Arizona Department of Agriculture
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Project no. 15-04

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

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Location of Research: Yuma Valley Agricultural Center

Objective 1: *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.*

New insecticides are being developed for insect control in head lettuce each year. This is extremely important given the recent losses of a number of important insecticide uses (e.g., endosulfan). Many in the industry expect restrictions in the uses of pyrethroids and other older products to follow in the future. Furthermore, the future of the neonicotinoids (imidacloprid) is uncertain. Although most of the newly developed products that growers use are very effective against the key lettuce insect pests, they tend to be very expensive. Thus, it is critical that growers continue to explore how to use newer products more cost-effectively. In addition, there are several new, unregistered insecticides that are under development that will likely provide activity against on many of the key pests that infest lettuce.

The continual occurrence of several key insect pests further justifies the need to explore new insecticides and their cost-effective use patterns for local growers and PCAs. Western flower thrips have become increasingly difficult and expensive to control in both spring and fall lettuce. Two of the primary products currently used for controlling thrips (Lannate and Orthene) are directly threatened by FQPA and their future registrations are uncertain. A complex of aphid species is well established in desert lettuce and their control can be expensive. Finally, whiteflies and worm pests such as beet armyworm and cabbage looper remain the most economically important pest in fall lettuce and typically require intensive management to prevent losses.

Newer insecticides currently available for control offer many favorable attributes to lettuce growers because they are very selective, environmentally friendly, and very effective against certain insect pests. Products such as Radiant and Proclaim have been the standards for worm control the past few years, but the recent registration of a Coragen, Voliam Xpress , Synpase and Vetica have recently provided more options. Similarly, Movento is clearly the most commonly used product for aphid control, and other foliar alternative products are available. Use of Admire and generic imidacloprid products as soil insecticides remains about the same, but their cost to the grower has dropped significantly. Finally, a number of new compounds with different modes of action are presently being developed that provide a wide spectrum of activity against many key insect pests **(Figure 1 below).** 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.

Figure 1. **Insecticidal activity of new insecticides alternatives against key insect pests relative to the industry standards currently used in desert head lettuce.**

	Beet armyworm	Cabbage looper	Sweetpotato whitefly	Aphid complex	Western flower thrips	Bagrada bug	Flea beetle	*Liriomyza* Leafminers	Seed corn maggot
Exirel	1	1	1	2	3	2	1-2	1	1
Verimark	1	1	1	2	3	2	1-2	1	1
Sivanto-soil	3	3	1	2	3	2			
Sivanto-foliar	3	3	1	2	3	2			
Pyrifluquinazon	3	3	1	2	2	2			
Closer	3	3	2	1	3	2			
Torac	2	2	2	2	2	2	2		
Standards	Radiant Proclaim Coragen	Radiant Proclaim Coragen	Neonics. Movento	Movento Imidacloprid Beleaf	Radiant Lannate Orthene	Pyrethroid Lannate	Pyrethroid Lannate	Radiant Coragen	Pyrethroid Diazinon

1	Consistent performance in UA research trials; As good as or better than the industry standard products currently used.
2	Inconsistent performance; Not as good as the industry standard products currently used.
3	Not considered economically effective.

For a list of the 15 most common products applied in head lettuce go to : http://extension.arizona.edu/sites/extension.arizona. edu /files /resourcefile/resource/marcop/2012_Lettuce%20Crop%20Losses%20Summary%20Data%20051612.pdf

Below are the results for six trials for Objective 1 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.

I. Efficacy against Worms

1. COMPARISON OF FOLIAR INSECTICIDE ALTERNATIVES FOR CONTROL OF LEPIDOPTEROUS LARVAE

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 6 Sep, 2014. Plots were two beds wide by 40 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 5, 17 Oct and 12 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 adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments. At various intervals after treatment (DAT), 10 plants were randomly selected from each replicate and destructively sampled for the presence of each insect species. Beet armyworm and cabbage looper (CL) control was based on the examination of whole plants for presence of large (2^{nd} or > instar) larvae. At harvest (24 Nov), estimates of head contamination were made by examining 10 mature heads (plus 2 wrapper leaves) from each plot for presence of feeding damage, frass and lepidopterous larvae. 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 (Proc GLM; SAS Institute 2009). Means were compared using an F-protected LSD ($P \leq 0.05$). At harvest, data for head contamination were converted to percentages by dividing the total number of contaminated heads by the total number of heads examined (n=10). The response variables (percentage damage, frass, and larvae) were subjected to arcsine square root transformation before analysis. Means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary: CL numbers were very low following the first application and differences among treatments were not observed until 11 DAT-1 where larvae numbers in the Proclaim and Belt treatments did not differ from the non-treated control (Table 1). Thereafter, differences among treatments and the non-treated control were observed. Overall, Proclaim and Belt provided the least consistent CL control. BAW was consistently heavy following the first and second applications. All treatments, except Belt at 1 DAT-1, significantly reduced BAW numbers compared to the non-treated check (Table 2). Following the third application control was less consistent. Overall, Exirel and Radiant provided the most consistent BAW control. Harvest quality evaluations showed that all spray treatments provided significant reductions in head contamination relative to the non-treated control, except for head damage in the Proclaim treatment (Table 3). No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1.

Treatment/formulation	Rate amt product/acre	CL larvae / 10 Plants					
		1 DAT-1 6-Oct	*3 DAT-1* 8-Oct	*7 DAT-1* 13-Oct	*11 DAT-1* 16-Oct	*3 DAT-2* 20-Oct	*7 DAT-2* 24-Oct
Radiant	5 oz	0.0a	0.0a	0.3a	0.0c	0.0b	0.0b
Intrepid + Warrior II	10 + 1.9 oz	0.0a	0.0a	0.3a	0.9bc	0.3b	0.0b
Proclaim	3.8	0.0a	0.0a	1.9a	4.4abc	1.3b	0.0b
Voliam Xpress	9 oz	0.0a	0.0a	0.0a	0.3c	0.0b	0.9b
Exirel	14 oz	0.0a	0.0a	0.3a	1.3bc	0.6b	0.0b
Coragen	5 oz	0.0a	0.0a	0.0a	0.9bc	0.3b	0.6b
Belt	1.5 oz	0.0a	0.0a	1.9a	5.9ab	0.3b	0.3b
Vetica	17 oz	0.0a	0.0a	0.3a	0.6bc	0.6b	0.3b
Non-treated check		0.0a	0.0a	3.1a	10.9a	6.6a	5.0a
	F value	*0*	*0*	*1.45*	*8.25*	*5.07*	*14.62*
	P > F	*0*	*0*	*0.22*	*<.0001*	*0.0009*	*<.0001*

Treatment/formulation	Rate amt product/acre	CL larvae/10 plants				
		11 DAT-2 28-Oct	*14 DAT-2* 31-Oct	*3 DAT-3* 15-Nov	*7 DAT-3* 19-Nov	Avg
Radiant SC	5 fl oz	0.3b	1.7b	2.5b	0.4b	0.5cd
Intrepid 2F+ Warrior II	10 + 1.9 fl oz	0.0b	0.8b	0.4b	0.0b	0.3d
Proclaim 5SG	3.8 oz	1.6b	2.9b	7.5a	2.1ab	2.2b
Voliam Xpress	9 fl oz	0.6b	0.0b	0.0b	0.4b	0.2d
Exirel0.83 OC	14 fl oz	1.3b	1.3b	1.3b	2.1ab	0.8bcd
Coragen 1.6SC	5 fl oz	0.6b	2.1b	1.7b	0.4b	0.7cd
Belt 4SC	1.5 fl oz	1.6b	4.2ab	2.5b	0.8b	1.8bc
Vetica	17 fl oz	2.2b	3.3b	0.8b	1.7ab	1.0bcd
Non-treated check	–	14.7a	9.6a	7.0a	5.8a	6.3a
	F value	*32.66*	*5.74*	*9.21*	*3.17*	*33.26*
	P > F	*<0.0001*	*0.0004*	*<0.0001*	*0.01*	*<0.0001*

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

Table 2.

