Arizona Department of Agriculture

AILRC Grants Program – Final Report for 2021

Project 21-02

Project Title **Insect Management in Desert Head Lettuce**

Project Investigator: John C. Palumbo, University of Arizona, Yuma Ag Center
Location of Research: Yuma Valley Agricultural Center

Project Goals and Objectives

The goal of this project is to continue to compare the efficacy of several new insecticides for thrips and aphid control relative to the industry standards currently used in conventional and organic head lettuce production. In addition, we will examine if modifications in spray applications with the use of water sanitizers and higher spray volumes impact insecticide efficacy.

The long-range objective of this work is to better understand the utility of using insecticides in desert lettuce with the goal of developing cost-effective insect management guidelines when they become available.

I. Comparative Efficacy of New and Experimental Insecticides*:*

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 several important insecticides (i.e., Belt, Vetica) and the gradual loss of efficacy of Admire after 27 years of use. Furthermore, the neonicotinoids just recently completed re-registration and restrictions on usage in lettuce have been proposed by USEPA.

Most of the newly developed products that growers use are effective against the key lettuce insect pests, but 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 experimental chemistries may fit into existing insect management programs in our unique desert cropping system.

Western Flower Thrips – EXP 245987-21 A trial was planted to lettuce' Salute MI' on 4 Feb 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 furrow irrigated 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. Two foliar sprays were applied on 13 and 29 Mar. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 24.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Dyne-Amic was applied to each spray treatment at 0.125% v/v. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). 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, WFT 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: *The new experimental compound (EXP 245987-21) provided knockdown and residual control of WFT adults and larvae comparable to the industry standards.*

		WFT Adults / Plant			
Treatment	**Rate/ac**	**3 DAA-1**	**7 DAA-1**	**10 DAA-1**	**14 DAA-1**
EXP 245987-21	15.6 oz	3.0 b	3.1 b	16.9 a	19.7 a
Radiant	7 oz	3.5 b	4.8 ab	19.1 a	22.1 a
Lannate	0.8 lb	2.2 b	3.1 b	10.3 a	19.1 a
Untreated	-	15.1 a	9.4 a	17.9 a	22.9 a
	F value	*17.26*	*4.21*	*2.77*	*0.28*
	P>F	*<.0001*	*0.01*	*0.06*	*0.91*

		WFT Adults / Plant			
Treatment	**Rate/ac**	**3 DAA-2**	**7 DAA-2**	**14 DAA-2**	**Trail Avg.**
EXP 245987-21	15.6 oz	4.8 b	10.2 b	41.5 a	14.2 b
Radiant	7 oz	7.4 b	18.0 ab	35.2 a	15.7 b
Lannate	0.8 lb	7.8 b	16.8 ab	54.5 a	16.2 b
Untreated	-	21.0 a	29.7 a	42.5 a	22.6 a
	F value	*13.92*	*5.61*	*0.98*	*19.73*
	P>F	*<.0001*	*0.004*	*0.46*	*<.0001*

		WFT Larvae / Plant			
Treatment	**Rate/ac**	**3 DAA-1**	**7 DAA-1**	**10 DAA-1**	**14 DAA-1**
EXP 245987-21	15.6 oz	4.2 bc	2.9 b	7.7 bc	6.4 b
Radiant	7 oz	3.2 bc	2.5 b	4.4 c	6.1 b
Lannate	0.8 lb	1.6 c	3.9 b	5.2 bc	7.2 b
Untreated	-	14.6 a	22.3 a	34.2 a	51.5 a
	F value	*10.61*	*9.13*	*17.25*	*27.27*
	P>F	*0.0002*	*0.0004*	*<.0001*	*<.0001*

		WFT Larvae / Plant			
Treatment	**Rate/ac**	**3 DAA-2**	**7 DAA-2**	**14 DAA-2**	**Trail Avg.**
EXP 245987-21	15.6 oz	16.8 b	14.1 b	96.0 a	21.1 b
Radiant	7 oz	8.4 b	9.9 b	89.0 a	17.6 b
Lannate	0.8 lb	11.3 b	15.3 b	94.0 a	19.8 b
Untreated	-	79.3 a	148.2 a	135.5 a	69.4 a
	F value	*12.92*	*26.45*	*0.87*	*64.87*
	P>F	*<.0001*	*<.0001*	*0.53*	*<.0001*

Western Flower Thrips – EXP 245987-21 and alternatives A trial was planted to lettuce' Salute MI' on 15 Mar 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 furrow irrigated 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. 3 foliar sprays were applied on 12, 20, 27 Apr. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 24.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Dyne-Amic was applied to each spray treatment at 0.125% v/v. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). 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, WFT 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: *The new experimental compound (EXP 245987-21) provided knockdown and residual control of WFT adults and larvae comparable to the Radiant, Lannate, Torac and Beleaf. Provided comparable control of larvae with Lannate and Radiant. Assail and Sequoia failed to provide efficacy against WFT in this trial.*

Treatment	Rate (oz/ac)	WFT Adults / Plant													
		3 DAA-1		7 DAA-1		3 DAA-2		7 DAA-2		3 DAA-3		7 DAA-3		Avg.	
Torac	21 oz	13.4	bcde	24.3	ab	29.0	bcd	53.0	a	36.5	abc	68.5	ab	37.4	b
Movento	5 oz	26.7	ab	21.5	ab	62.5	a	59.0	a	79.5	a	88.0	a	56.2	a
Sequoia	3 oz	25.3	abc	28.1	a	56.5	ab	49.5	a	63.0	ab	92.0	a	52.4	a
Assail	4	23.0	abc	27.7	a	44.0	abc	53.5	a	71.5	ab	95.5	a	52.5	a
Beleaf	2.8	12.9	de	19.5	ab	23.0	d	54.5	a	35.5	bc	69.0	ab	35.7	b
EXP 245987-21	4.1 oz	11.2	e	14.8	b	15.5	d	55.5	a	41.5	abc	48.0	b	31.1	b
Radiant	7 oz	13.4	de	24.2	ab	27.0	cd	46.0	a	42.5	abc	68.0	ab	36.8	b
Lannate	0.8 lb	13.3	de	24.9	a	26.0	cd	44.5	a	29.5	c	65.0	ab	33.9	b
UTC	-	33.3	a	32.8	a	50.0	ab	46.0	a	63.0	ab	71.5	ab	49.4	a
	F value	*8.62*		*4.31*		*11.01*		*0.38*		*5.94*		*3.27*		*18.37*	
	P > F	*>.0001*		*0.003*		*<.0001*		*0.92*		*0.0003*		*0.01*		*<.0001*	

