Arizona Department of Agriculture
AILRC Grants Program – Final Report for 2016
Project 16-03

Project title: **Insect Management in Desert Head Lettuce**

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Location of Research: Yuma Valley Agricultural Center

Objective: *To continue to compare the knockdown and residual efficacy of several new insecticides for* thrips, aphids, whiteflies and worms *control relative to the industry standards currently used in desert head lettuce production.*

Availability of cost-effective insecticides is very important in the production of desert lettuce. Fortunately, new insecticides continue to be developed that have a fit for insect control in desert head lettuce. This is extremely important given the recent losses of a number of important insecticides (i.e., Sequoia, Belt) and the restrictions in the uses neonictinoids expected 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. We continue to explore use patterns for existing products as well initiate research to determine how these new chemistries fit into existing insect management programs in our unique desert cropping system.

Key insecticides currently available for control of lettuce insect pests 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, Belt 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 have recently been or are currently under development that provides a wide spectrum of activity against many key insect pests**.** 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.

With the growth in organic lettuce production in desert lettuce, we have begun to study organically approved products for insect control and particularly for aphids. Although numerous organically-allowed (OMRI approved) biopesticides are registered for insect control, there is much uncertainty among growers and PCAs whether the products will actually control insects as advertised. Many of the biopesticide manufacturer's claim that their organic products will safely provide broad spectrum insect control that is "as good as or better" than conventional pesticides. Many local PCAs and organic growers are skeptical of these claims because local scientific information to support the manufactures claims is not currently available. In 2016-2017, will focus on determine the relative performance the key products (Entrust, Pyganic, M-Pede, Aza-Direct, Grandevo and Captiva) against worms, aphids and thrips. Spray timing, spray frequency and tank mixtures will also be evaluated.

This project is an on-going project and a continuation of the proposal submitted to the AILRC in 2015. Below are the results of a number of field trials conducted in fall of 2015 and spring 2016 that evaluated the efficacy of the new insecticide active ingredients shown in the figure above including lepidopterous larvae (beet armyworm and cabbage looper), sweet potato whiteflies, thrips and aphids, both for conventional and organic head lettuce.

I. Organically-Allowed Insecticide Alternatives For Beet Armyworm And Thrips Control In Head Lettuce

Methods: The objective of this trial was to compare the efficacy of foliar insecticide alternatives currently used in conventional lettuce production under fall growing conditions. Head lettuce 'El Guapo' was direct seeded into double row beds on 42 inch centers on 18 Sep, 2015. 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 sprays were applied on 6, 16 Oct and 2 Nov with a CO_2 pressurized boom sprayer that delivered a broadcast application through two TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 gpa. Various adjuvants were applied with the spray treatments at 0.25% vol/vol (see tables). At various intervals after treatment (DAT), 10 plants were randomly selected from each replicate and destructively sampled for the presence of BAW. Control was based on the examination of whole plants for presence of large (2^{nd} or > instar) larvae. Following the third application, plants were sampled for WFT by removing 5 plants per replicate 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, BAW and CL data were transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary: Entrust was clearly the most consistently efficacious product for BAW in this trial (Table 1). The addition of a specific adjuvant did not have a significant influence on performance, although Nu-Film P appeared to prolong residual control following the 2^{nd} application. The two Bt products, Xentari and Dipel, and the botanical Grandevo did significantly reduce BAW after the first two sprays compared to the check, but were not as efficacious as the Entrust treatments. They did not provide significant activity following the third spray. Xentari is advertised as a Bt that will provide better control of BAW compared to other Bt products. However, in this trial we found that it did not significantly control BAW any better than Dipel or Grandevo. Grandevo was also disappointing as it was advertised to be effective on BAW. At harvest the Entrust treatments all provided good protection from contamination, whereas, the Bt products and Grandevo had larval contamination levels exceeding 10% (Table 2). As for thrips, the addition of M-Pede to Entrust provided the most consistent control of adults and larvae. As expected the Bt did not control thrips, as it is selective for Lepidopterous larvae. Grandevo did not control thrips either, contrary to the manufacture's claims (Table 3).

Table 1.

Treatment	Rate/ac	BAW larvae / 10 Plants						
		3 DAA-1	***6 DAA-1***	***9 DAA-1***	***3 DAA-2***	***7 DAA-2***	***11 DAA-2***	***14 DAA-2***
Entrust SC +Oroboost	5 oz+0.25%	0.0b	0.0d	0.0b	0.0a	0.0c	0.9a	0.3cd
Entrust SC +M-Pede	5 + 2%	0.0b	0.0d	0.0b	0.0a	0.0c	0.0a	0.9bcd
Entrust SC +Mantis	5 +1 pt	0.0b	0.0d	0.0b	0.0a	0.0c	0.0a	0.9bcd
Entrust SC +Nufilm-P	5 oz+0.25%	0.3b	0.0d	0.0b	0.4a	0.0c	0.6a	0.0d
Dipel DF+NufilmP	2 lb+0.25%	0.9ab	2.2bc	0.6ab	0.0a	0.3bc	3.8a	5.9a
Xentari+NuFilm P	2 lb+0.25%	1.9ab	0.9cd	0.9ab	0.0a	0.0	1.9a	3.1abc
Grandevo+NuFilm P	3 lbs+0.25%	1.6ab	5.3ab	0.6ab	0.4a	1.3b	1.9a	3.8ab
Untreated	-	3.4a	5.9a	2.2a	1.3a	3.4a	4.1a	5.6a
	F	*6.51*	*17.18*	*5.95*	*0.81*	*12.83*	*1.66*	*9.23*
	P>F	*0.0004*	*<.0001*	*0.0007*	*0.59*	*<.0001*	*0.17*	*<.0001*

Table 1. continued

Treatment	Rate/ac	*BAW larvae / 10 Plants*				
		3 DAA-3	***7 DAA-3***	***11 DAA-3***	***14 DAA-3***	**Trial Avg.**
Entrust SC +Oroboost	5 oz+0.25%	1.6ab	0.6a	0.0b	0.6a	0.4c
Entrust SC +M-Pede	5 + 2%	2.5ab	0.9a	0.0b	0.3a	0.3c
Entrust SC +Mantis	5 +1 pt	1.6ab	0.3a	0.0b	0.6a	0.2c
Entrust SC +Nufilm-P	5 oz+0.25%	1.2b	0.3a	0.0b	0.0a	0.2c
Dipel DF+NufilmP	2 lb+0.25%	5.6ab	0.6a	1.3ab	0.6a	1.7b
Xentari+NuFilm P	2 lb+0.25%	3.1ab	1.9a	2.2ab	1.9a	1.5b
Grandevo+NuFilm P	3 lbs+0.25%	3.5ab	2.8a	2.2ab	1.3a	2.1b
Untreated	-	7.5a	3.8a	2.8a	2.5a	3.7a
	F	*3.28*	*2.21*	*5.19*	*2.34*	*27.48*
	P>F	*0.02*	*0.08*	*0.002*	*0.06*	*<.0001*

Table 2.