Treatment/formulation	Rate amt product/acre	BAW larvae/10 Plants					
		1 DAT-1 6-Oct	*3 DAT-1* 8-Oct	*7 DAT-1* 13-Oct	*11 DAT-1* 16-Oct	*3 DAT-2* 20-Oct	*7 DAT-2* 24-Oct
Radiant	5 oz	2.2bc	0.0b	0.0b	0.0b	0.0b	0.0b
Intrepid + Warrior II	10 + 1.9 oz	5.0ab	0.0b	1.3b	0.6b	2.2b	1.0b
Proclaim	3.8	1.9bc	0.0b	0.3b	0.6b	0.9b	0.3b
Voliam Xpress	9 oz	0.9bc	0.0b	0.3b	0.3b	0.9b	0.6b
Exirel	14 oz	1.3bc	0.3b	0.0b	0.6b	0.3b	1.0b
Coragen	5 oz	0.9bc	0.3b	0.6b	0.3b	0.3b	0.6b
Belt	1.5 oz	4.1ab	1.3b	1.3b	3.5b	1.6b	0.9b
Vetica	17 oz	0.6c	0.0b	0.0b	0.6b	0.9b	0.0b
Non-treated check		6.6a	8.8a	11.3a	14.1a	10.0a	11.3a
	F value	*6.45*	*51.64*	*38.78*	*20.58*	*11.11*	*13.95*
	P > F	*0.0002*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<.0001*

Treatment/formulation	Rate amt product/acre	BAW larvae/10 Plants				
		11 DAT-2 28-Oct	*14 DAT-2* 31-Oct	*3 DAT-3* 15-Nov	*7 DAT-3* 19-Nov	Avg
Radiant SC	5 fl oz	1.6b	0.8b	0.8a	0.0b	0.5c
Intrepid 2F+ Warrior II	10 + 1.9 fl oz	2.0b	2.5b	1.3a	0.0b	1.6b
Proclaim 5SG	3.8 oz	0.3b	1.7b	0.4a	0.0b	0.6bc
Voliam Xpress	9 fl oz	0.6b	2.1b	1.3a	0.0b	0.7bc
Exirel0.83 OC	14 fl oz	0.6b	0.0b	0.4a	0.4ab	0.5c
Coragen 1.6SC	5 fl oz	0.6b	3.8b	0.8a	0.4ab	0.9bc
Belt 4SC	1.5 fl oz	1.6b	2.5b	0.8a	0.4ab	1.8b
Vetica	17 fl oz	0.3b	2.1b	1.3a	1.7ab	0.8bc
Non-treated check		14.1a	10.0a	4.2a	2.1a	9.2a
	F value	*18.62*	*8.46*	*1.64*	*3.41*	*95.75*
	P > F	*<.0001*	*<.0001*	*0.17*	*0.0009*	*<.0001*

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

Table 3.

Treatment/formulation	Rate amt product/acre	Contaminated heads (%)		
		Damage	Frass	Larvae
Radiant SC	5 fl oz	5.0b	5.0b	0.0b
Intrepid 2F+ Warrior II	10 + 1.9 fl oz	10.0b	7.5b	0.0b
Proclaim 5SG	3.8 oz	30.0ab	17.5b	5.0b
Voliam Xpress	9 fl oz	10.0b	10.0b	2.5b
Exirel0.83 OC	14 fl oz	17.5b	12.5b	7.5b
Coragen 1.6SC	5 fl oz	7.5b	5.0b	2.5b
Belt 4SC	1.5 fl oz	22.5b	10.0b	2.5b
Vetica	17 fl oz	7.5b	5.0b	0.0b
Non-treated check		67.5a	45.0a	25.0a
	F value	*7.53*	*2.88*	*5.82*
	$P > F$	*<0.0001*	*0.02*	*0.0004*

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

2. CROSS-SPECTRUM INSECT CONTROL WITH FOLIAR INSECTICIDES

Methods: The objective of this trial was to evaluate the efficacy of insecticide mixtures, as opposed to Exirel applied alone, for cross-spectrum (sucking and chewing insect pests) control of major insects in broccoli under fall growing conditions. Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 4 Sep, 2014. 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 30 Sep and 15 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. For assessment of lepidopterous larvae, 10 plants were randomly selected from each replicate at 7 and 14 d after the 1st application and 7, 14 and 21 d after the 2nd spray. Whole plants were destructively sampled for the presence of large (2nd or > instar) Beet armyworm (BAW) and cabbage looper (CL) larvae. Sweet potato whitefly (SWF) immature densities were estimated on the same sample intervals as BAW and CL by examining 10 leaves per replicate (collected near the base node of the plant). Leaves were taken into the laboratory where the total number of nymphs was counted on two 2-cm^2 leaf discs from each leaf using a dissecting microscope. Adult SWF populations were estimated at 1, 3, 7 and 14 days after each spray using a modified vacuum method that employed a 2- gal 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 separate 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. Data for CL, BAW and SWF were averaged across all sample dates. Because of heterogeneity of mean variances, data were transformed using a $\log_{10}(x + 1)$ 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: SWF, BAW and CL pressure was low-moderate during the trial. All the foliar spray treatments provided significant control of CL following each application. In particular, the Proclaim+Endigo treatments provided the most consistent activity against CL larvae. Similarly, all of the spray treatments provided significant efficacy against BAW larvae compared to the non-treated check and Exirel overall provided the most consistent control of BAW. All spray treatments had significant activity against SWF adults except the Proclaim+Endigo combination. The Vetica+Pyrifluqionazon, Belt+Sivanto and Exirel treatments provided the most significant control of SWF adults relative to the other spray treatments. In terms of SWF nymphs, only the Proclaim+Endigo treatments failed to significantly reduce nymph densities compared with the non-treated control. Exirel provided the most consistent control of SWF nymphs across all samples. Overall these results are encouraging and suggest that the activity provided by Exirel as a standalone product can provide excellent levels of cross-spectrum activity in broccoli that is commonly expected from insecticide mixtures containing products that have activity against either sucking or chewing insect pests. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1

Treatment/formulation	Rate amt product/acre	CL, larvae/10 plants	BAW, larvae/10 plants	SWF, adults/sample	SWF, nymphs/cm^2
Radiant SC + Sequoia 2SC	5 fl oz + 5 fl oz	0.7bc	0.7bc	5.7b	3.8bcd
Vetica 20SC + Pyrifluquinazon 20SC	17 + 3.2 fl oz	1.1bc	0.3bc	3.3cde	3.3cd
Voliam Xpress + Actara 25WG	8 fl oz + 5.5 oz	2.1b	0.5bc	5.7b	6.0bc
Coragen 1.6SC + Assail 70W	5 fl oz + 2.3 oz	1.4bc	0.5bc	3.4cd	3.6cd
Exirel 0.83 SE	15 fl oz	1.5bc	0.1c	3.1de	1.0e
Proclaim 5SC + Endigo ZC	3.6 oz + 4.5 fl oz	0.4c	1.0b	10.3a	8.1ab
Belt 4SC + Sivanto 240SL	2 + 10.5 fl oz	1.2bc	0.4bc	2.7e	2.8cde
Belt 4SC + Movento 2SC	2 + 5 fl oz	1.5bc	0.8bc	4.7c	2.6de
Untreated check	—	3.5a	2.3a	8.7a	14.4a
	F value	3.81	5.44	20.81	21.48
	$P > F$	0.001	0.0006	<0.0001	<0.0001

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

II. Efficacy against Aphids

1. CONTROL OF GREEN PEACH APHID WITH FOLIAR INSECTICIDES

Methods: The objective of this study was to evaluate the residual efficacy of three industry standard insecticides at low label rates against green peach aphid in cabbage tested under desert growing conditions. Cabbage was direct seeded into double row beds on 42 inch centers on 24 Jan, 2014. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the table. Two foliar sprays were applied on 25 Feb and 19 Mar as a broadcast application delivered through 2 TXVS-18 ConeJet nozzles per bed at 20 gpa and 40 psi. Evaluations of green peach aphids (GPA) populations were assessed by estimating the number of apterous aphids / plant in whole plant, destructive samples. On each sample date, five plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of live aphids present. 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: GPA population pressure was heavy during the trial. Pre-spray aphid counts estimated plants were infested with an average of 86.5 GPA / plant. All three spray treatments significantly reduced GPA numbers at each sample interval relative to the untreated check following both applications. In terms of knockdown efficacy, Sequoia provided the most significant reduction in GPA numbers at 3 days following each application. By 7 days, differences among the three treatments were not observed. In terms of residual efficacy, Movento had lower numbers of GPA than Assail at 21 DAT for both applications. Overall, GPA control was most consistent in the Sequoia and Movento treatments. This study suggests that use of these products at low rates can provide significant GPA control. However, given the low tolerance for aphid contamination in heads by local grower/shippers, higher rates or tighter spray intervals may be required to achieve commercially acceptable control.

Table 1

Treatment/formulation	Rate amt product/acre	GPA/plant 3 DAT-1 1 Mar.	7 DAT-1 5 Mar.	10 DAT-1 8 Mar.	14 DAT-1 11 Mar.	21 DAT-1 18 Mar.
Assail 30SG	3 oz	48.0b	50.2b	90.7b	58.3b	64.1b
Sequoia 2F	1.4 oz	20.2c	42.0b	41.7bc	35.2bc	35.7bc
Movento 2F	4.3 oz	30.5c	23.5b	25.7c	24.1c	23.3c
Nontreated check	—	185.1a	251.8a	258.7a	311.6a	211.3a
	F value	96.07	8.83	30.13	39.43	20.81
	$P > F$	<0.0001	0.005	<0.0001	<0.0001	0.0002

Treatment/formulation	Rate amt product/acre	GPA/plant 3 DAT-2 22 Mar.	7 DAT-2 26 Mar.	14 DAT-2 2 Apr.	21 DAT-2 9 Apr.	Avg.
Assail 30SG	3 oz	27.3b	37.3b	103.0b	300.8b	86.5b
Sequoia 2F	1.4 oz	8.2c	19.1b	87.6b	121.3bc	45.5c
Movento 2F	4.3 oz	20.7bc	52.3b	49.7b	67.3c	35.2c
Nontreated check	—	160.1a	359.3a	930.0a	1112.3a	420.9a
	F value	22.63	28.48	38.55	30.89	104.56
	$P > F$	0.0002	<0.0001	<0.0001	<0.0001	<0.0001