Treatment	Rate (oz/ac)	WFT Larvae / Plant													
		3 DAA-1		7 DAA-1		3 DAA-2		7 DAA-2		3 DAA-3		7 DAA-3		Avg.	
Torac	21 oz	31.7	cde	36.4	bc	71.5	cd	87.5	bcd	66.0	cde	98.0	bcd	65.2	d
Movento	5 oz	73.5	a	55.8	abc	135.5	ab	109.0	abc	116.5	abc	110.0	abc	100.1	bc
Sequoia	3 oz	62.4	ab	74.0	ab	159.5	ab	152.5	ab	133.5	ab	183.0	a	127.5	ab
Assail	4	52.2	abc	63.4	abc	159.0	ab	175.6	a	141.5	ab	176.5	ab	128.0	ab
Beleaf	2.8	39.7	bcd	54.6	bc	85.0	bc	132.5	ab	95.5	bcd	122.0	abc	88.2	cd
EXP 245987-21	4.1 oz	27.0	de	33.3	c	36.5	e	66.0	cd	57.0	def	58.5	d	46.4	e
Radiant	7 oz	20.1	e	34.8	bc	36.0	e	59.0	cd	48.5	ef	74.5	cd	45.5	e
Lannate	0.8 lb	23.0	de	43.7	bc	42.0	de	55.0	d	38.0	f	78.5	cd	46.7	e
UTC	-	84.4	a	122.5	a	185.0	a	177.3	a	199.0	a	176.0	a	157.4	a
	F value	*8.62*		*4.31*		*11.01*		*0.38*		*5.94*		*3.27*		*18.37*	
	P > F	*>.0001*		*0.003*		*<.0001*		*0.92*		*0.0003*		*0.01*		*<.0001*	

Western Flower Thrips A trial was planted to lettuce' Salute MI' on 4 Feb 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 furrow irrigated 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. 2 foliar sprays were applied on 12 and 23 Mar. The applications were made with a

CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 26.4 gpa through 2 TXVS-18 ConeJet nozzles per bed. Dyne-Amic was applied to each spray treatment at 0.125% v/v. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). 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, WFT 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: The addition of Microthiol (soluble sulfur) with Radiant and Lannate did not improve efficacy against WFT. Microthiol applied by itself did not control WFT. Similarly, addition of Torac with Minecto Pro did not provide enhanced WFT control than Torac applied alone. Among the treatments only Torac provided WFT comparable to the industry standards (Radiant and Lannate).

		WFT Adults / Plant			
		Application 1 (7-8 leaf stage)			
Treatment	**Rate/ac**	**3 DAA**	**7 DAA**	**10 DAA**	**Avg**
Torac	21 oz	0.7 c	2.0 b	14.9	5.8 b
Movento	5 oz	4.7 a	13.4 ab	17.5	11.8 a
Sequoia	5.75 oz	1.3 abc	4.9 ab	18.2	8.1 ab
Minecto Pro	10 oz	1.8 abc	5.5 ab	15.9	7.7 ab
Torac+Minecto Pro	21 oz+ 10 oz	0.9 c	2.8 b	19.6	7.8 b
Microthiol	5 lbs	4.9 a	14.3 a	13.6	10.9 a
Radiant	7 oz	1.4 bc	3.8 ab	16.5	7.2 ab
Radiant+Microthiol	7 oz + 5 lbs	1.2 bc	3.3 ab	20.1	8.2 ab
Lannate	1.0 lb	0.6 c	2.2 b	16.9	6.6 b
Lannate+Microthiol	1.0 lb + 5 lbs	0.7 c	1.9 b	16.1	6.2 b
Untreated control	-	4.6 a	14.7 a	15.5	10.4 a
	F value	*7.28*	*7.16*	*2.02*	*6.69*
	P>F	*<.0001*	*<.0001*	*0.07*	*<.0001*

		WFT Adults / Plant				
		Application 2 (13-15 leaf stage)				**Trial**
Treatment	**Rate/ac**	**3 DAA**	**7 DAA**	**10 DAA**	**Avg**	**Avg**
Torac	21 oz	6.0 cde	13.5 bcd	44.5	21.3 def	13.6 d
Movento	5 oz	23.1 a	30.7 a	43.8	32.5 a	22.2 a
Sequoia	5.75 oz	11.2 abc	27.4 a	44.7	27.7 abc	17.9 abc
Minecto Pro	10 oz	10.1 bcd	16.7 abcd	34.8	20.5 bcde	14.1 bcd
Torac+Minecto Pro	21 oz+ 10 oz	5.3 de	18.4 abcd	53.1	25.6 cde	16.7 cd
Microthiol	5 lbs	15.5 ab	23.0 ab	38.6	25.7 abcd	18.3 ab
Radiant	7 oz	2.9 e	10.6 d	31.8	15.1 f	11.2 d
Radiant+Microthiol	7 oz + 5 lbs	5.2 cde	13.7 cd	41.9	20.2 ef	14.2 cd
Lannate	1.0 lb	5.4 cde	11.9 cd	39.3	18.9 ef	12.7 d
Lannate+Microthiol	1.0 lb + 5 lbs	5.7 cde	11.3 cd	46.6	21.2 ef	13.7 d
Untreated control	-	20.0 ab	25.1 ac	49.4	31.5 ab	21.0 ab
	F value	*17.55*	*8.45*	*1.35*	*14.47*	*15.11*
	P>F	*<.0001*	*<.0001*	*0.25*	*<.0001*	*<.0001*

