Arizona Department of Agriculture
AILRC Grants Program – Final Report for 2018
Project 18-03

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

Project Investigator: John C. Palumbo, University of Arizona, Yuma Ag Center

Location of Research: Yuma Valley Agricultural Center

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

Cost-effective insecticides are very important in the production of desert lettuce. New insecticides continue to be developed that have a fit for insect control in desert head lettuce, albeit at a slower rate than 5 years ago. 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 PCAs 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, Exirel, and Besiege 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 2017-2018, we focussed on determining the relative performance of key organic products (Entrust, Pyganic, M-Pede, Aza-Direct, Azera, Grandevo and Captiva) against worms, aphids and thrips.

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 2017 and spring 2018 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.

Conventional Insecticides in Head Lettuce

Reduced-risk Insecticide Alternatives for Worm Control

Objective: The objective of this trial was to compare the activity of several key insecticides for control of Beet Armyworm and Cabbage Looper on Conventional Lettuce under fall growing conditions.

Methods: Head lettuce ' EXP1221 SK' was direct seeded on 7 Sep, 2017 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 by3ft 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. Two foliar spray applications were made 29 Sep and 16 Oct with a CO_2 operated, back-pack sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. No adjuvants were added to any of the spray treatments. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol with these spray treatments. At various intervals after applications (DAA), 5-10 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 live larvae by instar. Neonate and 1st instar larvae were not included because they had not yet consumed treated leaf tissue. Only large larvae (2nd instar and >) are presented in the tables. Because of heterogeneity of mean variances, insect 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 non-transformed data are presented in the tables.

Summary: Worm pressure was light-moderate prior to the first application, but declined rapidly following the second spray. Averaged over both sprays, all spray treatments provided comparable levels of BAW, CL and CEW control relative to the untreated control. Radiant was equally effective at 3 oz compared to the 5 oz rate, and Minecto Pro was comparable to Exirel at 15 oz. This information may provide PCAs with cost-effective options for worm control in desert lettuce.

		Trial Average Mean Large Larvae / 10 plants			
Treatment	**Rate**	**CL**	**BAW**	**CEW**	**Total**
Radiant	3.0 oz	0.6b	0.3b	0.0a	0.9b
Radiant	5.0 oz	0.7b	0.3b	0.0a	1.0b
Exirel	15.0 oz	0.8b	0.1b	0.0a	0.9b
Proclaim+Warrior	4.0 + 1.92 oz	0.2b	0.5b	0.a	0.7b
Minecto Pro	10 oz	0.6b	0.4b	0.1a	1.1b
Untreated	-	6.0a	4.1a	1.0a	11.1a

Conventional Insecticides Alternatives for Thrips Control in Fall Head Lettuce

Objective: The objective of this trial was to evaluate the efficacy of several conventional insecticides products against western flower thrips (WFT) in Spring head lettuce.

Methods: Romaine' Del Sol' was direct seeded on 21 Sep, 2017 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 17 and 31 Oct . The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 40 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Dyne-Amic was applied to each spray treatment at 0.125% v/v. Numbers of Bean thrips and Western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAT). Relative thrips 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 population levels were light. Only Exirel did not provide significant control of bean thrips, whereas Minecto Pro, Agri-Mek, Lannate and Radiant provided the best control. Against WFT larvae, only Radiant and Lannate provided significant control. Overall, these two products were the most effective products against thrips in fall lettuce.

		Trial Average			
		Mean BT / Plant	Mean WFT / Plant		
Treatment	**Rate/ac**		**Adult**	**Larvae**	**Total**
Minecto Pro	10 oz	2.7c	6.7ab	7.4ab	14.2ab
Lannate	1 lb	3.0c	4.7cd	1.6c	6.3c
Radiant	7 oz	2.3c	4.4d	1.5c	6.0c
Exirel	13.5 oz	5.5ab	5.9abc	7.0ab	12.8ab
Agri-Mek	4.25 oz	2.5c	6.1ab	6.6ab	12.7ab
Torac	21 oz	5.0bc	5.7bc	4.6b	10.3b
Untreated	-	9.1a	7.2a	11.7a	18.9a

Conventional Insecticides Alternatives for Thrips Control in Spring Head Lettuce

Objective: The objective of this trial was to evaluate the efficacy of several conventional insecticides products against western flower thrips (WFT) in Spring head lettuce.

