pan (12 inch x 7 inch x 2 inch) for a predetermined time (10 s). A 6 inch by 6 inch sticky card was placed inside of the pan to catch the dislodged WFT. Sticky cards were then taken to the laboratory where adult and larvae were counted. Because of heterogeneity of mean variances, data were log transform (mean+1) and subjected to ANOVA; means were separated using an *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

WFT population levels were moderate during this trial. Torac is exclusively toxic by through contact activity. This trial was designed to determine specifically if high spray volumes (>50 GPA) could improve the efficacy of Torac against WFT relative to standard spray volumes (~20 GPA) applied in lettuce. Although Lannate and Warrior are largely active through contact activity, they are known to be toxic to WFT through ingestion as well. Radiant is toxic to WFT through both contact and ingestion activity. Based on the results of this trial, Torac significantly reduced WFT adults and larvae following each application relative to the untreated check, however increasing spray volume did not significantly improve the efficacy of Torac against adults or larvae. Surprisingly, when averaged across all sample dates, both the Radiant and Lannate+Warrior treatments provided significantly better control of WFT larvae when applied at the higher spray volume (62 GPA) relative to the standard spray volume. No phytotoxicity symptoms were observed following any of the insecticide treatments.

		Avg. Adults / Plant						
Treatment	**Spray Volume (GPA)**	**15-Mar 3-DAT1**	**19-Mar 7-DAT1**	**22-Mar 10-DAT1**	**26-Mar 4-DAT2**	**29-Mar 7-DAT2**	**2-Apr 11-DAT2**	**Avg**
Torac	23	6.3 bc	4.1 b	12.3 bcd	7.7 b	15.9 bc	32.4 a	13.1 bc
Torac	62	7.7 b	6.1 b	14.0 abc	8.5 ab	20.9 ab	31.6 a	14.8 b
Radiant	23	7.4 b	5.0 b	16.2 ab	8.8 ab	14.4 bc	20.6 a	12.0 bc
Radiant	62	6.6 bc	4.2 b	13.9 abc	5.9 bc	14.9 bc	29.7 a	12.5 cd
Lannate+Warrior	23	5.2 c	3.5 b	10.4 cd	5.9 bc	13.3 c	24.6 a	10.5 d
Lannate+Warrior	62	7.2 b	3.8 b	9.7 d	4.6 c	12.7 c	29.0 a	11.1 cd
Untreated	-	22.2 a	12.7 a	18.2 a	13.0 a	28.5 a	33.7 a	21.4 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).

Treatment	Spray Volume (GPA)	Avg. Larvae / Plant						
		15-Mar	19-Mar	22-Mar	26-Mar	29-Mar	2-Apr	
		3-DAT1	7-DAT1	10-DAT1	4-DAT2	7-DAT2	11-DAT2	Avg
Torac	23	61.3 a	45.5 b	44.4 b	14.0 b	5.2 b	21.4 b	31.9 b
Torac	62	53.1 a	41.7 b	44.3 b	11.8 b	5.0 b	14.4 b	28.4 b
Radiant	23	17.1 b	5.1 d	14.0 c	6.0 cd	3.8 b	6.0 cd	8.7 cd
Radiant	62	8.1 c	2.6 d	9.3 c	2.8 e	2.9 b	2.2 e	4.7 e
Lannate+Warrior	23	15.3 bc	9.5 c	18.1 c	10.8 bc	4.7 b	10.1 bc	11.4 c
Lannate+Warrior	62	17.8 b	11.1 c	15.5 c	5.0 de	2.6 b	3.9 de	9.3 d
Untreated	-	92.9 a	84.6 a	118.2 a	85.8 a	69.8 a	62.3 a	85.6 a

Means in a column followed by the same letter are not significantly different ($P > 0.05$, *F*-protected LSD).