		WFT Larvae / Plant			
		Application 1 (7-8 leaf stage)			
Treatment	**Rate/ac**	**3 DAA**	**7 DAA**	**10 DAA**	**Avg**
Torac	21 oz	5.6 bcd	6.2 c	6.9 cd	6.2 c
Movento	5 oz	9.8 ab	14.4 abc	16.4 abc	13.5 abc
Sequoia	5.75 oz	6.8 abcd	10.3 abc	25.3 ab	14.2 abc
Minecto Pro	10 oz	9.4 abc	11.3 abc	14.3 abcd	11.6 bc
Torac+Minecto Pro	21 oz+ 10 oz	4.1 bcde	8.7 bc	5.5 d	6.1 c
Microthiol	5 lbs	12.9 a	20.9 ab	32.2 a	22.0 ab
Radiant	7 oz	2.0 de	7.6 bc	8.5 cd	6.0 c
Radiant+Microthiol	7 oz + 5 lbs	1.7 e	6.8 c	5.9 cd	4.8 c
Lannate	1.0 lb	2.4 cde	8.8 cd	8.5 cd	6.6 c
Lannate+Microthiol	1.0 lb + 5 lbs	2.7 cde	7.8 cd	9.7 cd	6.7 c
Untreated control	-	14.8 a	30.1 a	28.2 a	24.4 a
	F value	*9.26*	*5.67*	*9.71*	*12.79*
	P>F	*>.0001*	*<.0001*	*<.0001*	*<.0001*

		WFT Larvae / Plant				
		Application 2 (13-15 leaf stage)				Trial
Treatment	Rate/ac	3 DAA	7 DAA	10 DAA	Avg	Avg
Torac	21 oz	3.7 def	11.7 c	25.9 bcd	13.8 cd	10.0 c
Movento	5 oz	11.8 cd	42.5 b	63.5 ab	39.3 b	26.4 b
Sequoia	5.75 oz	13.9 bc	62.1 ab	84.2 a	53.4 ab	33.8 b
Minecto Pro	10 oz	17.9 bc	35.4 b	56.6 ab	36.6 b	24.1 b
Torac+Minecto Pro	21 oz+ 10 oz	5.0 cde	11.5 c	26.8 bc	14.5 c	10.3 c
Microthiol	5 lbs	39.0 ab	97.6 a	79.9 a	72.2 a	47.1 a
Radiant	7 oz	1.0 f	5.0 c	6.7 e	4.2 f	5.1 e
Radiant+Microthiol	7 oz + 5 lbs	1.5 ef	6.8 c	8.8 de	5.7 ef	5.2 e
Lannate	1.0 lb	3.0 ef	5.0 c	14.6 cde	7.5 def	7.1 de
Lannate+Microthiol	1.0 lb + 5 lbs	4.6 cde	6.6 c	17.3 cde	9.5 cde	8.1 cd
Untreated control	-	47.9 a	82.2 ab	124.6 a	84.9 a	54.6 a
	F value	*24.85*	*30.65*	*21.26*	*56.71*	*64.94*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Aphids – Senstar Head lettuce 'Magosa' was direct seeded on Dec 20, 2020 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 applications were made 9 Feb and 5 Mar with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi and 24 GPA. Dyne-amic (0.25%) v/v was applied to all treatments. Evaluations of green peach aphid (GPA) and lettuce aphid (LA) populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. 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. At harvest, 8 plants were randomly selected from each plot and individually sampled by visually examining all foliage within a harvested head and 4 wrapper leaves. The total aphids per head and the percentage of heads infested with 1, 5 and 10 or more aphids was calculated. Data for all aphid species were analyzed. Because of heterogeneity of mean variances, data for all insect were transformed using a log10 (x+1) function before analysis for aphid data and an arcsine transformation for % heads infested. 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 treatments except Senstar, Sivanto and Sequoia (2 oz)provided significant control of green peach aphids. In contrast, Sentstar, Movento and Sivanto provided the best protection of lettuce head contamination from lettuce aphids.

		Avg. Green peach aphid / plant							
Treatment	**Rate/ac**	**10-Feb**	**12-Feb**	**16-Feb**	**23-Feb**	**3-Mar**	**10-Mar**	**17-Mar**	**Avg.**
Sequoia	2 oz	5.2 a	3.5 a	3.5 a	0.3 b	0.4 a	0.0 a	0.0	1.8 ab
Sequoia	4.3 oz	4.7 a	3.0 a	3.0 a	0.3 b	0.0 a	0.0 a	0.0	1.6 b
Movento	5.0 oz	2.8 a	3.7 a	3.7 a	0.5 b	0.0 a	0.1 a	0.0	1.5 b
Senstar	10 oz	3.4 a	4.1 a	4.1 a	0.8 ab	0.1 a	0.0 a	0.0	1.8 ab
Sivanto HL	5.0 oz	3.7 a	3.7 a	3.7 a	0.3 b	0.2 a	0.1 a	0.0	1.7 ab
Versys	1.5 oz	2.5 a	3.7 a	3.7 a	0.4 b	0.2 a	0.1 a	0.0	1.5 b
PQZ	3.2 oz	3.3 a	3.5 a	3.5 a	0.6 ab	0.3 a	0.0 a	0.0	1.6 b
UTC	-	5.9 a	5.9 a	5.9 a	2.7 a	0.2 a	0.5 a	0.0	3.0 a
	F	*1.04*	*0.47*	*2.17*	*4.89*	*0.66*	*1.62*	-	*3.09*
	P>F	*0.43*	*0.85*	*0.08*	*.002*	*0.71*	*0.19*	-	*0.02*

		Avg. Lettuce aphid / plant							
Treatment	**Rate/ac**	**10-Feb**	**12-Feb**	**16-Feb**	**23-Feb**	**3-Mar**	**10-Mar**	**17-Mar**	**Avg.**
Sequoia	2 oz	0.0	0.0 a	0.2 a	0.1 a	0.3 a	1.5 ab	2.6 bc	0.7 bc
Sequoia	4.3 oz	0.0	0.0 a	0.0 a	0.1 a	0.0 a	0.3 b	1.3 cd	0.2 cd
Movento	5.0 oz	0.0	0.0 a	0.0 a	0.0 a	0.0 a	0.3 b	0.1 e	0.1 d
Senstar	10 oz	0.0	0.0 a	0.0 a	0.0 a	0.2 a	0.1 b	0.3 de	0.1 d
Sivanto HL	5.0 oz	0.0	0.3 a	0.1 a	0.8 a	0.2 a	2.1 b	0.3 de	0.5 bcd
Versys	1.5 oz	0.0	0.0 a	0.0 a	0.7 a	0.9 a	5.2 ab	11.8 ab	2.7 ab
PQZ	3.2 oz	0.0	0.0 a	0.6 a	0.0 a	0.5 a	7.8 ab	8.7 ab	2.5 ab
UTC	-	0.0	0.0 a	0.5 a	1.6 a	2.2 a	16.4 a	20.5 a	5.9 a
	F	-	*1.1*	*1.08*	*1.84*	*1.31*	*5.13*	*23.03*	*15.11*
	P>F	-	*0.46*	*0.41*	*0.13*	*0.29*	*0.001*	*<.0001*	*<.0001*