Methods: Head lettuce 'PYB7101A' was direct seeded into double row beds on 42 inch centers on Jan 15, 2018. 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 6 and 22 Mar 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. 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 for all insect 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 WFT population levels were moderate for a spring trial. Against WFT adults, only Radiant, Lannate and Torac significantly reduced populations relative the untreated check when averaged across all sample dates. Similarly, against WFT larvae, only Radiant, Lannate and Torac provided significant control. Overall, Radiant and Lannate provided the most consistent efficacy thrips in spring lettuce.

		Trial Average - Mean Thrips/Plant		
Treatment	**Rate**	**Adult**	**Larvae**	**Total**
Minecto Pro	**10 oz**	11.2abc	29.9ab	41.1ab
Exirel	**13.5 oz**	14.0a	37.4a	51.4a
Agri-Mek	**4.25 oz**	13.2ab	46.5a	59.7a
Lannate	**1 lb**	7.8c	13.0c	20.8c
Radiant	**7 oz**	9.3bc	6.3c	15.6c
Torac	**21 oz**	9.5bc	17.6bc	27.1bc
Untreated		13.6a	55.2a	68.8a

Evaluation of a New Conventional Insecticide for Control of Aphids on Head Lettuce

Objective: The objective of the trial was to evaluate the efficacy of new aphicides (Versys and PQZ) against aphids when compared to industry standards under desert growing conditions.

Methods: Two trials were conducted in 2018. Head lettuce 'Magosa SK' was direct seeded on 17 Nov, and again on 15 Dec, 2017at 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. A single foliar application was made on 24 Jan in the first trial and 5 Feb in the second planting with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. Dyne-Amic (0.125%) v/v was applied to all treatments. Evaluations of green peach aphid (GPA) were assessed by estimating the number of aphids / plants in whole plant, destructive samples. On each sample date, 6 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. At harvest, plants were randomly selected from each plot and sampled by visually examining all foliage within a harvested head and 4 wrapper leaves. Because of heterogeneity of mean variances, data for all insect 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 non-transformed data are presented in the tables.

Summary: Aphid pressure was light during both trials and consisted mainly of green peach aphid. Foxglove aphid was present but at much lower numbers and their data is not reported. These trials were designed to evaluate both knockdown and residual control following a single spray application. In both trials, Versys, Beleaf, Sivanto and Sequoia provided the most consistent knockdown efficacy against GPA. All the spray products with the exception of Fulfill provided extended residual control. This study further demonstrated that the new insecticides Versys and PQZ, which have recently been registered for use in lettuce, can be used to effectively manage GPA in desert lettuce.

1st Trial – Nov 17 wet date

		Green peach aphid / plant						
		1 DAA	*4 DAA*	*7 DAA*	*14 DAA*	*21 DAA*	*28 DAA*	
Treatment	**Rate/ac**	**24-Jan**	**28-Jan**	**1-Feb**	**8-Feb**	**15-Feb**	**22-Feb**	**AVG**
Versys	1.5	3.3b	2.2b	1.5abc	1.4c	0.5b	0.2b	1.5c
Beleaf	2.8	2.7b	1.9b	1.2bc	1.3c	0.3b	0.4b	1.3c
Movento	5.0	5.4a	3.6ab	1.3abc	1.0c	0.2b	0.2b	1.9c
Sequioa	2.0	3.6b	2.3b	1.5abc	0.8c	0.4b	0.2b	1.5c
Sivanto	5.0	2.6b	3.4ab	3.3abc	3.3abc	1.0ab	0.3b	2.3bc
Fulfill	2.8	3.0b	4.9ab	3.6 ab	6.5ab	3.9a	1.6b	3.9ab
PQZ	3.2	4.1ab	3.0ab	2.3abc	2.1bc	0.7ab	0.4b	2.1bc
Untreated	-	6.0a	6.8a	5.9a	12.5a	2.4ab	3.5a	6.2a

