Arizona Department of Agriculture
AILRC Grants Program – Final Report for 2013
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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 being developed for insect control in head lettuce continues to increase each year. This is extremely important given the recent losses of a number of important insecticide uses (e.g., diazinon, dimethoate). Furthermore, this summer endosulfan will be permanently removed from the market. 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 the key lettuce insect pests, they tend to be very expensive. Thus, it is critical that growers continue to explore how to use newer 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. Western flower thrips have become increasingly difficult and expensive to control in both spring and fall lettuce. Two of the primary products currently used for controlling thrips (Lannate and Orthene) are directly threatened by FQPA and their future registrations are uncertain. A complex of aphid species are well established in desert lettuce and their control can be expensive. Finally, whiteflies and worm pests such as beet armyworm and cabbage looper remain the most economically important pest in fall lettuce and typically require intensive management to prevent losses.

Newer insecticides currently available for control of key insect pests are shown in ***Table 1.*** 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 **(Table 2).** Based on trials conducted last year, we are gaining important information on their activity and how they might best fit in desert lettuce management programs.

Table 1. Industry standards currently used for insect management in head lettuce[1].

Product	Chemical Name	IRAC MOA group [2]	Effective Insect Spectrum on Desert Lettuce				
			Worms	Leaf miners	Whiteflys	Thrips	Aphids
*Primarily considered **Worm** compounds*							
Radiant	Spinetoram	5	●	●		●	
Proclaim	Emamectin	6	●				
Intrepid	Methoxyfenozide	18A	●				
Voliam Xpress	Rynaxypyr+ Pyreth	28+3	●	●			
*Primarily considered **Aphid** compounds*							
Movento	Spirotetramat	23			●		●
Admire, Alias	Imidacloprid	4A			●		●
Assail	Acetamiprid	4A			●		●
Beleaf	Flonicamid	9C					●

[1] Based on 2010-2011 Lettuce Insect Losses Survey; http://extension.arizona.edu/sites/extension.arizona.edu /files/resourcefile/ resource/marcop/Lettuce%20Crop%20Losses%20Summary%20Data_2011_Final.pdf

[2] Numbers correspond to a group of insecticides that has a separate and unique mode of action from other compounds used in lettuce. These numbers can be found on the front of each insecticide label to identify its MOA.

Table 2. New insecticides currently in development for insect management

Active ingredient	Proposed Product Name	IRAC MOA group[1]	Presumed Spectrum of Insect Activity				
			Worms	Leaf miners	Whiteflys	Thrips	Aphids
Cyazypyr -soil	Verimark SE	28	●	●	●		
Cyazypyr-foliar	Exirel SE	28	●	●	●		
Pyrifluquinazon	N/A	Unknown			●	●	●
Sulfoxaflor	Closer 2SC	4C			●		●
Flupyradifurone	Sivanto 240SL	Unknown			●		●
Tolfenpyrad	Turoc 15EC	21	●			●	●

[1] Numbers correspond to a group of insecticides that has a separate and unique mode of action from other compounds used in lettuce. These numbers can be found on the front of each insecticide label to identify its MOA.

Project 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

Cross-Spectrum Insect Control with Foliar Insecticides – Fall 2012

The objective of this trial was to evaluate the efficacy of a several insecticide mixtures for cross-spectrum (sucking and chewing insect pests) control of major insects in head lettuce under fall growing conditions. Head lettuce '1221' was direct seeded into double row beds on 42 inch centers on 6 Sep, 2012. 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. Three foliar spray applications were made on 20Sep, 3 Oct and 19 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 19.5 GPA. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% v/v with all treatments. On the 3rd application, only the products with activity against Lepidopterous larvae were applied and included: Radiant, Vetica, Voliam xpress, Coragen, Cyazypyr, Belt, Proclaim and NNI-1171. At various intervals after application (3, 7, and 14 DAT), 10 plants were randomly selected from each replicate and sampled for the presence of each insect species. Beet armyworm (BAW) and cabbage looper (CL) control was based on the examination of whole plants for presence of large (2nd instar or older) larvae. Sweet potato whitefly (SWF) immature densities were estimated by examining 10 leaves per replicate (collected near the base node of the plant) on each sample date. Leaves were taken into the laboratory where the total number of nymphs was counted on two 2-cm^2 leaf discs from each leaf using a dissecting microscope. Data for CL, BAW and SWF were averaged across all sample dates and 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.