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

2. EFFICACY OF SIVANTO AGAINST GREEN PEACH

Methods: The objective of this study was to evaluate the efficacy of Sivanto, applied alone and in mixture with other insecticides, against green peach aphid in cabbage under desert growing conditions. Cabbage was direct seeded into double row beds on 42 inch centers on 24 Jan, 2014. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the table. Two foliar sprays were applied on 25 Feb and 12 Mar as a broadcast application delivered through 2 TXVS-18 ConeJet nozzles per bed at 20 gpa and 40 psi. Evaluations of GPA populations were assessed by estimating the number of apterous aphids / plant in whole plant, destructive samples. On each sample date, five plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of live aphids present. 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: GPA population pressure was heavy during the trial. Pre-spray aphid counts estimated plants were infested with an average of 32.8 GPA / plant. Following both spray applications, all treatments significantly reduced GPA numbers relative to the non-treated check at most sample intervals. Overall, the Movento and Sequoia treatments provided the most consistent control of GPA relative to the other spray treatments and non-treated control. Sivanto applied alone provided GPA control comparable to Assail and Sequoia treatments, all of which had significantly greater numbers of GPA than Movento (industry standard). The combinations of Sivanto with Admire Pro, Torac or Brigade did not significantly enhance GPA control. No phytotoxicity was observed.

Table 1

Treatment/formulation	Rate amt product/acre	GPA/plant				
		3 DAT-1 28 Feb.	7 DAT-1 4 Mar.	10 DAT-1 7 Mar.	14 DAT-1 11 Mar.	3 DAT-2 15 Mar.
Sivanto 240SL	14 oz	18.8b	28.8bc	45.3b	37.5bc	7.6b
Sivanto + Admire Pro	14 + 1.3 oz	19.6b	24.7bc	31.6bc	38.8bc	11.1b
Sivanto + Torac	14 + 21 oz	9.1b	16.7bc	37.0bc	26.1bc	4.6b
Sivanto + Brigade	14 + 5 oz	15.6b	49.9ab	50.7b	73.9b	12.3b
Assail 30SG	4.0 oz	24.0b	43.5abc	53.4b	57.3bc	7.3b
Sequoia 2F	2 oz	16.4b	26.8bc	28.5bc	37.4bc	7.8b
Movento 2F	5 oz	18.3b	13.0c	17.1c	24.4c	5.2b
Nontreated check	—	91.8a	174.4a	244.5a	292.3a	140.3a
	F value	6.41	8.08	18.51	10.37	27.35
	P > *F*	0.0004	<0.0001	<0.0001	<0.0001	<0.0001
		GPA/plant				
		7 DAT-2 19 Mar.	14 DAT-2 26 Mar.	21 DAT-2 3 Apr.	28 DAT-2 10 Apr.	Avg.
Sivanto 240SL	14 oz	18.1b	42.2bc	111.3bc	320.9b	70.0bcd
Sivanto + Admire Pro 4.6F	14 + 1.3 oz	14.3b	38.9bc	125.9bc	405.2b	78.9bcd
Sivanto + Torac 15EC	14 + 21 oz	7.4bcd	16.9bcd	129.4bc	242.6b	54.4cd
Sivanto + Brigade 2EC	14 + 5 oz	16.5b	51.7b	290.3ab	280.8b	93.5b
Assail 30SG	4.0 oz	8.5bc	37.2bc	178.3ab	244.1b	71.5bc
Sequoia 2F	2 oz	3.6cd	24.7cd	36.7cd	149.2b	36.8de
Movento 2F	5 oz	2.3d	8.2d	19.3d	32.1c	15.5e
Nontreated check	—	117.3a	288.0a	481.3a	2219.9a	450.5a
	F value	25.83	15.51	14.94	16.42	35.29
	P > *F*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

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

III. Efficacy against Western Flower Thrips

1. EVALUATION OF SEQUOIA AND MOVENTO FOR CONTROL OF WESTERN FLOWER THRIPS

Methods: The objective of the trial was to evaluate the efficacy of the aphicides Sequoia and Movento against western flower thrips relative to the industry standards on romaine lettuce. Head lettuce 'Pennylea' was direct seeded on 5 Dec, 2013 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 4 and 18 Feb. 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. An adjuvant Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all treatments. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample 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 population levels were moderate during this trial. Sequoia and Movento applied alone did not significantly reduce WFT adult numbers relative to the non-treated control (Table 1). However, in most case, combination of either compound with either Lannate or Radiant provided significant improvements in adult control. Movento, however did demonstrate significant efficacy against WFT larvae relative to the non-treated control on several post-spray evaluations (Table 2). In contrast, Sequoia did not reduce WFT larvae numbers compared to the non-treated control. Tank mixtures of Movento or Sequoia with Radiant and Lannate resulted in enhanced control of WFT larvae. The study was clearly showed that Movento and Sequoia did not provide adequate control of WFT. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1

Treatment/ formulation	Rate amt product/acre	WFT adults / plant						
		3 DAT-1	*7 DAT-1*	*14 DAT-1*	*3 DAT-2*	*7 DAT-2*	*14 DAT-2*	Avg
Sequoia 2F	2 fl oz	3.8ab	5.7ab	6.9a	5.5ab	3.8bc	9.9a	6.3abc
Sequoia + Radiant 1SC	2+7 fl oz	1.1c	2.4c	9.4a	4.3abc	3.2bc	11.9a	5.5cde
Sequoia + Lannate 90SP	2 fl oz + 0.75 lb	1.4bc	2.8bc	8.3a	2.3bc	2.1c	11.2a	4.9de
Sequoia + Torac 15EC	2 fl oz + 21 fl oz	2.4abc	3.3bc	8.7a	4.1abc	4.9ab	13.5a	6.1bcd
Movento 2F	5 fl oz	4.3a	7.0a	9.1a	6.1a	8.2a	9.6a	7.6a
Movento + Radiant	5 + 7 fl oz	1.1c	2.0c	6.8a	2.1bc	2.3bc	10.7a	4.3e
Movento + Lannate	5 fl oz + 0.75 lb	1.3c	2.0c	8.7a	1.9c	2.5bc	14.1a	5.3de
Movento + Torac	5 fl oz + 21 fl oz	2.5abc	2.1c	8.0a	3.8abc	3.4bc	13.8a	5.6bcde
Nontreated check	–	4.0ab	5.5ab	6.3a	7.5a	4.0abc	11.5a	6.8ab
	F value	*6.79*	*10.29*	*1.48*	*5.97*	*6.58*	*0.52*	*13.39*
	P > F	*0.0001*	*<.0001*	*0.22*	*0.0003*	*0.0001*	*0.83*	*<.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	WFT larvae / plant						
		3 DAT-1	*7 DAT-1*	*14 DAT-1*	*3 DAT-2*	*7 DAT-2*	*14 DAT-2*	Avg
Sequoia 2F	2 fl oz	4.2a	9.6ab	19.6a	12.4a	10.5a	3.0a	11.2a
Sequoia + Radiant 1SC	2 + 7 fl oz	1.7ab	1.5d	2.5cd	1.1cde	1.5bcd	0.5b	1.9d
Sequoia + Lannate 90SP	2 fl oz + 0.75 lb	0.7b	2.5cd	4.5bc	1.3cde	0.8cd	1.2ab	2.8cd
Sequoia + Torac 15EC	2 fl oz + 21 fl oz	3.3ab	5.9abc	8.0b	3.7b	3.5b	2.3a	5.5b
Movento 2F	5 fl oz	4.5a	9.3ab	9.2b	2.5bc	2.3bc	0.9ab	6.5b
Movento + Radiant	5 + 7 fl oz	1.2ab	0.8d	1.6d	0.8de	0.6d	0.2b	1.0e
Movento + Lannate	5 fl oz + 0.75 lb	0.6b	1.3d	3.5bcd	0.4e	0.7d	0.4b	2.2de
Movento + Torac	5 fl oz + 21 fl oz	2.4ab	4.6bc	5.1bc	1.8bcd	0.7d	0.6b	3.4c
Nontreated check	–	3.5a	16.3a	23.4a	16.8a	14.0a	2.8a	13.9a
	F value	*5.55*	*19.66*	*24.13*	*40.92*	*35.81*	*9.83*	*136.72*
	P > F	*0.0005*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

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

2. EVALUATION OF INSECTICIDES FOR CONTROL OF WESTERN FLOWER THRIPS

Methods: The objective of the trial was to evaluate the efficacy of foliar insecticides against western flower thrips relative to the industry standards on romaine lettuce. Romaine 'Sunbelt' was direct seeded on 24 Jan, 2014 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 6 and 17 Feb. 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. An adjuvant Dyne-Amic (Helena Chemical Co.), was applied at 0.25% to all treatments. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample 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 population levels were moderate during this trial. Movento did not significantly reduce WFT adult numbers relative to the industry standards (Warrior II+Lannate and Radiant) or the non-treated check on any of the sample dates (Table 1). Torac significantly reduced adult numbers compared to the non-treated check across the trial. The addition of Torac with Movento significantly reduced adult numbers on all sample dates except 3 DAT-2. Overall, the two industry standards, Warrior II+Lannate and Radiant, provided the most consistent adult WFT control. Movento did significantly reduce WFT larvae compared to the non-treated check at 11 DAT1 and on all samples following the second application (Table 2). The Torac + Movento mixture did not consistently improve the performance of either product applied alone. Overall, Radiant provided the most significant reduction in WFT larvae compared to all other spray treatments and the non-treated check. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1