2nd Trial – Dec 15 wet date

		Green peach aphid / plant						
		3 DAA	*7 DAA*	*14 DAA*	*21 DAA*	*28 DAA*	*35 DAA*	
Treatment	**Rate/ac**	**8-Feb**	**12-Feb**	**19-Feb**	**26-Feb**	**5-Mar**	**13-Mar**	**AVG**
Versys	1.5	2.3b	0.1c	1.0ab	0.6b	1.7a	1.7a	1.2c
Beleaf	2.8	2.9b	0.1c	0.4b	0.9b	1.3a	2.4a	1.3c
Movento	5.0	4.3ab	0.4bc	0.2b	0.4b	0.9a	2.3a	1.4c
Sequioa	2.0	2.5b	0.6bc	0.2b	1.0b	1.7a	1.0a	1.1c
Sivanto	5.0	2.8b	0.5bc	0.0b	0.3b	0.8a	1.7a	1.0c
Fulfill	2.8	6.9ab	3.0ab	0.7ab	1.6ab	1.9a	1.7a	2.6b
PQZ	3.2	4.8ab	0.6bc	0.2b	0.2b	0.8a	2.5a	1.5c
Untreated	-	14.5a	7.1a	3.8a	4.5a	2.4a	4.0a	6.0a

Evaluation of a New Conventional Insecticide for Control of Aphids on Cabbage

Objective: The objective of the trial was to evaluate the efficacy of a new aphicides (Versys and PQZ) against aphids when compared to industry standards under desert growing conditions.

Methods: Head lettuce 'Magosa SK' was direct seeded on 17 Nov, 2017at 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. Two foliar applications were made on 20 Feb and 16 Mar with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. Dyne-amic (0.125%) v/v was applied to all treatments. Evaluations of green peach aphid (GPA) and foxglove aphid (FGA) populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sample date, 6 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. At harvest, plants were randomly selected from each plot and sampled by visually examining all foliage within a harvested head and 4 wrapper leaves. Because of heterogeneity of mean variances, data for all insect 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 non-transformed data are presented in the tables.

Summary: Aphid pressure was heavy during the trial and consisted of green peach aphid. This trial was designed to evaluate both knockdown and residual control after each spray application. Following the 1st spray, Beleaf, Sequoia, Sibanto and Versys provided the most significant knockdown efficacy, whereas only Fulfill failed the provided significant residual control. A similar trend was observed following the 2nd application. Overall, Movento provided the most consistent control at 28 DAA the 2nd spray. Aphid numbers on lettuce plants at 28 DAA in the Fulfill, PQZ, and Sequoia plots were not different from the untreated control. Versys and PQZ appeared to provide comparable knockdown activity, but Versys had significantly better residual efficacy in this trial.

Foliar Treatment	Rate/ac	Mean Green Peach Aphid / plant				
		1 DAA-1	*3 DAA-1*	*7 DAA-1*	*14 DAA-1*	*21 DAA-1*
		21-Feb	**23-Feb**	**27-Feb**	**6-Mar**	**13-Mar**
Versys	1.5	164.9ab	57.6bcd	15.0d	9.6c	38.6c
Beleaf	2.8	108.0b	27.9d	13.3cd	19.4c	46.5c
Movento	5	229.9a	160.5a	56.1bc	21.4c	15.0c
Sequioa	2.8	173.7ab	38.9cd	27.1cd	31.8abc	41.6c
Sivanto HL	5	118.3ab	44.4cd	47.9bcd	39.3abc	62.3c
Fulfill	2.8	143.9ab	111.2ab	132.4ab	80.6ab	233.9a
PQZ	3.2	181.4a	61.4bc	56.4bc	35.7abc	56.1bc
Untreated	-	213.6a	221.3a	309.4a	98.4a	261.1ab

Foliar Treatment	Rate / ac	Mean Green Peach Aphid / plant				
		7 DAA-2	*14 DAA-2*	*21 DAA-2*	*28 DAA-2*	
		23-Mar	**29-Mar**	**6-Apr**	**13-Apr**	**Trial Avg.**
Versys	1.5	8.1b	11.9c	49.0bc	78.3cd	48.1c
Beleaf	2.8	8.3b	11.9c	61.9bc	68.3bcd	42.8c
Movento	5	9.4b	7.2c	27.9c	15.8d	60.4bc
Sequioa	2.8	18.8b	13.5c	59.2bc	137.5abc	60.2bc
Sivanto HL	5	33.0b	37.3bc	125.7b	78.7bcd	35.2c
Fulfill	2.8	314.4a	205.7ab	740.8a	761.3a	302.7a
PQZ	3.2	21.4b	35.9c	100.2bc	163.8abc	79.1b
Untreated	-	421.8a	483.1a	635.7a	713.9ab	373.1a