SWF pressure was moderate during the trial, while CL larvae numbers were high with levels reaching 13.0 larvae / 10 plants in the untreated check following the 3rd application. All the foliar spray treatments provided significant control of CL following the three applications. In particular, the Belt+Movento, Voliam Xpress+Actara and Exirel treatments provided the most consistent activity against CL larvae. All of the spray treatments provided significant efficacy against BAW larvae compared to the untreated check. All spray treatments had significant activity against SWF except the Voliam Xpress+Actara combination. The Vetica+NNI-0101 and Exirel treatmenst provided the most significant control of SWF relative to the other treatments and untreated check. Overall, these results are encouraging and suggest that the activity provided by foliar applications of Exirel, as a standalone product, can provide excellent levels of cross-spectrum activity in head lettuce that is commonly expected from insecticide mixtures containing products that have activity against either sucking or chewing insect pests. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Treatment	Rate/ac	CL larvae / 10 plants	BAW larva / 10 plants	SWF Nymphs /cm^2
Radiant SC+Closer 2SC	5 oz + 5 oz	0.8cd	0.8b	0.6cd
Vetica 20SC+ NNI-0101 20SC	17 + 3.2 oz	1.6bc	0.3b	0.2e
Voliam Xpress + Actara 25WG	8 + 5.5 oz	0.4d	0.3b	1.1ab
Coragen 1.6SC+ Scorpion 35SL	5 + 7 oz	1.0cd	0.5b	0.5cd
Exirel 10SC	14 oz	0.7d	0.3b	0.3e
Belt 4SC + Movento 2SC	1.5 + 5 oz	0.5d	0.1b	0.4de
Proclaim 5SG+ Endigo ZC	3.6 + 4.5 oz	0.9cd	0.5b	0.9bc
NNI-1171 SC	21 oz	2.1b	0.3b	0.6cd
Untreated	-	5.4a	2.7a	1.3a

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

<u>Soil Trial</u>

Cross-Spectrum Insect Control with Soil Systemic Insecticides - Fall 2012

The objective of this trial was to compare the efficacy of a new soil insecticide compound with insecticide mixtures for cross-spectrum (sucking and chewing insect pests) control of major insects in head lettuce under fall growing conditions. Head lettuce '1221' was direct seeded into double row beds on 42 inch centers on 6 Sep, 2012. Plots were two beds wide by 50 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 inches directly below each seed line with a modified fertilizer shank just prior to planting in a total water volume of 20.5 gpa. No other insecticides were applied to the soil treated plants during the trial. A foliar standard treatment was included. Two foliar sprays were applied in these plots on 19 Sep (Proclaim 5SG, 3.6 oz/acre + Brigade 2EC, 5.0 oz/) and 4 Oct (Radiant SC, 5 oz/acre +Movento 2SC, 5 oz/acre) with a CO_2 operated boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 19.5 GPA. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments.

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 leafminre (LM) control was conducted by examining all leaves on each plant and counting the number of mines on each leaf. Beet armyworm (BAW) and cabbage looper (CL) control was based on the examination of whole plants for presence of large (2nd instar or older) larvae. Sweet potato whitefly (SWF) immature densities were estimated by examining leaves collected from a basal node from each plant on each sample date. Leaves were taken into the laboratory where the total number of large nymphs (2nd, 3rd and 4th instars) was counted on two 2-cm^2 leaf discs from each leaf using a dissecting microscope. 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* ≤ 0.05). Actual non-transformed means are presented in the tables.