Treatment/ formulation	Rate amt product/acre	WFT adults/plant						
		3 DAT-1	7 DAT-1	11 DAT-1	3 DAT-2	7 DAT-2	11 DAT-2	Avg
Torac 15EC	21 fl oz	3.1 cd	3.4 c	4.5 b	3.0 bc	3.2 bc	3.6 cd	3.5 bc
Radiant 2SC	7 fl oz	1.8 d	2.7 cd	4.4 b	1.8 c	2.1 cd	2.7 d	2.5 d
Movento 2F	5 fl oz	5.5 ab	5.7 ab	8.6 a	5.8 a	7.3 a	9.0 a	6.9 a
Warrior II+ Lannate 90SP	1.9 fl oz + 0.75 lb	1.7 d	1.9 d	5.1 b	1.6 c	1.9 d	3.4 cd	2.6 d
Torac 15EC + Lannate 90SP	21 fl oz + 0.75 lb	2.0 d	3.2 cd	5.1 b	1.6 c	3.1 bc	3.4 cd	3.1 cd
Torac 15EC + Movento 2F	21 fl oz + 5 oz	3.3 bcd	3.7 bc	5.1 b	3.9 ab	3.6 b	4.0 bc	3.9 b
Non-treated check	–	7.6 a	6.9 a	8.6 a	5.2 ab	6.8 a	6.1 ab	6.8 a

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

Table 2

Treatment/ formulation	Rate amt product/acre	WFT larvae/plant						
		3 DAT-1	7 DAT-1	11 DAT-1	3 DAT-2	7 DAT-2	11 DAT-2	Avg
Torac 15EC	21 fl oz	3.6 ab	5.4 ab	11.1 c	5.4 bc	5.1 b	4.0 b	5.8 cd
Radiant 2SC	7 fl oz	0.7 c	1.4 c	2.0 e	0.7 e	0.7 d	1.1 d	1.1 f
Movento 2F	5 fl oz	7.6 ab	9.9 a	21.2 b	7.7 b	2.5 bc	2.1 bc	8.5 c
Warrior II+ Lannate 90SP	1.9 fl oz + 0.75 lb	0.2 d	1.9 bc	9.7 cd	2.9 d	1.0 cd	2.6 bc	3.1 e
Torac 15EC + Lannate 90SP	21 fl oz + 0.75 lb	0.8 c	1.2 c	6.1 d	2.3 d	1.2 cd	1.8 cd	2.2 e
Torac 15EC + Movento 2F	21 fl oz + 5 oz	3.1 b	5.1 ab	12.0 c	3.4 cd	1.9 c	2.4 bc	4.6 d
Non-treated check		7.0 a	14.1 a	39.4 a	33.4 a	30.3 a	29.2 a	25.6 a

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

Objective 2. *To continue an expanded Area-wide Insect Trapping Network in the Yuma Valley, Gila Valley, Dome Valley and Wellton/Roll areas that will provide real time information for PCAs on adult insect activity of important insect pests.*

In the 2014-2015 growing season, the *Area-wide Insect Trapping Network* was continued for a second year, and expanded from the previous year. Information was gathered from a network of traps that were placed and monitored weekly from mid-August through March. A total of fifteen trap locations (5 more than 2013-2014) were situated in the Yuma Valley (6), Gila Valley (3) and Dome Valley (2), Wellton (2) and Tacna/Roll (2) areas. Traps were located near or adjacent to the AZMET station when possible. The approximate location of traps in each valley was determined by a survey of Yuma growers and PCAs. At each site, pheromone traps were used to monitor for adult activity of corn earworm and tobacco budworm, as well as beet armyworm and cabbage looper. In addition, yellow sticky traps were used to monitor aphids, thrips and leafminer adults. Traps were checked weekly and data was processed at the Yuma Ag Center. The data was organized and presented by species and trap location. Relative weekly trends were also presented across the season.

Real-time information on trap captures at each location was provided bi-weekly to all PCAs and growers who receive our Veg IPM Updates via email. PCAs and growers can request weekly updates via individual emails. However, all trapping data during the course of the 2014-2015 lettuce growing season was also assessable at any time through will UA Crop Information website http://ag.arizona.edu/crops/crops.html

The project was designed to measure the activity and movement of adult populations of a number of key pests. The project provided an indication of when pest activity (e.g., corn earworm moth flights) is increasing based on pheromone / sticky trap captures. The data is not intended to indicate field infestations, as trap data is largely a reflection of adult movement. If nothing else, the data may make PCAs aware of increased pest activity in some areas and encourage intensified scouting in susceptible produce fields. The pests monitored included: corn earworm, tobacco budworm, beet armyworm, cabbage looper using pheromone traps; aphids, thrips and whiteflies using yellow sticky traps. A total of 8 trapping locations were established in the following areas (approximate location):

Trap Locations

1	Tacna/Texas Hill	47E and Co. 2 St.
2	Tacna/Roll	38E and Co. 4 St.
3	Roll/Wellton	33E and Co. 7 St.
4	Wellton	27E and Co. 10 St.
5	Dome Valley	21E and Co. 8 St.
6	Dome Valley	17E and Co. 6 St.
7	East Gila Valley	10E and Hwy 95
8	North Gila Valley	Laguna Dam Rd and Co. 3 St
9	South Gila Valley	5E and 24 st.
10	Yuma Valley	Co. 14 and Ave D
11	Yuma Valley	Co. 20 and Ave G
12	Yuma Valley	Co. 17 and Ave J
13	Yuma Valley	Co. 14.5 and Levee Rd
14	Yuma Valley	Co. 12 and Ave F
15	Yuma Valley	Co. 8 and Ave E