Harvest (7 DAA-4)		*25-Nov*		
		% Contaminated Heads		
Treatment	**Rate/ac**	**Damage**	**Frass**	**BAW larvae**
Entrust +Oroboost	5 oz+0.25%	5.0bc	10.0bc	2.5c
Entrust +M-Pede	5 + 2%	2.5c	0.0c	0.0c
Entrust +Mantis	5 +1 pt	0.0c	2.5c	0.0c
Entrust +Nufilm-P	5 oz+0.25%	2.5c	2.5c	0.0c
Dipel +NufilmP	2 lb+0.25%	15.0bc	10.0bc	10.0b
Xentari +NuFilm P	2 lb+0.25%	8.0bc	10.0bc	10.0b
Grandivo +NuFilm P	3 lbs+0.25%	30.0ab	22.5ab	15.0b
Untreated	-	65.0a	52.5a	40.0a
	F	*14.08*	*10.72*	*26.84*
	P>F	*<.0001*	*<.0001*	*<.0001*

Table 3.

		WFT / Plant					
		3 DAA-3		***7 DAA-3***		***11 DAA-3***	
Treatment	**Rate/ac**	**Adults**	**Larvae**	**Adults**	**Larvae**	**Adults**	**Larvae**
Entrust SC +Oroboost	5 oz+0.25%	1.7de	4.0cd	4.5ab	6.3bc	2.2cd	10.9a
Entrust SC +M-Pede	5 + 2%	1.1e	2.0d	1.4c	2.5d	1.7d	3.4c
Entrust SC +Mantis	5 +1 pt	2.1cd	2.7cd	4.0ab	5.7c	3.6bc	5.6bc
Entrust SC +Nufilm-P	5 oz+0.25%	2.7bcd	4.2bc	3.0b	7.0b	3.2bc	7.4ab
Dipel DF+NufilmP	2 lb+0.25%	4.1ab	10.0a	5.7a	12.0a	5.5a	12.1a
Xentari+NuFilm P	2 lb+0.25%	6.2a	10.4a	5.5a	14.3a	4.3ab	11.8a
Grandevo+NuFilm P	3 lbs+0.25%	4.6a	7.5ab	4.9ab	12.7a	3.9ab	10.8a
Untreated	-	3.5abc	8.5ab	5.0ab	14.1a	4.7ab	12.8a
	F	*8.12*	*6.22*	*4.96*	*9.94*	*6.93*	*5.03*
	P>F	*<.0001*	*0.0005*	*0.002*	*<.0001*	*0.0002*	*0.002*

II. Cross-Spectrum Insect Control with Conventional Tank-mixture and Exirel in Lettuce

Methods:

The objective of this trial was to evaluate the efficacy of various tank and in-can insecticide mixtures for control of major insect pests under fall growing conditions. Lettuce was direct seeded into double row beds on 42 inch centers on 8 Sep, 2015. 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. Product formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 9 and 18 Oct with a CO2 pressurized boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 gpa. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments. Beet armyworm (BAW) and CL (cabbage looper) control was based on the examination of 10 whole plants at 7 d intervals following each application (DAA) for the presence of large (2nd instar or older) larvae. Knockdown of adult Sweet potato whitefly (SWF) were estimated with leaf-turn direct counts of adults on a terminal leaf at 1, 3 and 7 DAA. On each sample date, 5 individual plants from each replicate were sampled by carefully turning over a leaf and counting the total number of adults on the leaf. Evaluations of SWF immature control was estimated by counting the number of eggs and immature life stages on two, 2-cm2 disk sections taken from 10 plants per replicate at 7 d intervals following each application. WF immature densities on each leaf disk were estimated under magnification in the laboratory. Because of heterogeneity of mean variances, data were transformed using a log10 (x + 1) function before analysis and subjected to ANOVA (Proc GLM; SAS Institute 2009). Means were compared means using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary:

Worm pressure was moderate during this trial. In this trial, Exirel and the tank-mixtures provided significantly better control of CL and BAW than the untreated check following each application (Table 1). Unfortunately, two of the worm products (Belt and Vetica) used in this trial have been cancelled by EPA and are no longer available. In terms of adult SWF control, Exirel provided the most consistent control, although it's activity was very slow following the second application (Table 2). Sivanto provided good knockdown control (1 DAA) but did not have the residual activity (7 DAA) as Exirel did. The Proclaim+Endigo and Voliam Xpress+Actara treatments were the weakest against SWF adults in the trial. Exirel was also the most consistent product against nymphs, followed by Vetica+PQZ, Belt + Sivanto, and Radiant+Scorpion (Table 3). SWF nymph numbers in the Proclaim+Endigo and Voliam Xpress+Actara treatmentsdid not significantly reduce nymphs. Overall, Exirel is an effective alternative to industry standard tank-mixtures for worm and SWF control.

Table 1.