LM population pressure was light and differences among treatments were not observed until 43 DAP where Verimark soil applications provided significant control of LM compared to the untreated check (Table 1.) At 50 DAP, all soil treatments had fewer leafmines per plant than the untreated. When averaged across all sample dates, Verimark provided significantly better LM control than the other soil treatments or foliar standard. Similarly, SWF pressure on the head lettuce was light and differences among treatments were not observed until 43 and 50 DAP where all treatments significantly reduced nymph colonization except the Durivo treatment. provided significant which point (Table 2). Overall, Verimark provided whitefly control comparable to the Coragen+imidacloprid treatments and the foliar standard (Movento). BAW pressure was moderate during this trial but large larvae were not observed on plants prior to 20 DAP. The Verimark, Coragen and Durivo treatments significantly reduced BAW larvae numbers compared to the untreated check for up to 42 DAP. CL pressure was moderate and did not significantly infest plots until 35 DAP. However, at 35 DAP, plants in the Verimark and Durivo treatments contained significantly fewer CL larvae than the untreated check. By 42 DAP, only the foliar standard had significantly few CL larvae than the untreated. 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 insecticide mixtures. No phytotoxicity symptoms were observed following any of the insecticide treatments. This research was supported by a grant from the Arizona Iceberg Lettuce Research Council, 13-01.

		Mean *Liriomyza* leaf mines / Plant				
		20 DAP	**32 DAP**	**43 DAP**	**50 DAP**	
Treatment	**Rate/acre**	26-Sep	8-Oct	19-Oct	26-Oct	**Avg.**
Verimark	13.5 oz	0.0 a	0.0a	0.5b	0.6 d	0.3 c
Coragen +Admire Pro	5 oz + 10.4 oz	0.0 a	1.5a	3.4a	2.1 c	1.8 ab
Coragen +Wrangler	5 oz + 12 oz	0.5 a	1.1a	3.5a	3.2 bc	2.4 ab
Durivo	13 oz	0.0 a	1.6a	3.2a	2.1 c	1.6 b
Foliar Standard [a]	**-** [a]	0.5 a	2.3a	2.4ab	3.6 ab	2.2ab
Untreated check	-	0.3 a	2.1a	6.7a	4.8 a	3.9 a

		Mean SWF Large Nymphs / cm^2				
		28 DAP	**37 DAP**	**43 DAP**	**50 DAP**	
Treatment	**Rate/acre**	3-Oct	12-Oct	19-Oct	26-Oct	**Avg.**
Verimark	13.5 oz	0.0a	0.6a	0.0d	0.5ab	0.3bc
Coragen +Admire Pro	5 oz + 10.4 oz	0.0a	0.2a	0.3bc	0.2b	0.2c
Coragen +Wrangler	5 oz + 12 oz	0.0a	0.3a	0.3bc	0.1b	0.2c
Durivo	13 oz	0.0a	0.0a	0.9ab	0.8a	0.4b
Foliar Standard [a]	**-** [a]	0.1a	0.2a	0.2cd	0.1b	0.1c
Untreated check	-	0.1a	0.9a	1.8 a	1.1a	1.0a

Treatment	Rate/acre	Mean CL larvae / 10 plants				
		14 DAP 20-Sep	21 DAP 27-Sep	28 DAP 4-Oct	35 DAP 11-Oct	42 DAP 18-Oct
Verimark	13.5 oz	0.0a	0.0a	0.0a	1.5 c	5.0 ab
Coragen +Admire Pro	5 oz + 10.4 oz	0.0a	0.0a	0.0a	4.1 b	10.0 a
Coragen +Wrangler	5 oz + 12 oz	0.0a	0.0a	0.0a	7.2 a	9.0 a
Durivo	13 oz	0.0a	0.0a	0.0a	1.6 c	5.5 ab
Foliar Standard [a]	- [a]	0.0a	0.0a	0.0a	0.6 c	2.5 b
Untreated check	-	0.0a	0.0a	1.3a	6.6 ab	9.0 a