Mar 17 Harvest

			% Heads infested with		
Treatment	**Rate/ac**	**Lettuce aphids / head**	**1 or > aphids**	**5 or > aphids**	**10 or > aphids**
Sequoia	2 oz	2.6 bc	40.6 bc	9.4 bcd	9.4 ab
Sequoia	4.3 oz	1.3 cd	25.0 c	12.5 bcd	6.3 b
Movento	5.0 oz	0.0 e	3.1 d	0.0 d	0.0 c
Senstar	10 oz	0.3 de	15.6 cd	0.0 d	0.0 c
Sivanto HL	5.0 oz	0.3 de	12.5 cd	6.3 cd	0.0 c
Versys	1.5 oz	11.8 ab	71.9 ab	40.6 ab	34.4 a
PQZ	3.2 oz	8.7 ab	65.6 ab	37.5 abc	18.8 ab
UTC	-	20.5 a	75.0 a	56.3 a	35.0 a
		23.23	*19.76*	*10.49*	*11.17*
		<.0001	*<.0001*	*<.0001*	*<.0001*

II. Organic Insect Control:

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 biopesticides are registered for insect control, there is much uncertainty among growers and PCAs whether the products will 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 2020-2021, we proposed to will focus on determine the relative performance the key products against thrips.

Biopesticide Efficacy against Western Flower Thrips I Romaine' Valley Heart' was direct seeded on 5 Feb, 2021 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 one untreated bed. Four replications of each treatment were arranged in a RCB design. Formulations, rates , adjuvants and spray dates for each compound are provided in the tables. Three applications were made on 10, 17 and 25 Mar with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50psi and 26.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Silwet, was added to all treatments at 0.25%v/v. Peroxyacetic acid, Oxidate 5 at 1:500, was added to the Neem/Azadirechtin treatments to lower the pH to 6.1. Numbers of Western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). 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. Pre-spray counts were 3.7 adults and 5.6 larvae per plant. 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: Among all the organically-approved biopesticides evaluated in this study only Entrust provided significant control of WFT adults and larvae.

		WFT Adults / Plant				
Treatment	**Rate/ acre**	**5-DAA1**	**6-DAA2**	**6-DAA3**	**12-DAA3**	**Trial avg.**
Radiant	7 oz	5.0 ab	11.3 c	24.0 a	41.0 a	20.3 c
Entrust	7 oz	3.4 b	14.2 bc	19.8 a	44.0 a	20.4 c
Venerate	1 qt	8.5 a	23.4 a	24.5 a	69.5 a	31.5 a
Aza-Direct+Pyganic	3 pts+15 oz	8.0 ab	18.9 ab	31.7 a	64.0 a	30.6 ab
Rango	1.8%	9.9 a	18.9 ab	22.7 a	61.5 a	28.2 ab
AP 8030	2.0%	6.9 ab	19.0 ab	21.3 a	46.0 a	23.3 abc
UTC	-	7.0 ab	18.8 ab	27.1 a	52.0 a	26.2 abc
	F	*4.04*	*6.69*	*1.38*	*1.25*	*4.96*
	P>F	*0.009*	*0.0008*	*0.28*	*0.33*	*0.004*

		WFT Larvae / Plant				
Treatment	**Rate/ acre**	**5-DAA1**	**6-DAA2**	**6-DAA3**	**12-DAA3**	**Trial avg.**
Radiant	7 oz	5.3 a	5.8 b	8.3 c	89.5 b	27.2 b
Entrust	7 oz	6.5 a	7.4 b	26.7 b	83.0 b	30.9 b
Venerate	1 qt	8.4 a	27.3 a	76.8 a	155.5 ab	67.0 a
Aza-Direct+Pyganic	3 pts+15 oz	8.6 a	21.6 a	46.3 ab	122.0 ab	49.6 a
Rango	1.8%	12.8 a	42.3 a	92.3 a	160.5 ab	77.0 a
AP 8030	2.0%	11.5 a	36.8 a	80.4 a	167.8 ab	74.1 a
UTC	-	9.4 a	39.1 a	97.4 a	190.8 a	84.1 a
	F	*2.19*	*16.52*	*28.76*	*4.04*	*30.79*
	P>F	*0.09*	*<.0001*	*<.0001*	*0.007*	*<.0001*

Biopesticide Efficacy against Western Flower Thrips II Romaine' Valley Heart' was direct seeded on 15 Mar , 2021 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 one untreated bed. Four replications of each treatment were arranged in a RCB design. Formulations, rates , adjuvants and spray dates for each compound are provided in the tables. Three applications were made on 10, 16 and 23 Apr with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50psi and 26.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Silwet, was added to all treatments at 0.25%v/v. Peroxyacetic acid, Oxidate 5 at 1:500, was added to the Neem/Azadirechtin treatments to lower the pH to 6.1. Numbers of Western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). 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. Pre-spray counts were 3.7 adults and 5.6 larvae per plant. 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: The Entrust and Entrust+M-Pede combination were the only treatments that significantly controlled WFT adults following 3 applications. The addition of M-Pede with Entrust did not enhance adult control. However, addition of M-Pede with Entrust provided significantly better control of WFT larvae than Entrust applied alone. Aza-Direct was the only other biopesticide product to provide WFT larva control.