Treatment/ formulation	Rate amt product / acre	Large Larvae / 10 plants					
		7 DAA-1		7 DAA2		14 DAA-2	
		CL	**BAW**	**CL**	**BAW**	**CL**	**BAW**
Exirel 1.6SE	15 fl oz	1.0 a	0.0b	0.0a	0.0b	1.3b	0.0b
Belt SC + Sivanto 240SL	2.4 fl oz+10.5 fl oz	0.0 a	0.0b	0.0a	0.0b	0.0b	0.1b
Proclaim 5SG+ Endigo ZC	4.0 oz+4.5 floz	1.0 a	0.0b	0.0a	0.0b	0.0b	0.0b
Voliam Xpress + Actara 25DG	9.0 fl oz + 5.5 oz	1.0 a	3.3ab	0.0a	0.0b	0.0b	0.0b
Vetica + PQZ 20SC	17 flo oz+3.2 fl oz	2.0 a	0.0b	0.0a	0.0b	0.4b	0.1b
Radiant SC+ Scorpion 35SL	5 fl oz + 7 fl oz	1.0 a	0.0b	0.0a	0.0b	0.1b	0.0b
Untreated check	-	2.0 a	5.5a	2.8a	3.5a	2.6a	2.8a
	F value	*0.95*	*14.01*	*2.14*	*10.81*	*2.83*	*3.52*
	P>F	*0.48*	*<.0001*	*0.09*	*<.0001*	*0.04*	*0.02*

Means in a column followed by the same letter are not significantly different (*P* > 0.05)

Table 2.

Treatment/formulation	Rate amt product/ acre	SWF Adults / Leaf						
		1 DAA-2	3 DAA-2	7 DAA-2	1 DAA-3	3 DAA-3	7 DAA-3	Trial Avg.
Exirel 1.6SE	15 fl oz	16.8ab	18.0b	5.0ab	1.6c	1.2b	0.8c	1.2c
Belt SC + Sivanto 240SL	2.4 fl oz+10.5 fl oz	7.9c	4.0d	4.6ab	1.7c	1.1b	1.2bc	3.1bc
Proclaim 5SG+ Endigo ZC	4.0 oz+4.5 floz	20.5ab	37.4ab	9.8ab	8.8ab	6.4a	4.0a	10.2a
Voliam Xpress + Actara 25DG	9.0 fl oz + 5.5 oz	16.1ab	34.2ab	11.1ab	5.4b	5.3a	3.5ab	8.8ab
Vetica + PQZ 20SC	17 flo oz+3.2 fl oz	12.3bc	20.6ab	3.9b	0.8c	0.6b	1.0c	2.3bc
Radiant SC+ Scorpion 35SL	5 fl oz + 7 fl oz	12.0bc	7.9c	5.2ab	0.7c	0.7b	0.4c	3.5bc
Untreated check	-	25.9a	38.5a	12.7a	19.5a	13.1a	7.3a	9.2ab
	F	*6.97*	*29.92*	*4.41*	*45.28*	*14.02*	*18.41*	*7.15*
	P>F	*0.0006*	*<.0001*	*0.007*	*<.0001*	*<.0001*	*<.0001*	*0.0005*

Means in a column followed by the same letter are not significantly different ($P > 0.05$)

Table 3.

Treatment/ formulation	Rate amt product / acre	SWF immature / cm2			
		7 DAA-2		14 DAA-2	
		Eggs	Total nymphs	Eggs	Total nymphs
Exirel 1.6SE	15 fl oz	1.2bc	0.7b	0.7b	0.2c
Belt SC + Sivanto 240SL	2.4 fl oz+10.5 fl oz	0.3c	0.9b	1.3ab	1.3bc
Proclaim 5SG+ Endigo ZC	4.0 oz+4.5 floz	4.5ab	9.7a	1.5ab	11.1a
Voliam Xpress + Actara 25DG	9.0 fl oz + 5.5 oz	6.7a	11.1a	3.3ab	5.7ab
Vetica + PQZ 20SC	17 flo oz+3.2 fl oz	2.6abc	2.1b	0.9b	0.8bc
Radiant SC+ Scorpion 35SL	5 fl oz + 7 fl oz	1.1bc	2.2b	1.2ab	1.5bc
Untreated check	-	7.4a	18.2a	6.7ab	24.6a
	F value	*7.03*	*23.45*	*3.25*	*14.68*
	P>F	*0.0004*	*<.0001*	*0.02*	*<.0001*

Means in a column followed by the same letter are not significantly different (*P* > 0.05)

III. Control of Whiteflies with New Foliar Insecticides in Head Lettuce

Methods: The objective of this trial was to evaluate the efficacy of various foliar insecticides against SWF in broccoli under fall growing conditions. Lettuce was direct seeded into double row beds on 42 inch centers on 8 Sep, 2015. 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. Product formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 7 and 16 Oct with a CO_2 pressurized boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 gpa. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments. Adult Sweet potato whitefly (SWF) were estimated using a modified vacuum method that employed a 2- gallon portable vacuum (DeWALT, Baltimore, MD) which was fitted with cloth-screened 40 Dram containers to capture and retain vacuumed adults. On each sample date, 5 individual plants from each replicate were sampled by vacuuming the terminal area of the plants for 3 s. Containers with adults were taken into the laboratory, placed in a freezer for 24 h after which the number of adults/ plant was recorded. Evaluations of immature SWF control was estimated by counting the number of eggs and nymphs on two, 2-cm^2 disk sections taken from basal leaves from 10 plants per replicate at various 7 and 14 days after the second application application (DAA). WF immature densities on each leaf disk were estimated under magnification in the laboratory. Because of heterogeneity of mean variances, data were transformed using a log10 (x-1) function before analysis. All data were subjected to ANOVA; means were compared using Turkey's HSD test (P=0.05). Means from nontransformed data are presented in the tables.

Summary:

Averaged across the two applications, Sivanto, Exirel and Venom provided the best knockdown of SWF adults (Table 1). Although Movento provided significant control, it did not provide the same level of adult suppression as the other spray treatments. This is expected since it is an IGR-type product with systemic activity against the immature stages. Accordingly, Movento provided excellent control of immature SWF, as did the other spray treatments (Table 2). Exirel again showed that it has excellent activity against adults and nymphs comparable to the neonicotinoids. The results of this trials show that growers have several foliar alternatives for controlling adult and immature SWF on lettuce.

Table 1.