Treatment	Rate/acre	Mean BAW larvae / 10 plants				
		14 DAP 20-Sep	21 DAP 27-Sep	28 DAP 4-Oct	35 DAP 11-Oct	42 DAP 18-Oct
Verimark	13.5 oz	0.2 b	0.0 b	0.0 b	0.0a	0.0c
Coragen +Admire Pro	5 oz + 10.4 oz	0.0 b	0.0 b	0.0 b	0.9a	2.0 bc
Coragen +Wrangler	5 oz + 12 oz	0.3 b	0.0 b	0.0 b	1.3a	6.0 ab
Durivo	13 oz	0.1 b	0.0 b	0.0 b	0.3a	2.5 bc
Foliar Standard [a]	- [a]	1.5 a	0.0 b	0.9 b	0.0a	3.0 b
Untreated check	-	1.5 a	3.8 a	7.5 a	1.6a	8.5 a

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

[a] 1st spray (19 Sep-Proclaim 5SG, 3.6 oz/acre + Brigade 2EC, 5.0 oz/); 2nd Spray (4 Oct - Radiant SC, 5 oz/acre +Movento 2SC, 5 oz/acre)

II. Efficacy against Aphids

<u>Foliar Trial I</u>

Control Of Green Peach Aphid with Closer Insecticide, Spring 2013

The Objective of this study was to evaluate the efficacy of several conventional and experimental insecticide compounds against aphids in lettuce tested under desert growing conditions. Head Lettuce was direct seeded into double row beds on 42 inch centers on 19 Jan, 2012. 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 table. Two foliar sprays were applied on 5 and 20 Feb as a broadcast application delivered through 2 TXVS-18 ConeJet nozzles per bed at 25 gpa and 40 psi. Evaluations of green peach aphid (GPA) populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sample date, five 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 live 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.

GPA population pressure was heavy during the trial. All spray treatments significantly reduced GPA numbers at each sample interval relative to the untreated check for 14 days. Among the treatments, Movento and Closer appeared to provide the most consistent control. Following the 2nd application, again all spray treatments significantly reduced GPA numbers relative to the untreated check for 14 days, and by 21 DAT only Sivanto failed to provide significant control. Overall, Closer provided the best knockdown control at 3 DAT each application largely due to its contact activity. In contrast, Movento provided the best residual control following both sprays due to its systemic activity. Closer will be available for use against aphids on lettuce in the 2013-2014 growing season and will be a good alternative for use with Movento.

		Mean green peach aphids / plant			
Treatment	**Rate/ac**	***3-DAA1***	***7-DAA1***	***11-DAA1***	***14-DAA1***
Torac 15EC	21 oz	37.2b	14.6bc	41.0b	27.8b
Torac 22SC	14.2 oz	22.5bc	17.8b	28.0bc	39.8bc
NNI 0101	3.2 oz	7.2de	5.8cde	11.3cde	22.2bc
NNI 0101	2.4 oz	13.9bcd	5.0cde	15.0cd	23.6bc
Closer	2.0 oz	3.5ef	3.3de	6.5de	8.7c
Closer	1.5 oz	2.4f	2.5e	11.2cde	13.4bc
Exirel	20 oz	7.2de	9.1cd	23.5bc	25.4bc
Sivanto	7 oz	6.1de	7.8bcde	34.8bc	26.3b
Movento	5 oz	9.5cd	2.7e	4.6e	3.4d
UTC		104.2a	133.2a	164.9a	248.8a

Treatment	Rate/ac	Mean green peach aphids / plant				
		3-DAA2	***7-DAA2***	***14-DAA2***	***21-DAA2***	**Avg.**
Torac 15EC	21 oz	20.5bc	39.7bc	184.2b	172.2bc	67.1b
Torac 22SC	14.2 oz	40.7b	79.1b	147.6bc	150.1cd	65.7bc
NNI 0101	3.2 oz	20.7bc	26.4c	114.7bc	134.1cde	42.8e
NNI 0101	2.4 oz	16.6bc	30.7bc	132.9bc	152.3cd	48.7de
Closer	2.0 oz	3.6d	7.9d	45.4d	87.0e	20.7f
Closer	1.5 oz	2.3d	9.4d	28.8d	98.1e	21.0f
Exirel	20 oz	9.4c	46.7bc	87.7c	189.4bc	49.4de
Sivanto	7 oz	14.6bc	42.5bc	168.6b	267.5ab	71.0cd
Movento	5 oz	15.8bc	11.3d	18.7e	16.6f	10.3f
UTC		239.9a	360.0a	710.3a	436.3a	299.7a

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

Soil/Foliar

Aphid Control on Head Lettuce Using Imidacloprid And Foliar Insecticides, Spring 2013

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 ($P \le 0.05$). Actual non-transformed means are presented in the tables.