Roll


Wellton


Dome Valley


S. Gila Valley

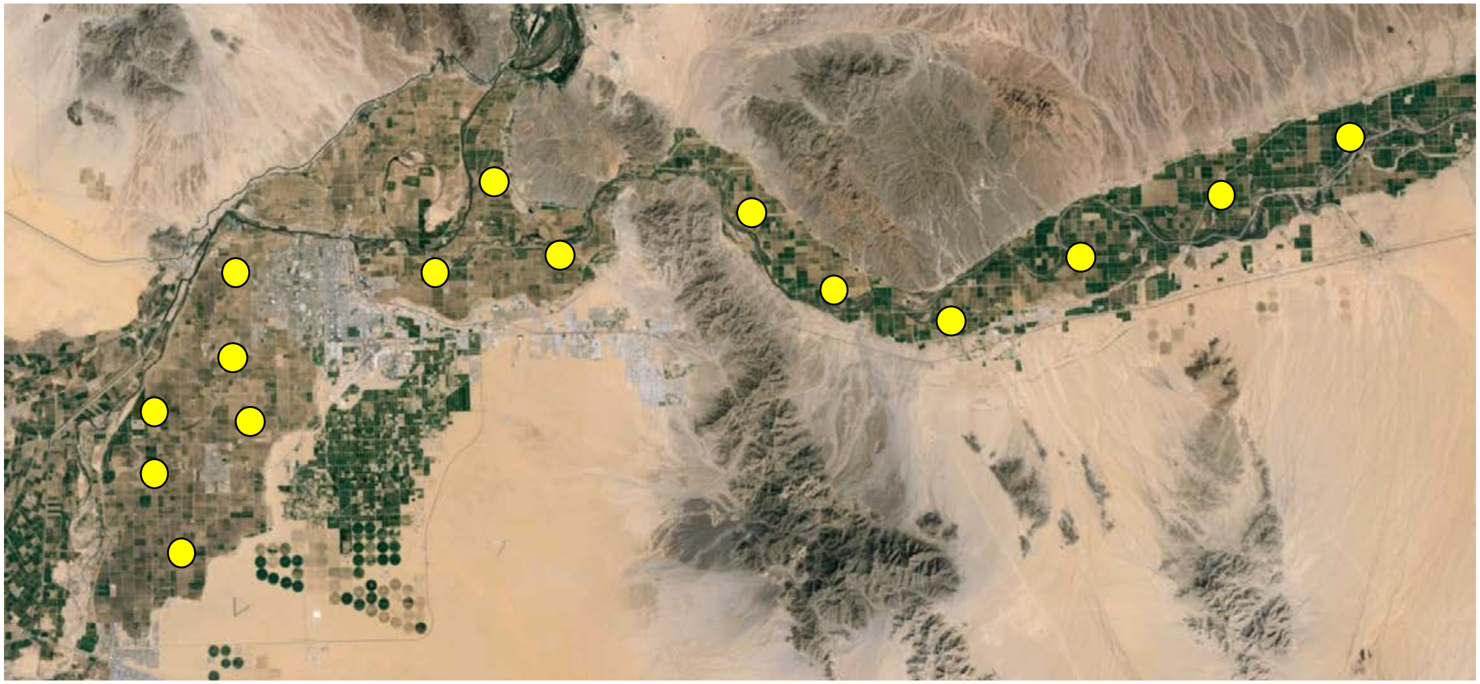

N. Gila Valley

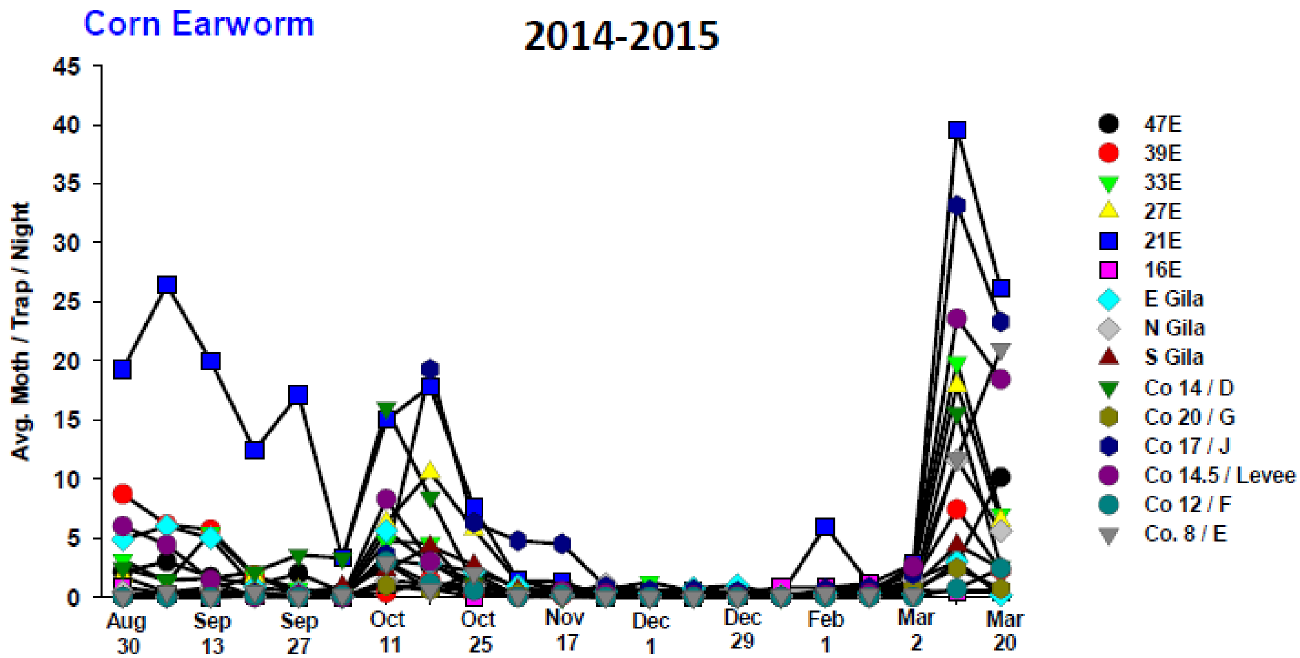

N. Yuma Valley

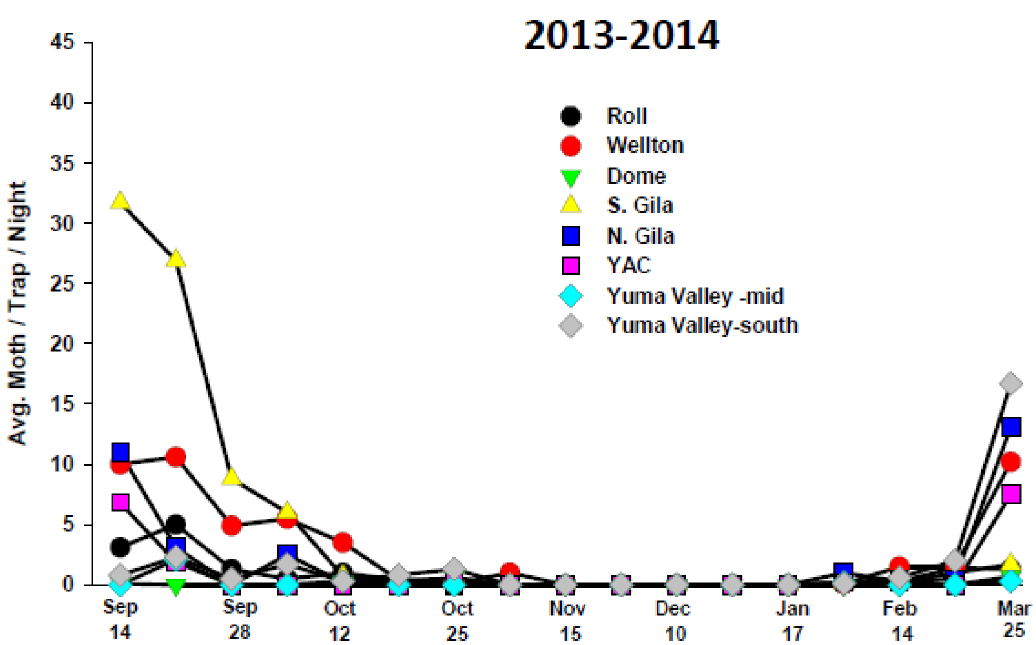

Mid-Yuma Valley


S. Yuma Valley

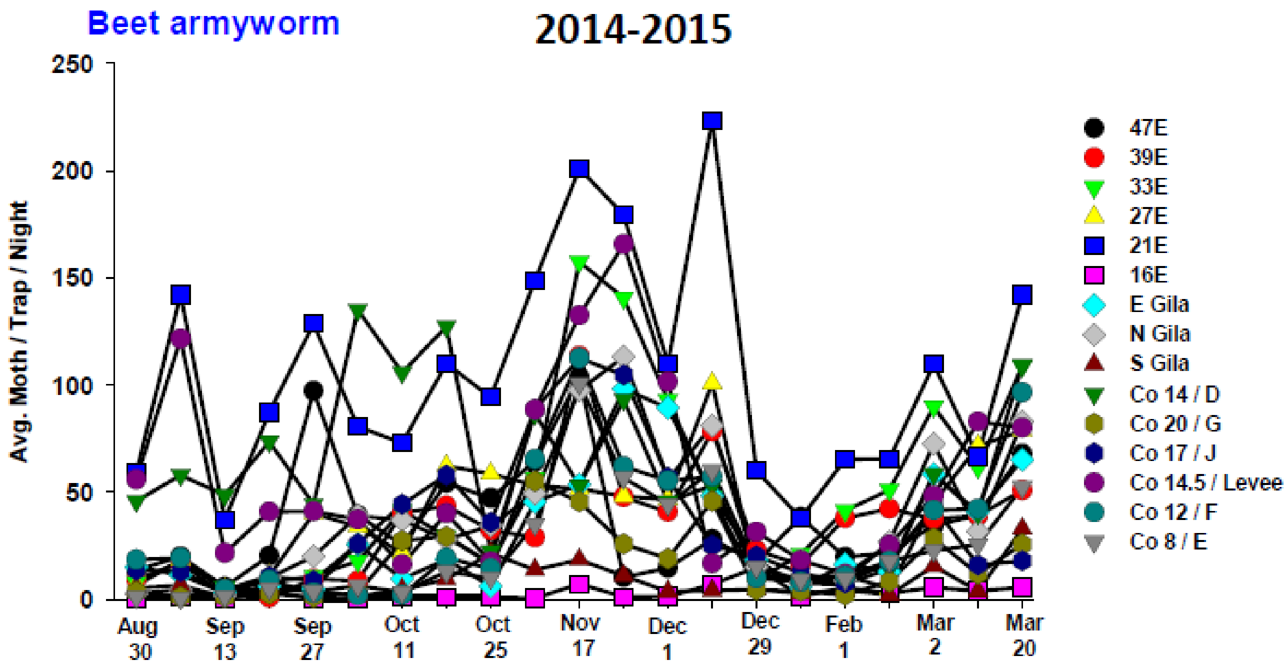
Area-wide Insect Trapping Network

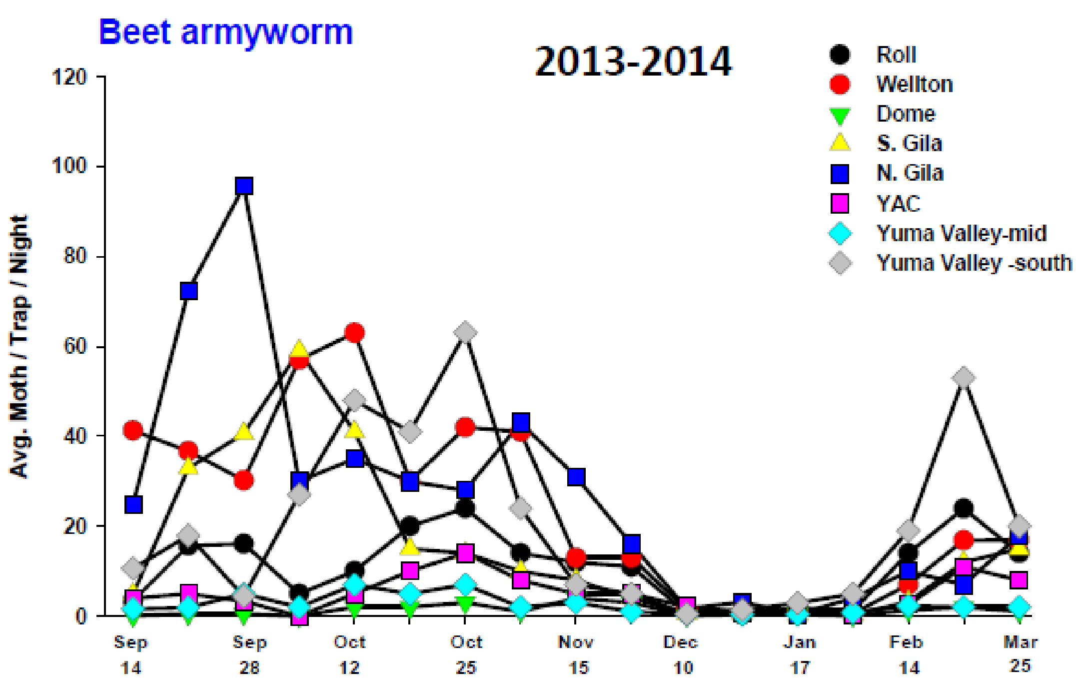




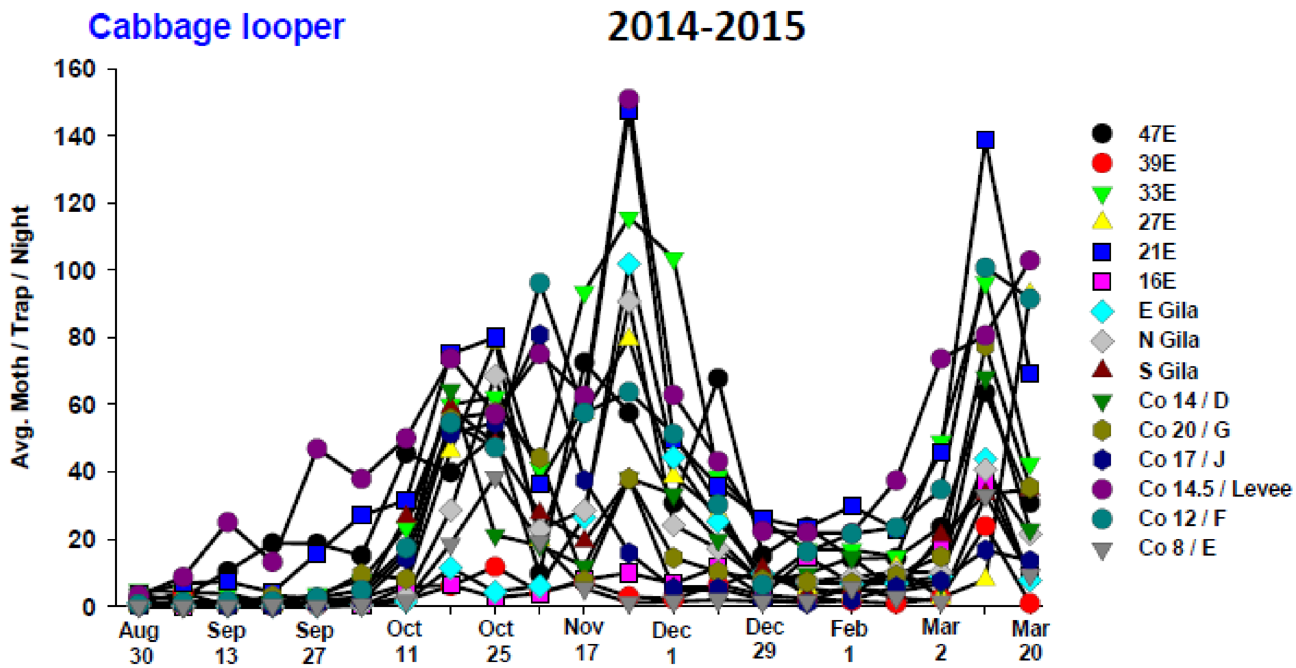


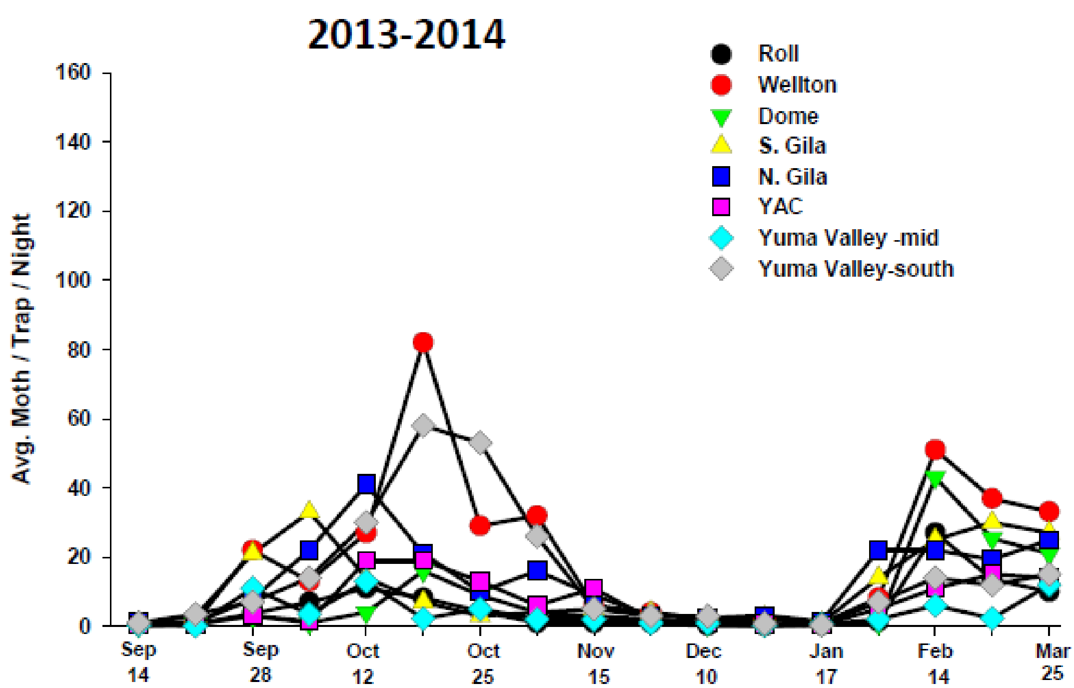
Corn Earworm: Moth activity in 2014-2015 was much greater than in 2013-2014, particularly during the early fall and again. The trends from these traps captures further illustrate the key periods during the produce season when lettuce is at highest risk from corn earworm: The first harvested fields in November and the last fields in March-April. Because of warm temperatures during Feb-March 2015, moth activity was almost 2X greater in some locations. These captures were consistent with field infestation near these traps as reported by PCAs.