Treatment/ formulation	Rate amt product/acre	SWF Adults / Sample							
		1 DAA-1	3 DAA-1	7 DAA-1	1 DAA-2	3 DAA-2	7 DAA-2	14 DAA-2	Trial Avg.
Sivanto 240SL	10.5 fl oz	8.2b	2.1b	14.1b	0.5bc	0.5bc	2.2c	3.4ab	4.4c
Exirel 1.6SE	16 fl oz	8.2b	3.2b	9.8b	1.1b	0.3c	2.7bc	3.3b	4.0c
Movento 2F	5 fl oz	15.1ab	11.2a	19.4ab	5.3a	1.8b	3.3ab	2.5b	8.3b
Venom 70WP	4 oz	12.4ab	2.4b	12.2b	0.2cd	0.6bc	0.9d	3.4b	4.6c
Untreated	-	21.6a	22.5a	34.8a	10.0a	7.0a	6.7a	8.7a	15.9a
	F	15.85	20.41	8.25	62.99	21.11	18.01	4.91	82.62
	P>F	<.0001	<.0001	0.0002	<.0001	<.0001	<.0001	0.0039	<.0001

Means in a column followed by the same letter are not significantly different ($P > 0.05$)

Table 2.

Treatment/ formulation	Rate amt product/acre	SWF immatures / cm^2			
		7 -DAA2		14 -DAA	
		Eggs	**Total Nymphs**	**Eggs**	**Total Nymphs**
Sivanto 240SL	10.5 fl oz	1.5a	1.5b	0.9ab	0.6b
Exirel 1.6SE	16 fl oz	2.8a	1.4b	0.4b	0.8b
Movento 2F	5 fl oz	1.7a	0.9b	0.7ab	0.6b
Venom 70WP	4 oz	0.6a	2.0b	0.5ab	1.9b
Untreated check	-	3.6a	5.0a	3.3a	7.8a
	F	*3.67*	*14.59*	*4.05*	*15.89*
	P>F	*0.01*	*<.0001*	*0.009*	*<.0001*

Means in a column followed by the same letter are not significantly different ($P > 0.05$)

IV. Control of Lepidopterous Larvae with Exirel on Head Lettuce

Methods: Head lettuce ' EL Guapo' was direct seeded on 18 Sep, 2015 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 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 treatment compound are provided in the tables. Three foliar spray applications were made 10 and 20 Oct and 16 Nov with a CO_2 operated, back-pack sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi and 25.5 GPA. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% v/v with all treatments. At various intervals after treatment, plants were randomly selected from each replicate and destructively sampled for the presence of each insect species. Beet armyworm (BAW), cabbage looper (CL) and Corn earworm (CEW) control was based on the examination of whole plants for presence of small (newly hatched and 1st instar) and large (2^{nd} instar or >) larvae. Only large larvae are presented in the tables. The number of plants in each plot with fresh feeding tracks on plants was also recorded. At harvest, the marketable portions (heads+4 wrapper leaves) on 10 plants in each plot were sampled for the presence of feeding damage, frass and lep larvae. Because of heterogeneity of mean variances, data were transformed using a log10 (x-1) function before analysis. Data for percentage of plants with fresh feeding damage on leaves and percentage of contaminated heads were subjected to an arcsine transformation before analysis. All data were subjected to ANOVA; means were compared using Turkey's HSD test (P=0.05). Means from nontransformed data are presented in the tables.

Summary:

All of the products tested in this trial provided significant knockdown and residual control of BAW and CL following each application (Table 1). Evaluation of lettuce contamination at harvest (7 days following the 4^{th} application), showed that all treatments significantly reduced head contamination compared to the control (Table 2). Exirel at 15 oz performed similarly to the Exirel+Brigade treatments, both of which were comparable to the standard Radiant. The addition of a pyrethroid with Exirel did not enhance its activity. In contrast, the addition of a pyrethroid with Proclaim did enhance its activity at harvest where heads were contaminated with worms in the Proclaim (alone) and Belt treatments. These results further show that growers have several alternatives with which to manage worms in head lettuce, including the new product Exirel.

Table 1.

		Avg Largae Larvae / 10 Plants											
		3 DAA-1 13-Oct				6 DAA-1 16-Oct				10 DAA-1 20-Oct			
Treatment	**Rate/ac**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**
Exirel	15 oz	12.5b	0	0.8b	0.8b	0.0a	0	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b
Exirel + Brigade	15 + 5 oz	8.3b	0	0.8b	0.8b	0.0a	0	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b
Proclaim + Warrior	4.0 + 1.9 oz	20.8b	0	1.3ab	1.3ab	6.3a	0	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b
Proclaim	4.8 oz	12.5b	0	0.0b	0.0b	6.3a	0	0.0a	0.0a	8.3b	0.0b	0.0b	0.0b
Voliam Xpress	9 oz	12.5b	0	0.4b	0.4b	6.3a	0	0.3a	0.3a	0.0b	0.0b	0.0b	0.0b
Belt SC	2 oz	12.5b	0	0.8b	0.8b	6.3a	0	0.0a	0.0a	4.2b	0.0b	0.0b	0.0b
Radiant	5 oz	8.3b	0	0.0b	0.0b	9.4a	0	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b
UTC	-	87.5a	0	5.8a	5.8a	25.0a	0	0.6a	0.6a	41.7a	0.4a	2.9a	3.3a
	F	7.97	-	4.51	4.51	2.11	-	1.75	1.75	9.41	1.01	4.61	12.42
	P>F	<.0001	-	0.005	0.005	0.09	-	0.15	0.15	<.0001	0.46	0.003	<.0001

Table 1. cont.