Aphid pressure was light in this trial and the aphid complex consisted predominantly of *green peach aphids* 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 about 10% of the heads contaminated, whereas all other treatments had significantly less contamination . In this trial, two applications of Closer, a new insecticide tat is currently registered on lettuce, 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.

Soil Treatment	Foliar Treatment	*Mean Aphids per Head*	*% Heads infested with > 5 aphids*
Admire Pro	-	1.29 b	10.0 ab
Admire Pro	Movento	0.58 c	0.0 b
Admire Pro	Closer	0.33 c	0.0 b
-	Movento	0.04 c	0.0 b
-	Closer	0.08 c	0.0 b
Untreated	-	5.13 a	25.0 a

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

III. Efficacy against Western Flower Thrips

<u>Trial I</u>

Thrips control on Lettuce with Lannate Tank-Mixtures, Spring 2013

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 7 Dec, 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 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. Two foliar sprays were applied on 4 and 17 Feb. The applications were made with a CO_2 operated boom sprayer that delivered a broadcast application at 40 psi and 20 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 Western flower thrips (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+Warrior and Radiant) and the other Lannate tank-mixtures significantly reduced adult WFT numbers relative to the untreated check. A similar response was observed for the larvae. Only the Movento treatment failed to provide significant activity against adults, and only marginal control of larvae. Among the Lannate tank-mixtures, the Lannat+Torac provided the most consistent control of adults and larvae. Previous studies have shown that Torac can be a reliable stand lone product for thrips, and based on this trial may be a viable alternative to pyrethroids for tank-mixtures with Lannate for effective WFT control in head lettuce.

		Adult WFT / Plant							
Treatment	**Rate**	**7-Feb**	**11-Feb**	**15-Feb**	**20-Feb**	**23-Feb**	**28-Feb**	**4-Mar**	**Avg.**
Radiant	7 oz	0.7b	0.2d	1.2c	0.7bc	1.2bcd	1.7b	2.0cde	1.1bc
Entrust SC	7 oz	0.7b	0.6bc	1.5c	1.2b	1.7b	1.9b	4.8bc	1.8b
Lannate+ Torac	0.75 lb + 21 oz	0.5b	0.3cd	1.3c	0.5bc	0.8d	0.9b	1.1e	0.7c
Lannate+Warrior II	0.75 lb + 1.9 oz	0.6b	0.2d	1.0c	0.6bc	1.4bc	1.5b	2.7cd	1.1bc
Lannate+Athena	0.75 + 17 oz	0.7b	0.3cd	1.1c	0.9bc	0.7cd	0.9b	2.6cd	1.0bc
Lannate+Leverage	0.75 + 3 oz	0.8b	0.4cd	1.5bc	0.5c	1.2bcd	1.1b	2.0de	1.1bc
Movento	2 qts + 5 oz	2.1a	1.4b	3.2ab	4.1a	5.5a	6.1a	8.8ab	4.4a
UTC		3.2a	3.5a	5.0a	4.6a	9.4a	5.7a	10.3a	5.9a

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

		WFT Larvae / Plant							
Treatment	**Rate**	**7-Feb**	**11-Feb**	**15-Feb**	**20-Feb**	**23-Feb**	**28-Feb**	**4-Mar**	**Avg.**
Radiant	7 oz	2.1a	0.6d	1.1d	0.5d	0.6d	0.3c	0.4d	0.8g
Entrust SC	7 oz	2.5a	1.1cd	2.8bc	2.4b	1.4c	1.0bc	4.3b	2.2c
Lannate+ Torac	0.75 lb + 21 oz	1.3a	1.6bc	2.2cd	1.0c	0.9cd	0.5bc	0.4d	1.1ef
Lannate+Warrior II	0.75 lb + 1.9 oz	2.7a	2.0abc	2.2cd	0.8cd	1.1cd	0.7bc	1.1c	1.5de
Lannate+Athena	0.75 + 17 oz	1.7a	0.5d	1.3cd	1.0c	1.2cd	0.3c	0.7cd	0.9fg
Lannate+Leverage	0.75 + 3 oz	2.9a	1.8bc	3.1bc	0.8cd	1.4c	1.5b	1.1c	1.8cd
Movento	2 qts + 5 oz	2.9a	3.2ab	6.6ab	3.0b	4.2b	1.1b	0.8cd	3.1b
UTC		4.4a	4.7a	8.3a	11.2a	21.4a	18.0a	39.2a	15.3a