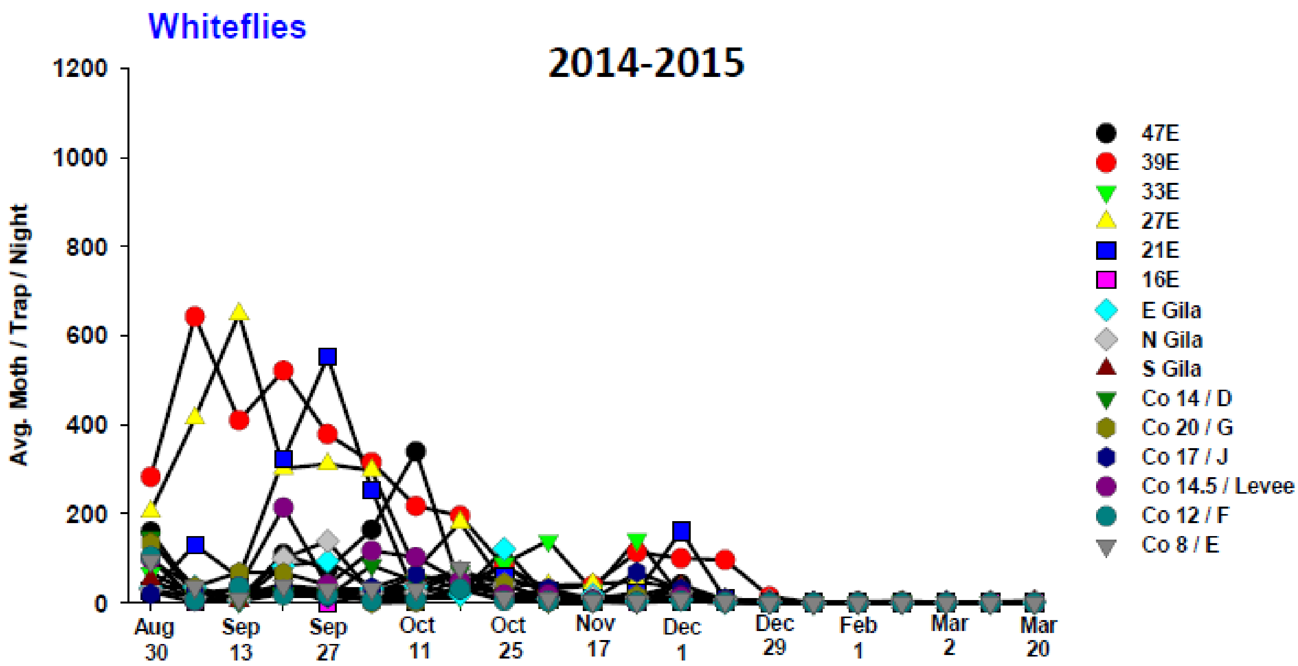


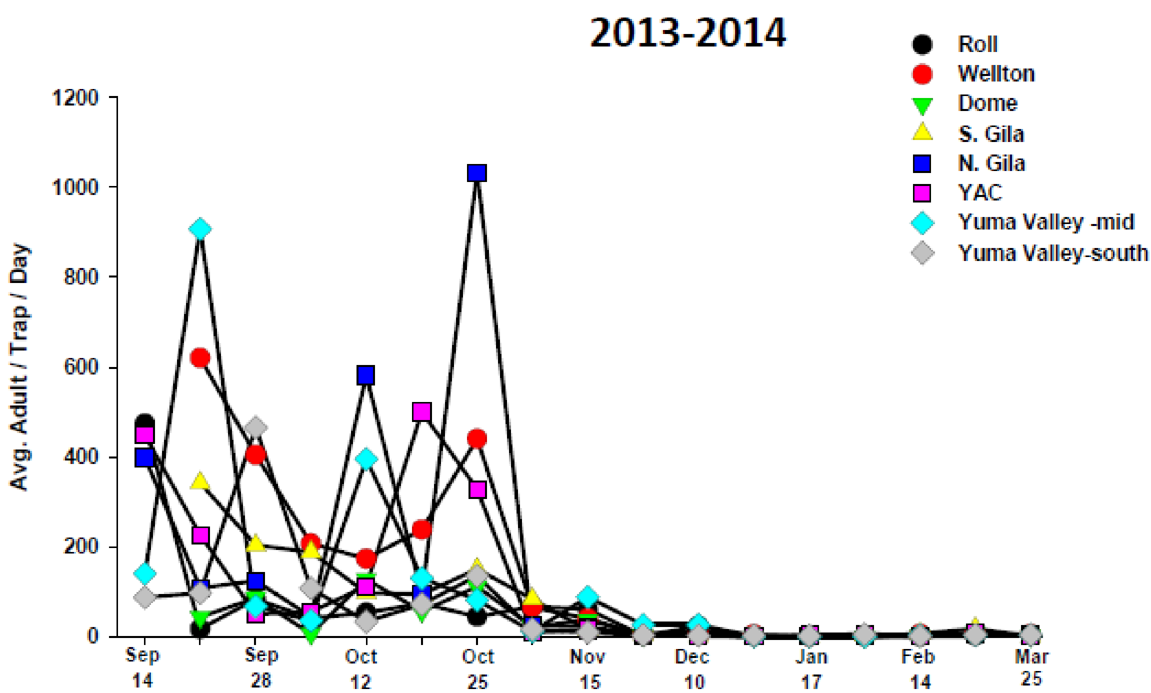
Beet armyworm: Fall and warm temperatures were unusually warm during the 2014-2015 season and are reflected in the extended high moth activity during November, December and again in March. Larval infestations in are fields were similar to these trap trends as reported by PCAs



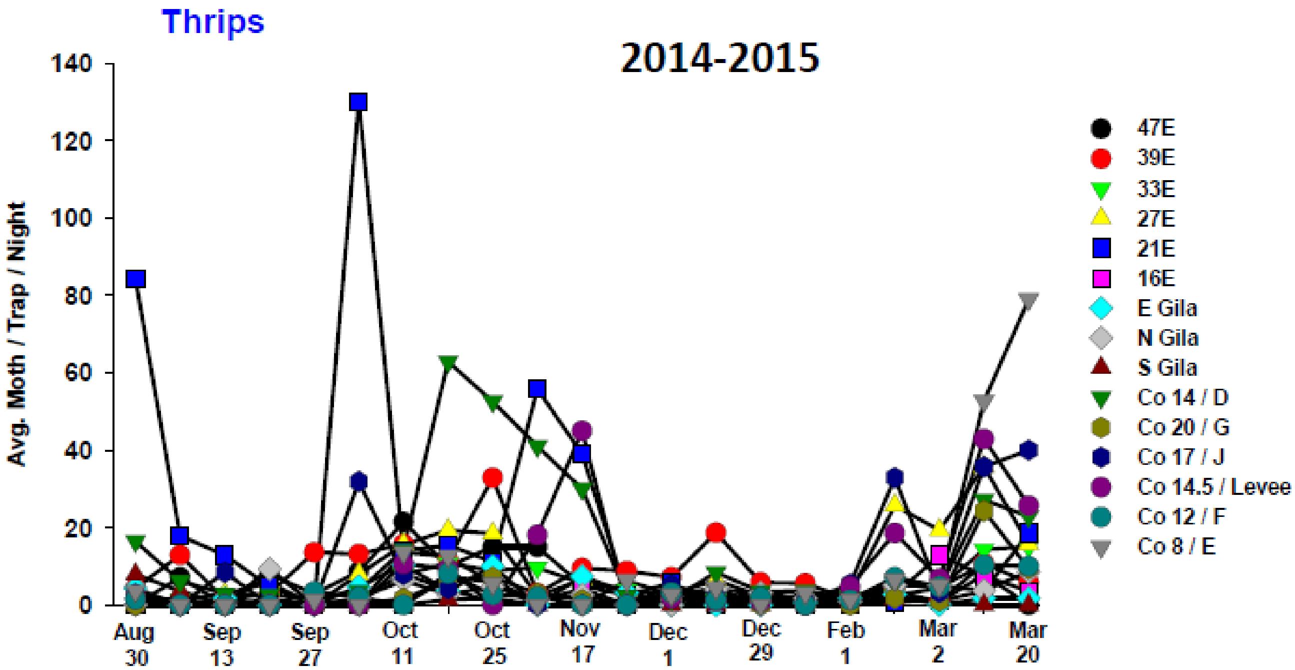


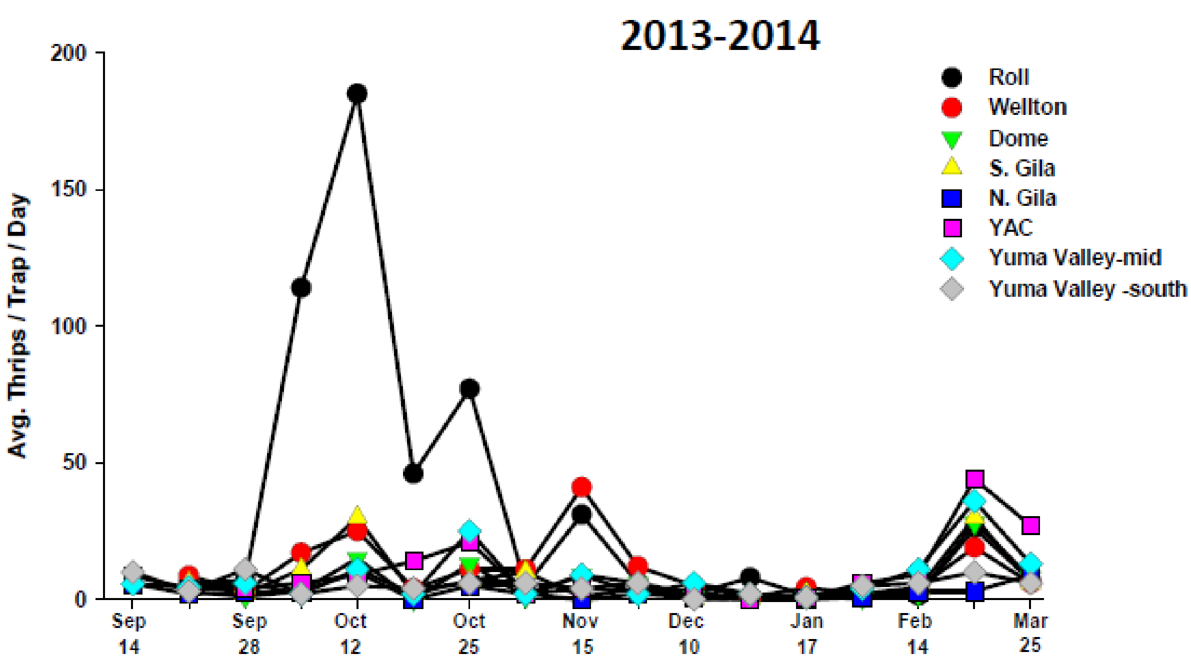
Cabbage looper: Similar, due to the unusually warm during the 2014-2015 season cabbage looper moths were considerably more active activity during November and December as compared to the previous season. Similarly, larvae in fields were observed at treatable levels season long as reported by PCAs.