		Avg Largae Larvae / 10 Plants											
		3 DAA-2 23-Oct				6 DAA-2 26-Oct				10 DAA-2 30-Oct			
Treatment	**Rate/ac**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**
Exirel	15 oz	4.2b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	0.0b
Exirel + Brigade	15 oz + 5 o	4.2b	0.0a	0.0a	0.0a	4.2b	0.0b	0.0b	0.0b	12.5b	0.4a	0.4b	0.8b
Proclaim + Warrior	4.0 + 1.9 oz	0.0b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
Proclaim	4.8 oz	4.2b	0.0a	0.4a	0.4a	8.3b	0.0b	0.0b	0.0b	8.3b	0.4a	0.0b	0.4b
Voliam Xpress	9 oz	12.5b	0.0a	0.4a	0.4a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
Belt SC	2 oz	4.2b	0.0a	0.0a	0.0a	8.3b	0.0b	0.0b	0.0b	4.2b	0.0a	0.4b	0.4b
Radiant	5 oz	4.2b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
UTC	-	50.0a	0.8a	0.8a	1.6a	66.7a	0.8a	5.0a	5.8a	83.3a	0.8a	7.9a	8.8a
	F	*6.84*	*1.01*	*1.51*	*1.73*	*13.49*	*3.01*	*8.63*	*28.31*	*13.41*	*1.71*	*28.95*	*22.67*
	P>F	*0.0003*	*0.46*	*0.22*	*0.16*	*<.0001*	*0.02*	*<.0001*	*<.0001*	*<.0001*	*0.16*	*<.0001*	*<.0001*

Table 1. cont.

		Avg Largae Larvae / 10 Plants											
		3 DAA-2 23-Oct				6 DAA-2 26-Oct				10 DAA-2 30-Oct			
Treatment	**Rate/ac**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**	**Damage**	**CL**	**BAW**	**Total**
Exirel	15 oz	4.2b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b	0.0b
Exirel + Brigade	15 oz + 5 oz	4.2b	0.0a	0.0a	0.0a	4.2b	0.0b	0.0b	0.0b	12.5b	0.4a	0.4b	0.8b
Proclaim + Warrior	4.0 + 1.9 oz	0.0b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
Proclaim	4.8 oz	4.2b	0.0a	0.4a	0.4a	8.3b	0.0b	0.0b	0.0b	8.3b	0.4a	0.0b	0.4b
Voliam Xpress	9 oz	12.5b	0.0a	0.4a	0.4a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
Belt SC	2 oz	4.2b	0.0a	0.0a	0.0a	8.3b	0.0b	0.0b	0.0b	4.2b	0.0a	0.4b	0.4b
Radiant	5 oz	4.2b	0.0a	0.0a	0.0a	0.0b	0.0b	0.0b	0.0b	4.2b	0.0a	0.0b	0.0b
UTC	-	50.0a	0.8a	0.8a	1.6a	66.7a	0.8a	5.0a	5.8a	83.3a	0.8a	7.9a	8.8a
	F	*6.84*	*1.01*	*1.51*	*1.73*	*13.49*	*3.01*	*8.63*	*28.31*	*13.41*	*1.71*	*28.95*	*22.67*
	P>F	*0.0003*	*0.46*	*0.22*	*0.16*	*<.0001*	*0.02*	*<.0001*	*<.0001*	*<.0001*	*0.16*	*<.0001*	*<.0001*

Table 2.

Harvest (8 DAA-3)	*24-Nov*						
		% Contaminated Heads					
Treatment	**Rate/ac**	**Damage**	**Frass**	**CL**	**BAW**	**CEW**	**Total larvae**
Exirel	15 oz	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b
Exirel + Brigade	15 oz + 5 oz	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b
Proclaim + Warrior	4.0 + 1.9 oz	0.0.b	0.0b	0.0b	0.0b	0.0a	0.0b
Proclaim	4.8 oz	2.5a	2.5b	2.5ab	0.0b	0.0a	2.5b
Voliam Xpress	9 oz	2.5b	0.0b	0.0b	0.0b	0.0a	0.0b
Belt SC	2 oz	7.5b	5.0b	0.0b	0.0b	5.0a	5.0b
Radiant	5 oz	0.0b	0.0b	0.0b	0.0b	0.0a	0.0b
UTC	-	40.0a	30.0a	7.5a	10.0a	5.0a	22.5a
	F	*14.87*	*15.01*	*4.81*	*7.95*	*1.01*	*12.97*
	P>F	*<.0001*	*<.0001*	*0.002*	*<.0001*	*0.46*	*<.0001*

VI. Control of Aphids with Organically -Allowed Insecticides

Methods: Lettuce was planted on 42 inch beds on 21 Dec, 2015. Stands were established with sprinkler irrigation and irrigated with furrow irrigation thereafter. Plots were arranged in a randomized complete block design with 4 replications. Formulations and rates for each compound are provided in the tables. Three applications were made on 3, 14 and 20 March, with the exception of Beleaf which was only applied twice on 3 and 20 Mar. The foliar sprays were applied with a CO_2 operated boom sprayer at 50 psi and 25 gpa. A broadcast application was delivered through 4 TX-18 ConeJet nozzles per bed. No adjuvants were applied to any of the treatments. Green peach aphid (GPA) populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sampling date, 10 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 (non-winged) aphids present. Because of heterogeneity of mean variances, data were transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the table.

Summary: Aphid pressure was low in this trial but differences among treatments were observed. Following each application, none of the biopesticides provided significantly better control than the untreated check except for Aza-Direct at 5 DAA-2 (Table 1). When averaged across sample evaluations, all of the insecticide treatments had significantly fewer aphids then the untreated control. Aphid numbers were lowest in the conventional standard Beleaf treatment with one less spray, and aphid numbers did not differ significantly among the biopesticide treatments. Unfortunately, the biopesticides only provided ~ 50% reduction in aphid numbers, whereas the Beleaf provided ~95% control.

Table 1.