Treatment	Rate (oz/ac)	WFT adults / Plant											
		3 DAA-1		6 DAA-1		3 DAA-2		6 DAA-2		6 DAA-3		Avg.	
Entrust**	7 oz	5.6	bc	29.4	a	16.9	b	52.5	a	64.5	a	33.8	c
M-Pede	4.00%	10.7	ab	25.8	a	29.7	a	38.0	a	71.0	a	35.0	abc
Entrust + M-Pede	7 oz + 2%	3.4	c	30.2	a	20.3	ab	52.5	a	63.5	a	34.0	c
PureCrop1	1.60%	19.1	a	26.7	a	23.4	ab	45.5	a	93.0	a	41.5	a
AP 8030	2.00%	20.2	a	24.0	a	30.9	a	44.5	a	69.0	a	37.7	ab
AZA-Direct**	3.5 pts	15.3	a	30.7	a	27.3	ab	55.0	a	82.0	a	42.1	a
Prevam	0.80%	20.4	a	26.5	a	26.1	ab	46.5	a	102.5	a	44.4	a
Garlic Barrier**	11.00%	24.0	a	31.8	a	27.9	ab	40.0	a	104.5	a	45.6	a
UTC	-	22.1	a	32.6	a	25.0	ab	41.5	a	85.5	a	41.3	a

Treatment	Rate (oz/ac)	WFT larvae / Plant											
		3 DAA-1		6 DAA-1		3 DAA-2		6 DAA-2		6 DAA-3		Avg.	
Entrust**	7 oz	7.0	b	35.8	a	7.9	c	37.0	cd	49.0	bc	27.3	d
M-Pede	4.00%	23.9	a	47.5	a	33.6	ab	63.5	bcd	105.0	a	54.7	bc
Entrust + M-Pede	7 oz + 2%	1.7	c	12.0	b	2.2	d	26.0	d	25.5	c	13.5	e
PureCrop1	1.60%	22.6	a	47.4	a	49.0	a	99.0	ab	113.5	a	66.3	ab
AP 8030	2.00%	30.7	a	52.5	a	56.4	a	112.5	ab	82.0	ab	66.8	ab
AZA-Direct**	3.5 pts	15.8	a	39.5	a	17.3	bc	58.5	bc	93.0	ab	44.8	c
Prevam	0.80%	27.0	a	44.7	a	53.3	a	106.5	ab	129.5	a	72.2	ab
Garlic Barrier**	11.00%	31.5	a	61.1	a	41.3	a	127.5	ab	100.5	ab	72.4	ab
UTC	-	26.2	a	57.0	a	74.1	a	130.0	a	145.5	a	86.6	a

III. Water Sanitizers Used as Fungicides

Research conducted in 2019-2020 demonstrated that anti-microbial water sanitizers (Peroxyacetic acid and chlorine) did not impact insecticide efficacy when used in spray application solutions at low, labeled rates (*see 2020 AILRC Final Report*). However, questions have recently arisen concerning use of PAA at 3-5X higher rates as a fungicide. We wonder whether using PAA at these higher rates will dramatically lower spray pH below 4, and subsequently impact the efficacy of some products (Ensure). We proposed to examine tank mixtures of Entrust with higher rates of PAA and measure the impact on residual activity against worms and thrips.

Beet Armyworm Efficacy with Entrust and Oxidate 5.0 Head lettuce 'PYB7101A' was direct seeded on 8 Sep, 2020 at the Yuma Valley Agricultural Center (YAC), 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. Entrust was applied at 5 oz/ac to all treatments. Oxidate 5.0 were applied at the following concentrations: Sanitizer rate: 1:1500 dilution, Preventative rate: 1:500 dilution and Curative rate at 1:256 dilution. Two foliar applications were made on 8 and 29 Oct with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi and 21.5 GPA. Beet armyworm (BAW) control was based on the examination of 5-10 whole plant at various intervals following each application (DAA). The presence of large (2^{nd} or > instar) larvae was recorded from each plant. 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: The addition of Oxidate 5.0, regardless of rate-dilution, did not lower the pH below 5.0, and accordingly did not affect the efficacy of Entrust against BAW in lettuce.

Oct 9 (3-4 leaves plant stage)

				BAW / 10 plants		
Treatment	**Oxidate5.0 - dilution**	**pH**	**% feeding damage**	**Small larvae**	**Large larvae**	**Total larvae**
Entrust - 5 oz	-	7.9	4.2 ab	0.0 a	0.0 a	0.0 a
Entrust - 5 oz	1:2500	6.9	0 b	1.3 a	0.0 a	1.3 a
Entrust - 5 oz	1:500	6.1	12.5 ab	0.0 a	1.3 ab	1.3 a
Entrust - 5 oz	1:256	5.1	0 b	0.0 a	0.0 a	0.0 a
UTC	-		37.5 a	0.8 a	3.8 a	4.6 a

Oct 12 (5-6 leaves plant stage)

				BAW / 10 plants		
Treatment	**Oxidate5.0 - dilution**	**pH**	**% feeding damage**	**Small larvae**	**Large larvae**	**Total larvae**
Entrust - 5 oz	-	7.9	8.3 a	0.4 a	1.3 ab	1.7 ab
Entrust - 5 oz	1:2500	6.9	4.2 a	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:500	6.1	16.7 a	0.0 a	1.3 ab	1.3 ab
Entrust - 5 oz	1:256	5.1	8.3 a	0.0 a	0.8 ab	0.8 ab
UTC	-		33.3 a	0.0 a	3.8 a	3.8 a

Oct 15 (6 leaves plant stage)

				BAW / 10 plants		
Treatment	**Oxidate5.0 - dilution**	**pH**	**% feeding damage**	**Small larvae**	**Large larvae**	**Total larvae**
Entrust - 5 oz	-	7.9	0.4 b	0.4 a	0.0 b	0.4 b
Entrust - 5 oz	1:2500	6.9	0 b	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:500	6.1	0 b	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:256	5.1	12.5 b	0.0 a	1.3 b	1.3 b
UTC	-		45.8 a	0.4 a	5.0 a	5.4 a

Oct 19 (7-8 leaves plant stage)

Treatment	Oxidate5.0 - dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	8.3 b	0.0 a	0.4 b	0.4 b
Entrust - 5 oz	1:2500	6.9	0 b	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:500	6.1	0 b	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:256	5.1	4.2 b	0.0 a	0.4 b	0.4 b
UTC	-		29.2 a	0.0 a	2.5 a	2.5 a

Oct 22 (8-9 leaves plant stage)

Treatment	Oxidate5.0 - dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	17.3 b	0.0	0.8 b	0.8 b
Entrust - 5 oz	1:2500	6.9	0 b	0.0	1.3 ab	1.3 ab
Entrust - 5 oz	1:500	6.1	0 b	0.0	0.0 b	0.0 b
Entrust - 5 oz	1:256	5.1	17.3 b	0.0	0.4 b	0.4 b
UTC	-		89.6 a	0.0	5.4 a	5.4 a

Oct 30 (10-12 leaves plant stage)