Biopesticides in Organic Lettuce

Insecticide Alternatives for Beet Armyworm and Cabbage Looper Control in Organic Head Lettuce

Objective: To compare the efficacy of novel nuclear polyhedrosis viruses currently being developed for use in organic lettuce production us.

Methods: Head lettuce ' EXP1221 SK' was direct seeded on 7 Sep, 2017 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 two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations, rates and spray timing for each treatment compound are provided in Table 1. Four foliar spray applications were made 2, 10, 19 Oct and 2 Nov with a CO_2 operated, back-pack sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. No adjuvants were added to any of the spray treatments.

At 6-7-day intervals after applications (DAA), 10 plants were randomly selected from each replicate and destructively 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 live larvae by instar (1^{st}-5th instar). Because of heterogeneity of mean variances, insect data were transformed using a log10 (x-1) function before analysis. Harvest data for percentage of heads contaminated with fresh feeding damage, frass, and larvae 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: Table 1 shows the biopesticides, rates and sequence of applications for each spray program. Loopex and Spexit were the two NPV products used to control cabbage looper and beet armyworm, respectively. CL numbers were moderate and peaked in the untreated check following the 3^{rd} spray. The most consistent treatment was the Grower standard, followed by the BT and BT+NPV tank-mix spray programs. Neither of the high or low rate of NPV spray programs provide significant CL control. BAW pressure was moderate early but became lighter as the trial progressed. Only the Grower Stand and Entrust+NPV spray programs significantly reduced BAW larvae compared to the untreated control. The results of this trial corroborate previous trials that NPV use for control of BAW and CL in desert lettuce is not acceptable at this time.

Table 1.

Spray program	1st Spray	2nd Spray	3rd Spray	4th Spray
Grower Standard	Entrust-5 oz	Xentari-1.5 lbs	Xentari-1.5 lbs	Entrust-5 oz
Entrust + NPV	Entrust-5 oz	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Entrust-5 oz
Bt Program	Dipel-1.5 lb	Xentari - 1.5 lb	Dipel-1.5 lb	Xentari - 1.5 lb
Bt + NPV rotation	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Dipel-1.5 lb	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Xentari - 1.5 lb
Bt + NPV tankmix	Xentari-1.5 lbs Spexit 1 fl.oz Loopex 1 fl.oz	Dipel-1.5 lb Spexit 1 fl.oz Loopex 1 fl.oz	Xentari-1.5 lbs Spexit 1 fl.oz Loopex 1 fl.oz	Dipel-1.5 lb Spexit 1 fl.oz Loopex 1 fl.oz
NPV high rate	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Spexit 2.5 fl.oz Loopex 2.75 fl.oz	Spexit 2.5 fl.oz Loopex 2.75 fl.oz
NPV low rate	Spexit 1 fl.oz Loopex 1 fl.oz	Spexit 1 fl.oz Loopex 1 fl.oz	Spexit 1 fl.oz Loopex 1 fl.oz	Spexit 1 fl.oz Loopex 1 fl.oz

Table 2.

	Mean CL larvae / 10 plants					
	6-DAA1	*7-DAA2*	*6-DAA3*	*12-DAA3*	*7-DAA4*	
Spray program	**8-Oct**	**17-Oct**	**25-Oct**	**1-Nov**	**9-Nov**	**Trial Avg.**
Grower Standard	0.0 a	4.6 b	6.5 a	3.0 c	0.2 b	2.9 c
Entrust + NPV	0.0 a	8.8ab	18.0 a	11.5 abc	1.0 b	7.9 ab
Bt Program	0.0 a	3.3b	4.5 a	6.5 bc	1.2 ab	3.1 bc
Bt~NPV rotation	0.4 a	4.2 b	11.0 a	16.0 ab	2.3 ab	6.8 abc
Bt+NPV tankmix	0.8 a	8.8ab	7.0 a	7.0 abc	0.8 b	4.8 bc
NPV - High Rate	0.8 a	17.5 a	15.5 a	17.5 a	1.8 ab	10.6 a
NPV - Low Rate	1.3 a	6.7 ab	9.0 a	11.5 abc	2.2 ab	6.2 abc
Untreated	1.3 a	12.9 ab	18.0 a	13.0 abc	4.3 a	10.0 a

Table 3.