Foliar Treatment	Rate/ac	GPA / 10 Plants 5 DAA-1 8-Mar		10 DAA-1 13-Mar		5 DAA-2 19-Mar		5 DAA-3 25-Mar		10 DAA-3 30-Mar		Trial avg.	
Aza-Direct	3.5 pt	11.5	a	14.5	a	11.5	b	7.3	a	7.3	a	10.4	b
Pyganic 5.0	17 oz	9.3	a	22.0	a	23.0	ab	11.5	a	9.3	a	15.0	b
M-Pede	2%	12.0	a	17.3	a	22.8	ab	10.8	a	10.8	a	13.1	b
PFR-97	2 lbs	8.5	a	20.8	a	24.3	ab	9.8	a	8.3	a	14.3	b
Grandivo	3 lbs	5.3	ab	17.3	a	21.8	ab	9.0	a	12.3	a	13.1	b
Azera	3.5 pt	7.0	a	22.5	a	19.3	ab	8.8	a	8.0	a	13.1	b
BugBomber	2.30%	4.5	ab	16.8	a	19.3	ab	12.8	a	6.5	a	12.0	b
Beleaf*	3.8 oz	0.3	b	0.5	b	2.8	c	1.5	b	1.8	a	1.4	c
UTC		14.3	a	36.3	a	53.0	a	10.3	a	12.5	a	25.3	a
	F	*4.36*		*26.5*		*8.17*		*3.85*		*1.99*		*26.67*	
	P>F	*0.002*		*<.0001*		*<.0001*		*0.005*		*0.09*		*<.0001*	

***Bealf only applied twice on 3 and 20 March; all other treatments applied three times**

V. Evaluation of Torac for Control of Western Flower Thrips on Lettuce

Methods:

The objective of the trial was to evaluate the efficacy of Torac, when applied alone and in combination with other insecticides, against western flower thrips on lettuce. Romaine 'S7735LD' was direct seeded on 5 Nov, 2015 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 15 and 23 Jan. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 20.8 gpa through two 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 five 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 transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary:

Thrips populations were light-moderate in this trial. Knockdown and residual control of thrips varied among treatments following each application, and all treatments significantly reduced adults when compared to the check (Table). When averaged across all sample dates, numbers of thrips in the Torac applied alone treatments did not differ from the Torac tank-mixtures and industry standards (Radiant, Lannate, Orthene). In contrast, Torac applied alone significantly reduced thrips larvae numbers compared to the check (Table 2). However, the Torac tank-mixtures and industry standards provided significantly better control of larvae than the Torac applied alone. These results show that Torac does have activity against thrips, but at a level comparable to Radiant and Lannate.

Table 1.

Treatment/ formulation	Rate amt product/acre	Adults / Plant						
		3 DAA-1	*7 DAA-1*	*3 DAA-2*	*6 DAA-2*	*11 DAA-2*	*14 DAA-2*	**Trial**
		18-Jan	**22-Jan**	**26-Jan**	**29-Jan**	**3-Feb**	**6-Feb**	**Avg.**
Torac 15C	21 oz	0.8a	0.8ab	0.6b	0.6b	0.6abc	1.6b	0.8b
Torac + Orthene 97	21+1 lb	1.0a	0.3b	0.2b	0.3b	0.3bc	1.0b	0.5b
Torac + Lannate SP	21+0.75 lb	1.5a	1.3ab	0.2b	0.6b	0.7abc	1.4b	0.9b
Torac + Radiant SC	21+5 oz	0.5a	0.5b	0.7ab	0.6b	0.6bc	2.0b	0.8b
Orthene 97	1 lb	0.5a	0.3b	0.3b	0.3b	0.2c	1.5b	0.5b
Lannate SP	0.75 lb	0.7a	0.3b	0.3b	0.3b	0.4bc	1.9b	0.7b
Radiant SC	7 oz	0.9a	0.4b	0.6b	0.7b	0.8ab	1.7b	0.8b
Untreated check		1.7a	2.7a	2.7a	2.3a	1.8a	5.2b	2.7a
	F	*1.85*	*4.77*	*5.12*	*7.03*	*6.56*	*7.31*	*14.68*
	P>F	*0.13*	*0.002*	*0.002*	*0.0002*	*0.0004*	*0.0002*	*<.0001*

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

Table 2.

Treatment/ formulation	Rate amt product/acre	Larvae / Plant 3 DAA-1 18-Jan	7 DAA-1 22-Jan	3 DAA-2 26-Jan	6 DAA-2 29-Jan	11 DAA-2 3-Feb	14 DAA-2 6-Feb	Trial Avg.
Torac 15C	21 oz	10.0ab	13.8ab	6.0ab	4.2b	1.9b	1.0b	6.1b
Torac + Orthene 97	21+1 lb	7.0ab	4.3c	1.7a	2.1bc	0.5cd	0.7b	2.4c
Torac + Lannate SP	21+0.75 lb	8.0ab	8.5abc	1.4a	1.0c	0.7bcd	0.6b	3.4c
Torac + Radiant SC	21+5 oz	9.0ab	6.5abc	2.7a	1.2bc	0.2d	0.3b	3.3c
Orthene 97	1 lb	7.5ab	6.0bc	1.7a	2.7bc	1.5bc	0.7b	3.3c
Lannate SP	0.75 lb	4.2b	4.8c	1.7a	1.4bc	0.4d	0.4b	2.1c
Radiant SC	7 oz	9.3ab	3.7c	1.5a	2.0bc	0.3d	0.5b	2.9c
Untreated check		18.8	18.9c	12.5a	16.4a	7.3a	8.1a	13.6a
	F	*3.61*	*7.71*	*3.58*	*10.31*	*19.14*	*8.99*	*22.06*
	P>F	*0.01*	*0.0001*	*0.01*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

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

VI. Evaluation of Organically-Allowed Insesticides for Control of Western Flower Thrips on Head Lettuce

Methods: The objective of the trial was to evaluate the efficacy of several organically-allowed insecticides against western flower thrips under desert growing conditions. Head lettuce 'Domingos 67' was direct seeded on 5 Nov, 2015 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. Four foliar sprays were applied 31 Jan, 10, 16, and 26 Feb. The Entrust +M-Pede treatment only received M-Pede (2%) on the 3rd spray date. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 25 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Silwet, was applied at 0.125% to all treatments. Numbers of WFT from five 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 transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary:

WFT populations were light-moderate in this trial. Among the organically-allowed biopesticides evaluated, only the Entrust+M-Pede treatment provided consistently significant control of WFT adults and larvae following each application (Table 1 and 2). The other biopesticides were not effective against the adult WFT, but were somewhat more efficacious against the WFT larvae. In particular, AZA-Direct and Azera (Neem/Azadirachtin compounds) provided significantly better control than the check, but not as effective as the Entrust+M-Pede. Several products appeared to be ineffective against the larvae including Pyganic, PFR-97, Grandivo and BugBomber. Based on the manufacturers recommendation's, Grandivo and Pyganic have WFT activity, however this trial suggest they are not effective alternatives for WFT on lettuce.