Treatment	Oxidate5.0 - dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	0 a	0.0	0.0 a	0.0 a
Entrust - 5 oz	1:2500	6.9	0 a	0.0	0.0 a	0.0 a
Entrust - 5 oz	1:500	6.1	0 a	0.0	0.0 a	0.0 a
Entrust - 5 oz	1:256	5.1	8.3 a	0.0	0.4 a	0.4 a
UTC	-		8.3 a	0.0	0.4 a	0.4 a

Nov 2 (12-14 leaves plant stage)

Treatment	Oxidate5.0 - dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	0.0	0.0	0.0	0.0
Entrust - 5 oz	1:2500	6.9	0.0	0.0	0.0	0.0
Entrust - 5 oz	1:500	6.1	0.0	0.0	0.0	0.0
Entrust - 5 oz	1:256	5.1	0.0	0.0	0.0	0.0
UTC	-		0.0	0.0	0.0	0.0

Nov 5 (14-16 leaves plant stage)

Treatment	Oxidate5.0 - dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	4.2 a	0.0	0.4 a	0.4 a
Entrust - 5 oz	1:2500	6.9	4.2 a	0.0	0.4 a	0.4 a
Entrust - 5 oz	1:500	6.1	0.0 a	0.0	0.0 a	0.0 a
Entrust - 5 oz	1:256	5.1	4.2 a	0.0	0.4 a	0.4 a
UTC	-		8.3 a	0.0	1.3 a	1.3 a

Nov 9 (14-16 leaves plant stage)

Treatment	Oxidate5.0 -dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	0.0 a	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:2500	6.9	4.2 a	0.0 a	0.4 b	0.4 b
Entrust - 5 oz	1:500	6.1	0.0 a	0.0 a	0.0 b	0.0 b
Entrust - 5 oz	1:256	5.1	0.0 a	0.0 a	0.0 b	0.0 b
UTC	-		16.7 a	0.4 a	2.1 a	2.5 a

Nov 12 (14-16 leaves plant stage)

Treatment	Oxidate5.0 -dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	0.0 a	0.0	0.0 b	0.0 b
Entrust - 5 oz	1:2500	6.9	0.0 a	0.0	0.0 b	0.0 b
Entrust - 5 oz	1:500	6.1	4.2 a	0.0	0.4 b	0.4 b
Entrust - 5 oz	1:256	5.1	8.3 a	0.0	0.4 b	0.4 b
UTC	-		12.5 a	0.0	2.5 a	2.5 a

Nov 12 (14-16 leaves plant stage)

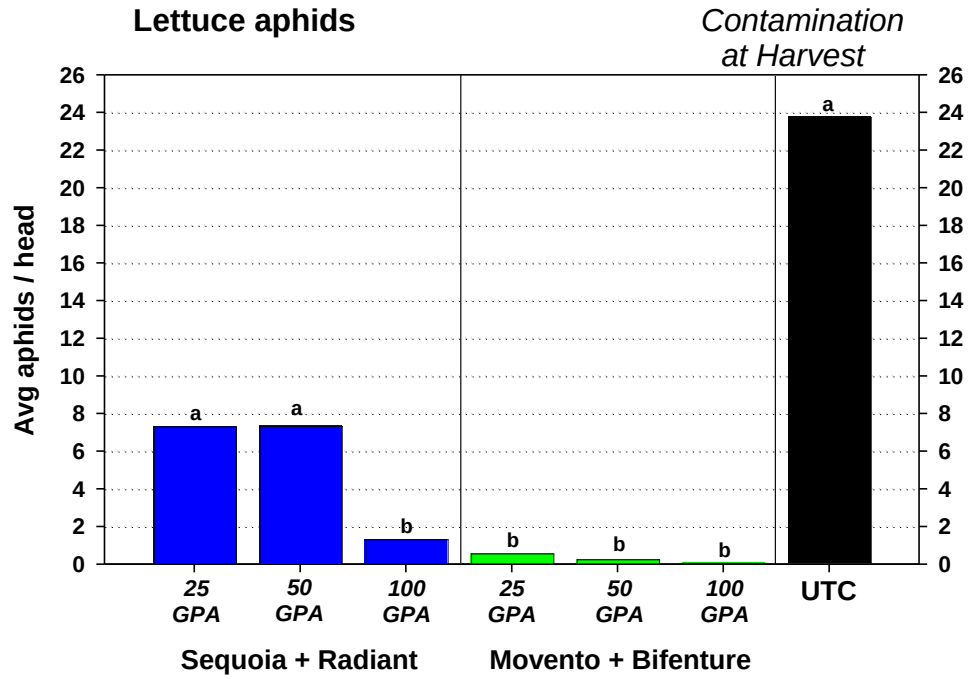
Treatment	Oxidate5.0 -dilution	pH	% feeding damage	BAW / 10 plants		
				Small larvae	Large larvae	Total larvae
Entrust - 5 oz	-	7.9	0.0 a	0.0	0.0 b	0.0 b
Entrust - 5 oz	1:2500	6.9	0.0 a	0.0	0.0 b	0.0 b
Entrust - 5 oz	1:500	6.1	4.2 a	0.0	0.4 b	0.4 b
Entrust - 5 oz	1:256	5.1	8.3 a	0.0	0.4 b	0.4 b
UTC	-		12.5 a	0.0	2.5 a	2.5 a