	Mean BAW larvae / 10 plants					
	6-DAA1	*7-DAA2*	*6-DAA3*	*12-DAA3*	*7-DAA4*	
Spray program	**8-Oct**	**17-Oct**	**25-Oct**	**1-Nov**	**9-Nov**	**Trial Avg.**
Grower Standard	0.4 c	0.8b	0.5b	0.5a	0.2a	0.5c
Entrust + NPV	1.3 bc	2.1 ab	2.0ab	2.5a	0.0a	1.6bc
Bt Program	9.6a	3.3 ab	1.5ab	1.5a	0.7a	3.3ab
Bt~NPV rotation	7.5 ab	1.7 ab	3.0ab	1.0a	0.3a	2.7abc
Bt+NPV tankmix	5.8 abc	4.6 ab	1.5ab	0.5a	0.2a	2.5abc
NPV - High Rate	6.7 abc	2.9 ab	3.5ab	0.5a	0.5a	2.8abc
NPV - Low Rate	10.0 a	2.5 ab	1.5b	0.5a	0.2a	3.7ab
Untreated	12.1 a	6.3 a	5.0a	3.0a	0.7a	5.4a

Lepidopterous Larvae Control in Organic Head Lettuce Fall 2017

<u>Objective</u>: To compare the efficacy of organically approved biopesticidees currently being developed for use in organic lettuce production us.

<u>Methods</u> Head lettuce 'EXP1221 SK' was direct seeded on 5 Sep, 2017 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 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. Two foliar applications were made on 29 Sep and 6 Oct with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. An adjuvant, Silwet was applied as an adjuvant @ 0.125%. The pH of the spray water in the Aza-Direct and Azera treatments was lowered to a pH of 5.5-6 using Neutralizer at 0.1% v/v.
Beet armyworm (BAW) and cabbage looper (CL) control was based on the examination of 10 whole plant at 3, and 7 days following each application (DAA) for the presence of large (2^{nd} or > instar) larvae. The number of plants in each plot with fresh feeding tracks on plants was also recorded. Because of heterogeneity of mean variances, insect data were transformed using a log10 (x-1) function before analysis. Data for percentage of plants with fresh feeding damage on leaves 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 non-transformed data are presented in the tables.

<u>Summary</u> CL populations were light and no differences were observed among the spray treatments and the untreated control. In contrast, BAW numbers were moderate to heavy. Entrust provided the best BAW control. Venerate and Xentari significantly reduced BAW numbers relative to the untreated check. Aza-Direct, Azera, Dipel, and Grandivo did not provide significant BAW control.

		Trial Average Mean Larvae / 10 plants		
Treatment	**Rate**	**CL**	**BAW**	**Total**
Entrust	5 oz	0.0a	0.1c	0.1c
Aza-Direct	3 pts	1.0a	3.5ab	3.5ab
Azera	32 oz	0.5a	4.8ab	4.8ab
Dipel	1 lbs	0.8a	4.0ab	4.0ab
Xentari	1 lbs	0.6a	3.1b	3.1b
Grandivo	2 lbs	1.5a	5.5ab	5.5ab
Venerate	2 qts	0.8a	2.8b	2.8b
Untreated		0.9a	7.2a	7.2a

Organically-Allowed Insecticide Alternatives for Thrips Control in Fall Head Lettuce

Objective: The objective of this trial was to evaluate the efficacy of several organically allowed products against bean thrips and western flower thrips (WFT) in fall head lettuce.