Table 1.

		Adults / Plant									
		6 DAA-1		**6 DAA-2**		**6 DAA-3**		**6 DAA-4**		**Trial**	
Treatment	**Rate**	**8-Feb**		**16-Feb**		**23-Feb**		**3-Mar**		**Avg.**	
Entrust+M-Pede	5 oz+2 %	1.0	a	1.4	b	9.0	b	14.1	c	6.4	b
Aza-Direct	3.5 pts	1.2	a	5.7	a	14.8	ab	24.7	ab	11.6	a
Pyganic	17 oz	2.0	a	4.4	a	14.5	ab	19.5	abc	10.1	a
Azera	3 pts	2.2	a	5.3	a	17.2	a	22.9	ab	11.9	a
PFR-97	2 lbs	2.4	a	5.3	a	17.4	a	20.5	abc	11.4	a
Grandivo	3 lbs	1.2	a	5.5	a	14.4	ab	23.4	ab	11.1	a
BugBomber	2.3%	2.0	a	4.4	a	13.6	ab	30.1	a	12.5	a
PFR-97+Aza-Direct	2lbs + 3.5 pts	1.9	a	4.8	a	13.5	ab	17.2	bc	9.3	a
Untreated	-	1.7	a	5.6	a	16.1	a	21.4	abc	11.2	a
	F value	*1.29*		*8.68*		*3.36*		*4.63*		*16.51*	
	P>F	*0.29*		*<.0001*		*0.01*		*0.002*		*<.0001*	

Table 2.

Treatment	Rate	Larvae / Plant *6 DAA-1* 8-Feb		6 DAA-2 16-Feb		6 DAA-3 23-Feb		6 DAA-4 3-Mar		Trial Avg.	
Entrust+M-Pede	5 oz+2 %	0.5	b	0.2	b	0.7	d	3.3	d	1.2	d
Aza-Direct	3.5 pts	2.2	a	1.8	a	5.2	c	10.0	c	4.8	c
Pyganic	17 oz	3.8	a	3.2	a	11.7	ab	39.7	ab	14.6	abc
Azera	3 pts	2.5	a	3.5	a	5.9	bc	14.8	bc	6.6	bc
PFR-97	2 lbs	2.5	a	2.5	a	10.3	abc	34.2	ab	12.4	ab
Grandivo	3 lbs	2.7	a	3.9	a	8.7	bc	38.0	a	13.3	ab
BugBomber	2.3%	1.6	ab	2.8	a	5.8	bc	30.8	ab	10.2	abc
PFR-97+Aza-Direct	2lbs + 3.5 pts	2.3	a	1.9	a	6.2	bc	12.8	bc	5.8	bc
Untreated	-	3.9	a	3.0	a	19.7	a	49.3	a	19.0	a
	F value	*5.26*		*8.11*		*33.05*		*18.01*		*43.63*	
	P>F	*0.0007*		*<.0001*		*<.0001*		*<.0001*		*<.0001*	

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

VII. Evaluation of Entrust and Aza-Direct for Control of Western Flower Thrips on Lettuce

Methods:

The objective of the trial was to evaluate the efficacy of Entrust and AZA-Direct, applied alone and in combination with other compounds, against western flower thrips under desert growing conditions. Romaine' Solid King' was direct seeded on Jan 25, 2015 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 the treatments are provided in the tables. Two foliar sprays were applied 9 and 16 Mar. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. No adjuvants were applied to the treatments. Numbers of western flower thrips (WFT) from five 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 transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary:

WFT populations were moderate in this trial. The results showed variable activity against adult in knockdown and residual control. The combination of Entrust+M-Pede, and to a lesser extent Entrust+Pyganic, provided the most consistent control of Adult WFT (Table 1). The Entrust-alone and AZA-Direct treatments did not provide significant control of WFT adults. The AZA-Direct treatments were more active against the immature WFT; however, they did not control WFT larvae as effectively as the Entrust treatments (Table 2). Among the Entrust treatments, the Entrust-tank mixtures were significantly better than the Entrust-alone for controlling WFT larvae.

Table 1.

Treatment/Formulation	Rate-amt product / ac	WFT Adults / Plant						
		3 DAA1 12-Mar	**7 DAA1** 16-Mar	**3 DAA2** 19-Mar	**7 DAA2** 23-Mar	**11 DAA2** 27-Mar	**14 DAA2** 31-Mar	**Trial Avg**
AzaDirect	2.5 pts	21.3a	37.8a	26.1a	39.0a	46.2a	41.7a	35.3ab
AzaDirect+M-Pede	2 pts + 2%	22.8a	36.6a	30.5a	41.7a	53.1a	35.4a	36.7ab
AzaDirect+Captiva	2 pts + 8 oz	19.8a	32.4a	31.8a	27.9a	40.5a	27.0a	29.9ab
Aza-Direct+Pyganic 5.0EC	2 pts + 17 oz	25.8a	37.8a	43.5a	43.2a	59.1a	38.4a	41.3a
Entrust SC	7 oz	20.5a	30.9a	16.2ab	28.8a	60.9a	36.6a	32.3ab
Entrust SC+M-Pede	6 oz + 2 %	2.4c	26.7a	6.9b	14.7a	33.9a	37.5a	20.4c
Entrust SC+Captiva	6 oz + 8 oz	15.0ab	38.7a	18.9ab	23.4a	60.3a	36.3a	32.1ab
Entrust SC+Pyganic 5.0 EC	6 oz + 17 oz	3.9bc	31.8a	14.4ab	21.0a	43.8a	43.8a	26.4bc
Untreated check		18.9a	43.8a	33.2a	38.1a	59.5a	36.3a	38.3ab
	F value	*12.53*	*1.63*	*6.22*	*1.55*	*1.21*	*0.63*	*6.26*
	P>F	*<.0001*	*0.17*	*0.0002*	*0.19*	*0.33*	*0.75*	*0.0002*

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

Table 2.