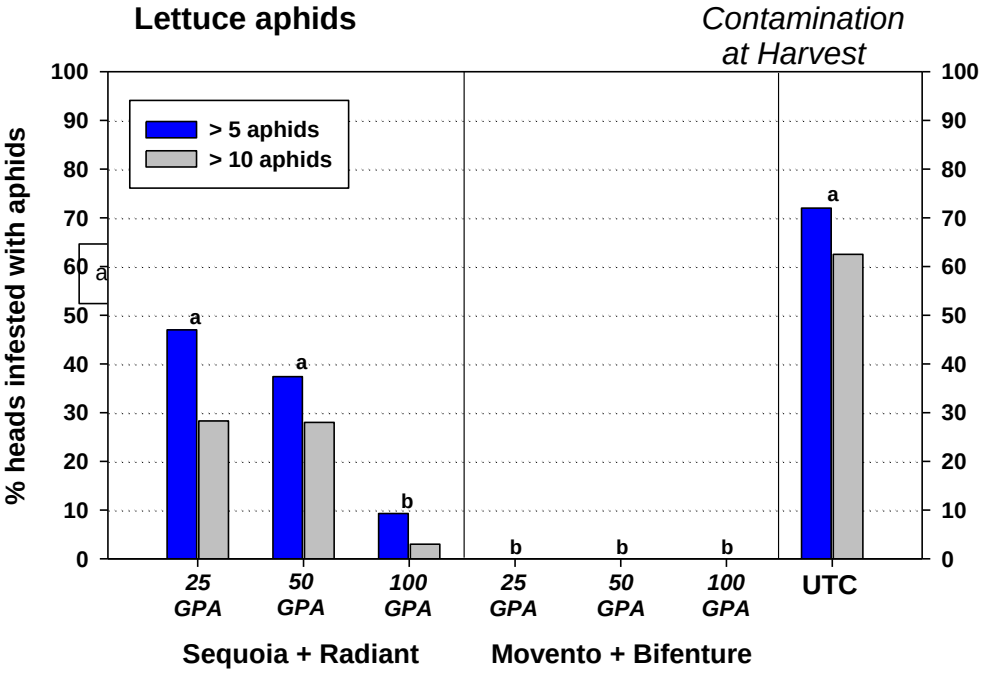
IV. Spray Volumes – High vs. Low

There has been an ongoing debate concerning the optimal spray volume needed for applying insecticides against pest like Worms, Thrips and Aphids on lettuce. PCAs from coastal growing regions feel higher spray volumes (80-100 GPA) are necessary to achieve maximum efficacy, while local PCA (and myself) are confident that optimal efficacy is achieved at lower spray volumes (20-30 GPA). Furthermore, EPA is proposing to establish mandatory spray drift language on all pesticide labels that requires applicators to use a medium or coarser droplet size. In my experience, to produce lager spray droplets, applicators will have to increase spray volume, use lower spray pressure, and/or use different spray nozzles. Unfortunately, we don't know how larger droplet sizes will affect spray efficacy on desert lettuce? We proposed to evaluate the efficacy of key insecticides against worms, aphid and thrips using standard application methods (40-50 psi; hollow cone nozzles) compared with high spray volume applications (75-100 gpa).

Trial I - Aphids Head lettuce 'Magosa' was direct seeded on Dec 9, 2020 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. A single foliar applications wase made on 8 Mar *(10 days pre-harvest)* with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi. Three sprays volumes were delivered: 25, 50 and 100 GPA. Two spray combinations were compared for each spray volume: 1) Sequoia (3 oz) + Radiant (7 oz), and 2) Movento (5 oz) + Bifenture (5 oz). Dyne-amic (0.25%) v/v was applied to both treatments. Evaluations of lettuce aphid (LA) populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. At harvest (18 Mar), 10 plants were randomly selected from each plot and individually sampled by visually examining all foliage within a harvested head and 4 wrapper leaves. The total aphids per head and the percentage of heads infested with > 1, 5 or 10 aphids was calculated. Because of heterogeneity of mean variances, data for all insect were transformed using a log10 (x+1) function before analysis for aphid data and an arcsine transformation for % heads infested. 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.

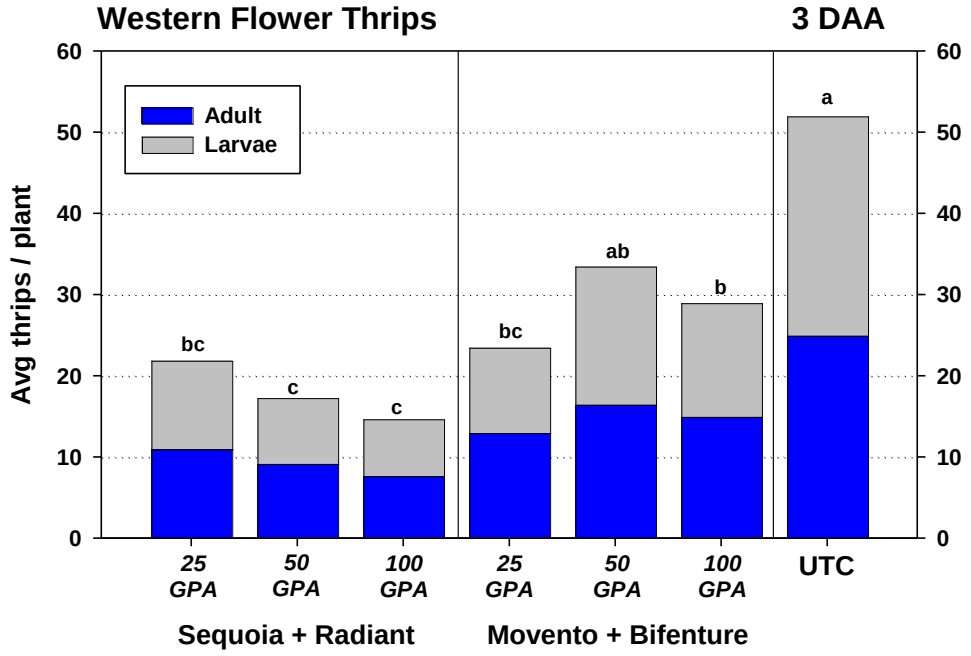
Summary: Movento provided excellent control of lettuce aphids regardless of spray volume. This makes sense because Movento is fully systemic in the plant and whole leaf coverage is not necessary for control of sucking pests like aphids. Efficacy of Sequoia, on the other hand, was significantly improved at 100 GPA. Sequoia has limited systemic activity, and good contact and translaminar activity. Thus improved coverage would be expected to provide better control.