Methods: Head lettuce 'EXP1221 SK' was direct seeded into double row beds on 42 inch centers on 21 Sep, 2017. 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 22 Oct and 3 Nov 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 acidifier (Neutralizer) was applied to Aza-Direct, Azera, DeBug Turbo and Neemix at 0.1% vol/vol to adjust the pH to 5.5. Silwet at 0.125% vol/vol was applied all sprays. Numbers of Bean Thrips (BT) and Western flower Thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAT). Relative BT and 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 thrips. Sticky cards were then taken to the laboratory where adult and larvae were counted. Because of heterogeneity of mean variances, data for all insect 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 non-transformed data are presented in the tables.

Summary WFT population levels were light. Only Entrust provided significant reduction of BT compared to the untreated control. Against WFT larvae, only Entrust and Aza-Direct provided significant control. Overall Entrust was the most effective biopesticide against thrips in romaine.

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		Trial Average			
		Mean BT / Plant	Mean WFT / Plant		
Treatment	**Rate/ac**		**Adult**	**Larvae**	**Total**
Entrust	7 oz	3.9b	6.5a	4.2c	10.7c
Veratrand-D	15 lbs	5.7ab	8.1a	12.6ab	20.7ab
Aza-Direct*	3 pts	5.0ab	7.2a	10.5b	17.6b
Azera*	48 oz	6.0a	7.8a	11.5ab	19.3ab
DeBug Turbo*	32 oz	5.8ab	7.6a	12.3ab	19.8ab
Neemix 4.5*	10 oz	5.9ab	7.7a	11.9ab	19.6ab
Trilogy	2%	5.6ab	7.5a	13.8ab	21.6ab
M-Pede	2%	6.3a	7.4a	12.0ab	19.4ab
SuffOil-X	2%	6.3a	8.6a	12.4ab	21.0ab
Untreated	-	6.0a	8.0a	14.7a	22.7a

Organically-Allowed Insecticide Alternatives for Thrips Control in Spring Head Lettuce

Objective: The objective of this trial was to evaluate the efficacy of several organically allowed products against bean thrips and western flower thrips (WFT) in spring head lettuce.

Methods: Romaine 'Del Sol' was direct seeded on 17 Jan, 2018 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. Two foliar application was made on 8 and 20 Mar with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 18 GPA. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Aza-Direct treatment o modify spray pH to ~5.5. No adjuvants were applied with any of the sprays.Numbers of WFT from 5 plants per replicate were recorded at 3, 7 and 11 days 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 for all insect 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 non-transformed data are presented in the tables.

Summary Thrips populations were moderate-heavy in the trial. Among the biopesticide treatments only Entrust and Entrust+M-Pede consistently provided significant WFT control compared to the untreated control. Aza-Direct+M-Pede had significantly lower larvae and total WFT numbers compared to the untreated check, but did not provide control comparable to the Entrust treatments. This corroborates previous studies showing that M-Pede combined with a 5 oz rate of Entrust provided control comparable to Entrust at a 7 oz rate.

		Mean WFT / Plant		
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Total**
Entrust	7 oz	12.6bc	6.6c	19.2c
M-Pede	2%	13.6ab	34.1ab	47.6ab
Aza-Direct	3 pts	14.1ab	33.5ab	47.6ab
Entrust + M-Pede	5 oz + 2 %	10.0c	4.9c	14.9c
Aza-Direct + M-Pede	2.5 pts + 2 %	11.6abc	30.7b	42.4b
Grandivo	2 lbs	15.5a	48.5ab	64.1a
Venerate	2 qts	16.3a	48.0ab	64.3a
Untreated	-	16.1a	55.9a	72.0a

Organically-Allowed Insecticide Alternatives for Aphid and Thrips Control in Spring Head Lettuce

Objective: to evaluate several biopesticides for control of thrips and aphids used in organic spring lettuce production.

Methods Head lettuce 'Magosa' was direct seeded on 17 Dec, 2017 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 application was made on 3, 9 and 17 Feb with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 22.5 GPA. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Ecozin, DeBug Turbo, Aza-Direct and Azera treatments to modify spray pH to ~5.5. No adjuvants were applied with any of the sprays. Evaluations of aphid populations were assessed by estimating the number of aphids / plants in whole plant, destructive samples at 6 days following each application (DAA). On each sample 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 live aphids present. Numbers of WFT from 5 plants per replicate were recorded at 6 days following each application (DAA). 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 for all insect 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 non-transformed data are presented in the tables.