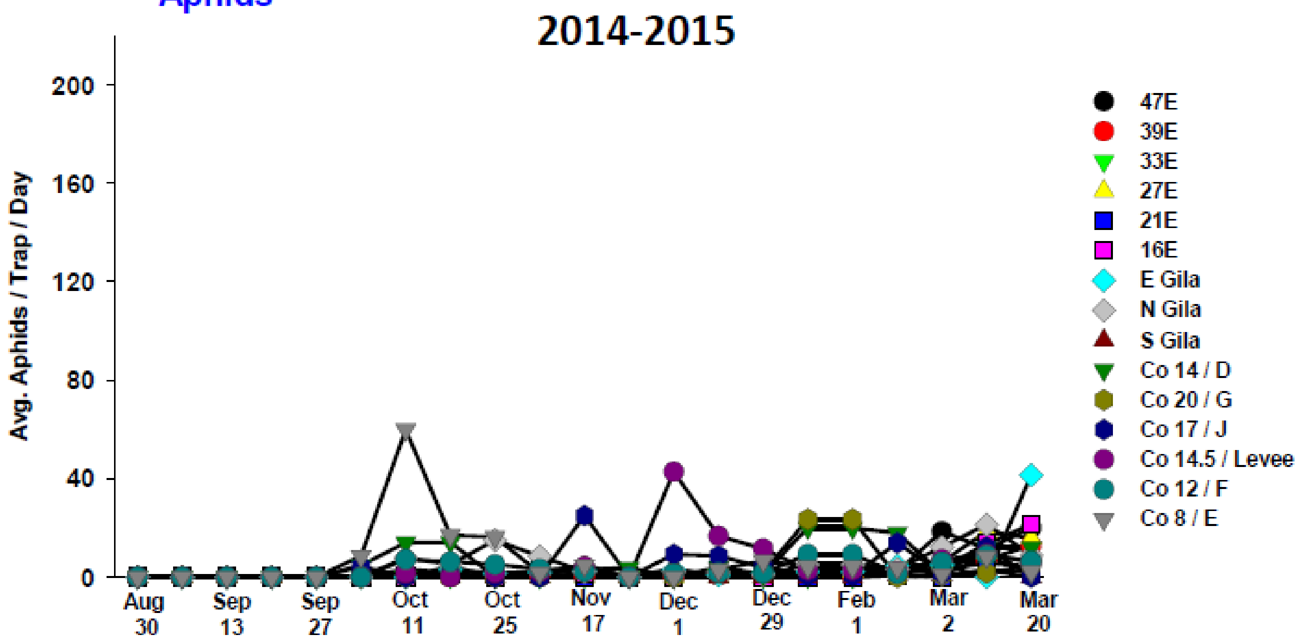
Sweeetpotato whitefly: These graphs clearly demonstrate that whitefly movement is greatest during the fall when adults are migrating out of cotton, alfalfa and melons onto lettuce. In contrast, whiteflies move very little during the spring. Due to higher fall temperatures in 2014-2015, adults were still moving well into December in the Wellton area.

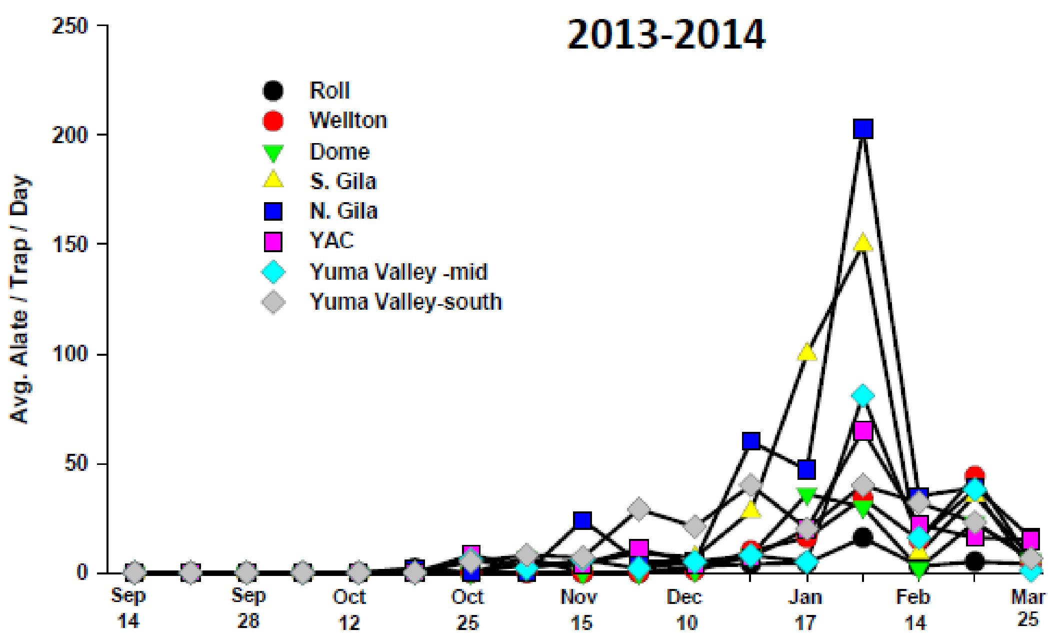




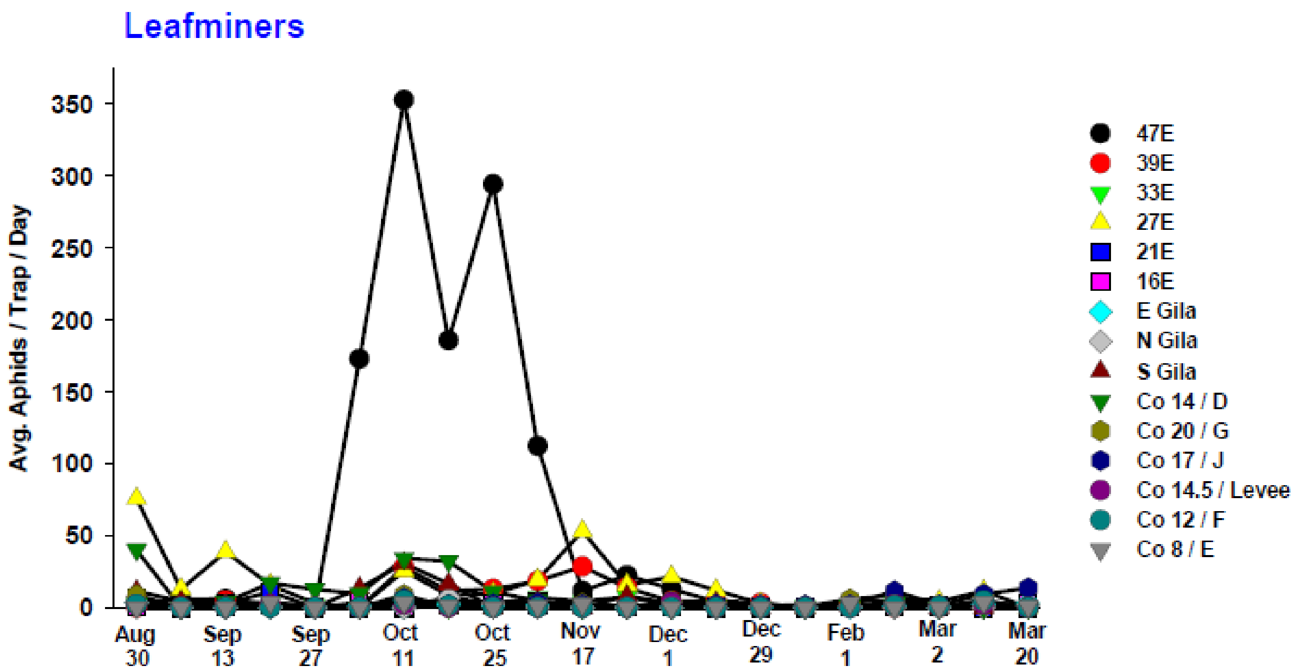
Western Flower Thrips: Trends observed in bot h years show that thrips tend to move primarily in October (likely coming off of melons, alfalfa and cotton) and then again in March as a result of “bioconcentration” which occurs each year as lettuce acreage declines. Each time a lettuce field is harvested and disked, adult thrips populations disperse from these areas into the next available lettuce field. As the number of lettuce acres becomes reduced near the end of the season, this creates a bottleneck effect that concentrates high numbers of thrips adults on the remaining fields under production.

Aphids





Aphids: Aphid pressure and movement in 2014-2015 was much lighter than the previous season. This is likely due to the dry and warm weather conditions. Aphids prefer cooler weather than the other pests and did not buildup to high levels like in previous years due to sub-optimal conditions for development and lack of desert habitat. The majority of aphid species captured on these traps in both years were green peach aphids.



***Liriomyza* Leafminers:** Leafminers were monitored on sticky traps for the first time in 2014-2015. A single peak in movement was observed in October/November, particularly in traps near fall melons. Cooler temps in the winter, associated with the areawide usage of Radiant in lettuce for thrips control, likely explains the low captures in the spring. The majority of adults trapped with *Liriomyza sativae.*