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

Trial II

Control Of Western Flower Thrips with Torac on Head Lettuce, Spring 2013

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 27 Nov, 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 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. Three foliar sprays were applied on 1, 13 and 26 Feb. The applications were made with a CO_2 operated boom sprayer that delivered a broadcast application at 40 psi and 20 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 log transform (mean+1) and subjected to ANOVA; 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 tank mixtures and Torac alone treatments. However, by 7 DAT2 the Torac mixtures treatment provided significantly better control than the Torac alone. When averaged across all sample dates, WFT adult numbers in the Torac-only treatment were significantly higher than in the Torac mixtures. The Torac+Lannate and Torac+Radiant treatments provided more consistent control of WFT larvae than the Torac treatment applied alone (Table 2). When averaged across all sprays and sample dates, the Torac-alone treatment was not different from the Torac+Warrior treatment, but did not provide control comparable the other mixtures. As a stand-alone treatment Torac provides significant activity against adult WFT comparable to the pyrethroid. However, when used in combination with Lannate or Radiant , it provided enhanced control of WFT larvae comparable to the standard Lannate+Warrior II mixture presently used by desert lettuce growers.

		WFT Adults/ Plant							
		3-DAA1	***7-DAA1***	***11-DAA1***	***3-DAA2***	***7-DAA2***	***10-DAA2***	***3-DAA3***	***7-DAA3***
Treatment	**Rate**	4-Feb	8-Feb	12-Feb	16-Feb	20-Feb	23-Feb	1-Mar	5-Mar
Torac	21 oz	1.1bc	1.3b	1.1bcd	1.1bc	1.7bc	3.7bcd	4.5bc	10.1b
Torac+Warrior	21 + 1.9 oz	0.9bcd	0.7b	0.7cd	0.7cd	0.8de	1.9de	3.2bcd	5.6c
Torac+Radiant	21 + 7 oz	1.0bcd	0.7b	1.0bcd	1.0bc	0.6de	1.7de	2.0def	5.2cd
Torac+Lannate	21 + 0.75 lb	0.6cd	1.2b	0.4d	0.6cd	0.8de	1.8cde	2.3cde	4.0cd
Radiant	7 oz	1.1bcd	1.1b	1.1bcd	0.7cd	1.2bcd	1.7de	1.6ef	4.9cd
Warrior+Lannate	0.75 lb + 1.9 oz	0.5d	0.7b	0.5d	0.4d	0.4e	1.1e	1.1f	3.5d
UTC		3.3a	2.9a	3.1a	3.8a	4.3a	7.9a	8.8a	17.5a

Treatment	Rate	WFT Larvae / Plant							
		3-DAA1	***7-DAA1***	***11-DAA1***	***3-DAA2***	***7-DAA2***	***10-DAA2***	***3-DAA3***	***7-DAA3***
		4-Feb	8-Feb	12-Feb	16-Feb	20-Feb	23-Feb	1-Mar	5-Mar
Torac	21 oz	9.8ab	11.4ab	11.0ab	8.9bc	7.1ab	6.3bc	1.1cd	4.3c
Torac+Warrior	21 + 1.9 oz	6.5bc	9.3ab	6.5b	4.8c	2.8bc	4.5c	1.4c	2.3c
Torac+Radiant	21 + 7 oz	8.5ab	3.7cd	1.6c	1.7d	0.8d	0.9d	0.7cd	0.2d
Torac+Lannate	21 + 0.75 lb	4.6c	2.3d	1.8c	1.8d	1.2cd	1.1d	0.4de	0.6d
Radiant	7 oz	6.0bc	4.3cd	2.0c	1.5d	0.9d	1.5d	0.8cd	0.6d
Warrior+Lannate	0.75 lb + 1.9 oz	4.9bc	4.3cd	2.1c	2.3d	1.5cd	1.1d	0.2e	0.2d
UTC		16.3a	19.3a	19.5a	19.3a	16.3a	16.4a	18.3a	31.7a