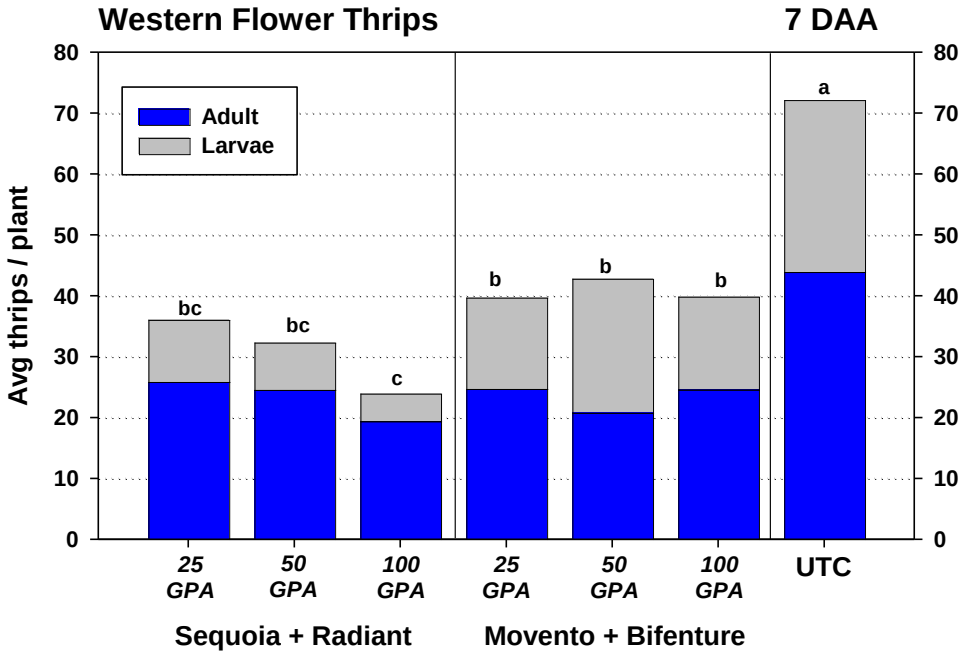

Lettuce aphids
Contamination at Harvest
Avg aphids / head
26
24
22
20
18
16
14
12
10
8
6
4
2
0
a
a
b
b
b
b
a
25 GPA
50 GPA
100 GPA
25 GPA
50 GPA
100 GPA
UTC
Sequoia + Radiant
Movento + Bifenture


Lettuce aphids
Contamination at Harvest
% heads infested with aphids
> 5 aphids
> 10 aphids
100
90
80
70
60
50
40
30
20
10
0
a
a
a
b
b
b
b
a
25 GPA
50 GPA
100 GPA
25 GPA
50 GPA
100 GPA
UTC
Sequoia + Radiant
Movento + Bifenture

Trial I – Western Flower Thrips Head lettuce 'Magosa' was direct seeded on Dec 9, 2020 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. A single foliar application was made on 22 Feb *(21 days pre-harvest)* with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi. Three sprays volumes were delivered: 25, 50 and 100 GPA. Two spray combinations were compared for each spray volume: 1) Sequoia (3 oz) + Radiant (7 oz), and 2) Movento (5 oz) + Bifenture (5 oz). Dyne-amic (0.25%) v/v was applied to both treatments. At 3 and 7 days after application, 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: Radiant applied at both 50 and 100 gpa appeared to provide significantly better control of WFT, and control did not differ significantly between the 2 rates at 3 DAA. However, residual control at 7 DAA suggests that 100 gpa provided significantly better control. Movento provided only suppression of adult and larva WFT and significant differences among rates was not observed.





Trial I – Western Flower Thrips Lettuce ' Del Sol' was direct seeded on Feb 4, 2021 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 applications were made on 26 Mar and 12 Apr with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi. Three sprays volumes were delivered: 25, 50 and 100 GPA. Two spray insecticides were compared for each spray volume: 1) Radiant (7 oz), and 2) Lannate (0.8 lb). Dyne-amic (0.25%) v/v was applied to both treatments. At various intervals after application (DAA), 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: Higher spray volumes (50-100) appeared to provide better knockdown control of WFT adults and larvae for both Radiant and Lannate, but residual control (10-14) was not significantly influenced by spray volume.

		WFT Adults / Plant													
Treatment	**GPA**	**3 DAA-1**		**7 DAA-1**		**10 DAA-1**		**14 DAA-1**		**3 DAA-2**		**7 DAA-2**		**Avg.**	
Radiant	25	4.8	bc	12.6	ab	24.9	a	42.5	a	10.5	ab	17.0	a	18.7	ab
Radiant	50	5.9	bc	16.0	ab	25.9	a	49.5	a	10.0	b	26.0	a	22.2	ab
Radiant	100	3.4	c	11.4	b	25.5	a	31.5	a	11.0	ab	17.0	a	16.6	b
Lannate	25	11.3	ab	21.8	ab	18.5	a	38.5	a	6.5	b	20.5	a	19.5	ab
Lannate	50	5.5	bc	9.8	b	18.8	a	30.0	a	8.5	b	23.5	a	16.0	b
Lannate	100	8.4	bc	12.3	b	17.3	a	47.0	a	22.3	a	25.0	a	22.1	ab
Untreated	-	23.2	a	27.3	a	27.2	a	40.0	a	13.0	ab	19.7	a	25.1	a
	F	*9.27*		*4.25*		*1.12*		*1.39*		*3.76*		*1.17*		*3.24*	
	P>F	*0.0001*		*0.008*		*0.38*		*0.27*		*0.01*		*0.36*		*0.02*	

		WFT Larvae / Plant													
Treatment	**GPA**	**3 DAA-1**		**7 DAA-1**		**10 DAA-1**		**14 DAA-1**		**3 DAA-2**		**7 DAA-2**		**Avg.**	
Radiant	25	8.2	bc	8.1	c	5.4	bc	40.0	bc	38.5	abc	20.0	ab	20.0	b
Radiant	50	7.5	bc	8.8	c	7.6	bc	50.5	ab	48.5	ab	18.5	ab	23.6	b
Radiant	100	5.0	c	3.5	c	3.8	c	40.0	bc	24.0	abc	11.5	b	14.6	b
Lannate	25	25.1	b	55.1	ab	42.0	b	38.5	bc	11.0	c	11.0	b	30.4	b
Lannate	50	7.6	bc	8.9	c	10.9	bc	27.5	bc	22.0	abc	24.0	ab	16.8	b
Lannate	100	8.6	bc	15.6	bc	9.7	bc	19.5	c	25.0	bc	32.5	ab	18.5	b
Untreated	-	78.8	a	109.4	a	105.1	a	97.8	a	107.5	a	65.0	a	93.9	a
	F	*15.85*		*16.64*		*13.34*		*9.61*		*4.71*		*4.37*		*27.32*	
	P>F	*<.0001*		*<.0001*		*<.0001*		*<.0001*		*0.005*		*0.007*		*<.0001*	