Summary Aphid and thrips population levels were light. Averaged across all sample dates, none of the biopesticide treatments had significantly fewer aphids than the untreated control. Only the conventional standard, Sequoia, significantly reduced aphid numbers. None of the biopesticide treatments significantly reduced numbers of WFT adults, whereas only Aza-Direct, Ecozin, Azera, and Debug Turbo had significantly few larvae than the untreated control.

Aphids

		Green peach aphids / Plant			
Treatment	**Rate/ac**	**6 DAA1**	**6 DAA2**	**6 DAA3**	**Trial Avg**
Aza-Direct	3 pts	5.1 a	0.9 ab	0.8 ab	3.1 a
Ecozin	30 oz	3.2 ab	0.9 ab	1.9 a	3.2 a
PFR 97	2 lbs	4.2 a	1.4 a	1.3 a	3.6 a
Azera	2 pts	4.0 ab	1.7 a	1.5 a	3.6 a
DeBug Turbo	32 oz	4.2 a	1.3 ab	1.6 a	3.2 a
Trilogy	2%	5.3 a	2.7 a	2.9 a	4.2 a
M-Pede	2%	4.2 a	1.4 a	2.0 a	4.0 a
Sequoia	2 oz	1.0 b	0.1 b	0.2 b	1.5 b
Untreated		6.2 a	1.5 a	1.7 a	4.3 a

Thrips

		Western Flower Thrips / Plant		
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Total**
Aza-Direct	3 pts	8.4a	6.8cd	15.2abc
Ecozin	30 oz	7.8a	7.0cd	14.8bc
PFR 97	2 lbs	8.3a	9.0abc	17.3ab
Azera	2 pts	7.8a	7.8bcd	15.6abc
DeBug Turbo	32 oz	8.6a	7.7bcd	16.3ab
Trilogy	2%	8.7a	9.3abc	18.0ab
M-Pede	2%	8.9a	10.6ab	19.4a
Sequoia	2 oz	6.5a	6.3d	12.8c
Untreated		9.2a	11.3a	20.4a

Organically-Allowed Insecticide Alternatives for Aphid Control in Spring Cabbage

Objective: to evaluate several biopesticides for control of thrips and aphids used in organic spring lettuce production.

Methods Cabbage 'Primo vantage' was direct seeded was direct seeded on 17 Nov, 2017 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. Plots were arranged in a randomized complete block design with 3 replications. Formulations and rates for each compound are provided in the tables. Three applications were made on 13 and 21 Feb and 3 March. 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. Oroboost was applied to all treatments at 0.25% vol/vol. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Ecozin, PFR-97, DeBug Turbo, Aza-Direct and Azera treatments to modify spray pH to ~5.5. No adjuvants were applied with any of the sprays. Green peach aphid (GPA) populations were assessed at 6 days following each application (DAA) by estimating the number of aphids / plants in whole plant, destructive samples. On each sampling date, 6-8 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 population levels were heavy**.** At 6 DAA1, only the PFR 97 treatment had significantly fewer aphids than the untreated control, and at 6DAA3, only Aza-Direct had fewer aphids than the untreated control. Averaged across all four sample evaluations (6 DAA), only the Aza-Direct treatments had significantly fewer aphids than the untreated control. However, this resulted in less than 50% control.

		Green Peach Aphids / Plant			
Treatment	**Rate/ac**	**6 DAA1**	**6 DAA2**	**6 DAA3**	**Trial Avg.**
Aza-Direct	30 oz	125.3a	119.2 a	35.9 b	93.5 b
Ecozin	2 lbs	118.8a	150.1 a	57.1 ab	108.7 ab
Azera	2 pts	135.9a	156.8 a	42.1 ab	111.6 ab
DeBug Turbo	32 oz	137.3a	155.3 a	56.9 ab	116.5 ab
M-Pede	2%	145.9a	216.2 a	49.9 ab	137.4 ab
PFR 97	2%	90.2b	288.3 a	63.6 ab	147.4 ab
Trilogy	2 oz	133.9a	301.9 a	45.1 ab	160.3 ab
Untreated		161.8a	277.8 a	81.2 a	173.5 a