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

Trial III

Comparison of Lannate with a generic methomyl (Nudrin) for Thrips in Lettuce, Spring 2013. The objective of the trial was to compare the efficacy of two methomyl formulations relative to industry standards for control of western flower thrips on lettuce under desert growing conditions. Head lettuce was direct seeded on 24 Jan, 2013 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. Three foliar sprays were applied on 5, 13 and 25 Mar. The applications were made with a CO_2 operated boom sprayer that delivered a broadcast application at 40 psi and 20 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 (DAA). 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 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. Nudrin is a generic methomyl formulated identically to Lannate SP. There was concern that because Nudrin (manufactured by Rotam NA, Inc) is made in China it would be of inferior quality to Lannate. However, after the product was applied 3 times alone and in combination with pyrethroid and Torac, our results show that it statistically provided the same level of thrips control as Lannate. Overall, the Lannate and Nudrin treatments provided adult control comparable to the Radiant and Torac mixtures, but not as efficacious against larvae as the Radiant treatments.

1st Application

		WFT / Plant			
		3 DAT		7 DAT	
Treatment	**Rate**	**Adult**	**Larvae**	**Adult**	**Larvae**
Nudrin SP	0.75 lbs	1.0b	1.9b	4.5b	11.9bc
Lannate SP	0.75 lbs	0.5b	2.4b	4.4b	11.5bc
Requiem+Movento	2 qts + 5 oz	5.0a	7.0a	8.2a	14.1ab
Torac+Movento	21 +5 oz	0.9b	1.4b	3.0b	7.2c
Radiant	7 oz	0.6b	0.6c	3.4b	1.5d
UTC		7.1a	12.8a	10.3a	23.0a

2nd Application

		WFT / Plant					
		3 DAT		7 DAT		10 DAT	
Treatment	**Rate**	**Adult**	**Larvae**	**Adult**	**Larvae**	**Adult**	**Larvae**
Nudrin+Warrior	0.75 +1.9 oz	3.5b	2.8c	20.3b	10.9b	36.9c	12.3b
Lannate+Warrior	0.75 +1.9 oz	3.7b	3.7bc	21.0b	12.1b	33.9c	9.0bc
Requiem+Movento	2 qts + 5 oz	10.3a	9.8b	48.2a	7.2bc	69.6a	7.5bc
Torac+Movento	21 + 5 oz	4.1b	3.4c	21.8b	3.8c	54.0ab	5.4c
Radiant	7 oz	5.0b	0.4d	17.75b	0.8d	45.6bc	2.1d
UTC	-	13.9a	42.5a	43.9a	143.7a	57.0ab	98.4a

3rd Application

		WFT / Plant					
		3 DAT		7 DAT		Trial Avg.	
Treatment	**Rate**	**Adult**	**Larvae**	**Adult**	**Larvae**	**Adult**	**Larvae**
Nudrin+Torac	0.75 + 21 oz	27.0c	16.0bc	20.0a	20.3d	16.2c	10.9c
Lannate+Torac	0.75 +21 oz	28.5c	9.0c	24.0a	29.0cd	16.6c	10.9c
Requiem+Torac	2 qts + 21 oz	48.0ab	24.5b	33.5a	87.0b	31.8b	22.4b
Mustang+Torac	4 oz +21 oz	33.0bc	16.0bc	30.0a	53.5bc	20.1c	13.1c
Radiant+Torac	7 oz+ 21 oz	33.0bc	8.5c	26.0a	16.5d	18.8c	4.3d
UTC	-	72.5a	212.5a	70.2a	272.5a	39.3a	115.0a

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