Treatment/Formulation	Rate-amt product / ac	WFT Larvae / Plant						
		3 DAA1	**7 DAA1**	**3 DAA2**	**7 DAA2**	**11 DAA2**	**14 DAA2**	**Trial**
		12-Mar	16-Mar	19-Mar	23-Mar	27-Mar	31-Mar	**Avg**
AzaDirect	2.5 pts	81.9ab	111.0a	40.5ab	47.7ab	43.5ab	78.9abc	67.3b
AzaDirect+M-Pede	2 pts + 2%	107.6a	127.8a	48.9ab	61.2a	30.0abc	81.6abc	76.2ab
AzaDirect+Captiva	2 pts + 8 oz	119.4a	109.5a	46.5ab	36.6ab	27.3bc	64.2abcd	67.2b
Aza-Direct+Pyganic 5.0EC	2 pts + 17 oz	106.6a	122.1a	49.8ab	63.9a	27.9bc	58.8bcd	71.5b
Entrust SC	7 oz	58.2ab	86.7a	22.1bc	13.8bc	12.9cd	63.6bcd	42.9c
Entrust SC+M-Pede	6 oz + 2 %	12.3cd	10.5c	4.8c	5.1cd	5.1d	32.4d	11.7d
Entrust SC+Captiva	6 oz + 8 oz	29.6bc	37.8b	9.0c	3.9d	6.3d	41.4cd	21.3d
Entrust SC+Pyganic 5.0 EC	6 oz + 17 oz	8.4d	16.2bc	4.8c	7.7cd	6.9d	48.9bcd	15.4d
Untreated check		108.4a	127.2a	128.1a	76.8a	83.5a	140.1a	110.7a
	F value	*20.58*	*29.55*	*15.21*	*18.02*	*19.13*	*7.78*	*81.52*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

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

VIII. Influence of Adjuvants on Control of Thrips with Entrust on Lettuce

Methods:

Romaine' Solid King' was direct seeded on 3 Dec, 2015 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 12 and 27 Feb. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Various adjuvant was applied to the treatments at various rates. Numbers of western flower thrips (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 transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary:

WFT populations were moderate-heavy in this trial. As seen in previous trials, the addition of an adjuvant can enhance the activity of Entrust against WFT. In this trial, the addition of M-Pede with the Entrust provided significantly better adult control compared to Entrust alone, whereas none of the other adjuvant+Entrust treatments provided as consistent adult control (Table 1). Similarly, the Entrust+M-pede combination provided significantly better control of WFT larvae than all the other Entrust treatments and the check (Table 2). Among the other treatments, only the Entrust+NuFilm P treatment failed to provide better control than the Entrust applied alone. This may be due to the fact that Nu-Film P is a sticker-type adjuvant and likely did not allow for the translaminar penetration of Entrust into the leaf tissue. It is unknown why the addition of M-Pede provided significantly enhanced activity.

Treatment/ Formulation	Rate-amt fl oz/ac	Adjuvant	Rate-amt %vol/vol	Adults / Plant							
				3 DAA-1 15-Feb	**7 DAA-1 19-Feb**	**11 DAA-1 23-Feb**	**14 DAA-1 26-Feb**	**3 DAA-2 1-Mar**	**6 DAA-2 4-Mar**	**12 DAA-2 10-Mar**	**Trial Avg.**
Entrust SC	5 oz	NuFilm P	0.25%	3.9b	4.0ab	8.6b	9.3a	9.1b	9.3ab	15.6a	8.5b
Entrust SC	5 oz	M-Pede	2.0%	2.6b	2.6c	5.7b	8.4a	5.2c	6.3b	9.0a	5.7c
Entrust SC	5 oz	Oroboost	0.25%	2.7b	2.7bc	8.2b	10.9a	9.5b	9.3ab	15.3a	8.4b
Entrust SC	5 oz	Silwet	0.25%	2.7b	2.7bc	10.0b	11.6a	7.2bc	8.7ab	10.5a	7.6bc
Entrust SC	5 oz	Mantis	0.63%	2.7b	2.7bc	8.8b	11.6a	6.8bc	6.9ab	13.5a	7.6bc
Entrust SC	7 oz	-	-	3.2b	3.2bc	7.0b	9.4a	8.7bc	13.8ab	13.2a	8.3b
Untreated	-	-	-	9.0b	8.9a	16.8b	21.2a	23.1a	19.8a	18.6a	16.8a
			F	*9.71*	*8.61*	*6.97*	*1.91*	*15.66*	*2.76*	*1.36*	*13.67*
			P>F	*<.0001*	*0.0002*	*0.0006*	*0.13*	*<.0001*	*0.04*	*0.28*	*<.0001*

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

Treatment/ Formulation	Rate-amt fl oz/ac	Adjuvant	Rate-amt %vol/vol	Larvae / Plant 3 DAA-1 15-Feb	7 DAA-1 19-Feb	11 DAA-1 23-Feb	14 DAA-1 26-Feb	3 DAA-2 1-Mar	6 DAA-2 4-Mar	12 DAA-2 10-Mar	Trial Avg.
Entrust SC	5 oz	NuFilm P	0.25%	6.5ab	5.6b	8.7b	6.5b	13.4b	21.6b	16.5b	11.3b
Entrust SC	5 oz	M-Pede	2.0%	3.1bc	1.9c	1.7d	1.0c	2.0c	5.4c	4.5c	2.8d
Entrust SC	5 oz	Oroboost	0.25%	3.8bc	4.9bc	2.9cd	3.6bc	3.0c	9.0bc	6.3bc	4.8c
Entrust SC	5 oz	Silwet	0.25%	4.0bc	3.6bc	8.1b	3.5bc	4.3c	8.4bc	5.1c	5.3c
Entrust SC	5 oz	Mantis	0.63%	2.2c	4.7bc	5.2bc	3.9bc	4.8c	11.7bc	7.5bc	5.7c
Entrust SC	7 oz	-	-	3.0bc	6.0b	7.4b	7.7b	6.2bc	12.6bc	9.0bc	7.4bc
Untreated	-	-	-	9.4a	20.7a	30.1a	30.2a	88.2a	143.7a	107.7a	61.4a
			F	*6.21*	*9.01*	*26.11*	*14.09*	*30.77*	*12.36*	*18.21*	*47.69*
			P>F	*0.001*	*0.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

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