Biopesticide Efficacy in Desert Produce Crops

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Arizona is a leading producer of fresh-market vegetables in the U.S., producing high quality produce on greater than 130,000 acres at an estimated value of almost $ 1 billion annually. Similarly, Arizona has recently become a major producer of certified-organic, fresh market vegetables (particularly leafy vegetables and cole crops).

Presently, Arizona growers have established a reputation for providing high quality produce for the fresh market. This is especially critical for the organic industry as expectations from the shippers/ buyers and consumers is that organically grown leaf vegetables be of the same high-quality standards as conventionally produced crops. Consequently, production of organically-certified leafy vegetables is very challenging in Arizona due to the multitude of insect pests that growers must control to ensure a cosmetically acceptable product that meets the industry and consumer standards. Unfortunately, their options for controlling insects are limited.

Currently, organic growers rely heavily on a select few chemical biopesticides, and to a lesser extent, non-chemical tactics to control insect pests in organic leafy vegetables. Based on conversations with growers and PCAs, these control tactics are often marginally effective, and require intensive usage to meet quality standards. Furthermore, among the numerous pests they battle, aphids, bagrada bugs and flea beetles are almost impossible to control in organic crops, and reliable control options are essentially not available. Other major pests such as beet armyworm and western flower thrips can be effectively controlled with microbial insecticides (e.g., spinosad, Bt), but additional alternatives to be used in rotational programs for resistance management are lacking. Although numerous organically-allowed (USDA and OMRI approved) biopesticides are registered for insect control in Arizona, there is much uncertainty among growers and PCAs whether the products will actually work or 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, largely because local scientific information to support the manufactures claims is not currently available. Given the demands for high-quality organic vegetables from Arizona, applied research providing this information would clearly benefit Arizona organic growers. This project was initiated because the research knowledge necessary for implementing effective insect management approaches in local organic vegetables must be developed specifically for Arizona's unique desert growing conditions, leafy vegetable crops and pest spectrum. The overall goal of this project was to enhance pest management programs for the organic industry by developing new educational information on technologies for controlling insect in organically-certified leafy vegetable crops in Arizona (i.e., lettuce, romaine, cauliflower, cabbage, broccoli and spinach). Below are the results on numerous efficacy trials with biopesticides on leaf vegetables grown in the desert southwest.

Biopesticide products evaluated for efficacy against insect pests in desert produce crops.

Biopesticide	Active Ingredient	Mode of action
Entrust	Spinosad	Neurotoxic
Pyganic	pyrethrins	Neurotoxic
Veratran-D	Sabadilla	Neurotoxin
Aza-Direct	azadirachtin	IGR, repellent, anti-feedant
DeBug Turbo	Azadirachtin	IGR, repellent, anti-feedant
AzaGuard	Azadirachtin	IGR, repellent, anti-feedant
Ecozin	Azadirachtin	IGR, repellent, anti-feedant
Neemix	Azadirachtin	IGR, repellent, anti-feedant
Trilogy	Neem oil	IGR, repellent, anti-feedant
Azera	Azadirachtin + pyrethrin	IGR, repellent, anti-feedant and neurotoxic
Mantis	Rosemary, Peppermint and Soybean oils	Cell membrane, respiration disruptors
M-Pede	Potassium salts of fatty acids	Desiccation or Membrane disruptors
Xentari	*Bacillus thuringiensis 'aizawai'*	Disruptors of Insect Midgut Membranes
Dipel	*Bacillus thuringiensis 'kurstaki'*	Disruptors of Insect Midgut Membranes
Venerate	*Burkholderia* spp. strain A396)	exoskeleton degradation/ molting interference
Botanigard	*Beauveria bassiana*	Fungal infection in host
PFR-97	*Isaria fumosorosea*	Fungal infection in host
Oroboost	Alcohol ethoxylate	Organic adjuvant
BugBomber	Garlic extract	Repellency
Captiva	Garlic/Capsicum extract	Repellency, anti-feeding, anti-oviposition
Grandivo	*Chromobacterium subtsugae*	Repellency, Reduced egg hatch, and fecundity
SuffOil-X	Mineral oil	Suffocation

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Cross-spectrum Insect Control in Organic Broccoli, Fall 2015

Methods Broccoli "Emerald crown' was direct seeded on 6 Sep, 2016 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each treatment compound are provided in the tables. Three foliar spray applications were made on 24 Sep, and 11 and 19 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. An adjuvant, Oroboost, was applied at 0.25% v/v with all treatments. The pH of the spray water in the Pyganic, Azera and Aza-Direct treatments was lowered to a pH of 5.5-6 using Neutralizer at 0.1% v/v.

At various intervals after treatment (DAA) , plants were randomly selected from each replicate and destructively sampled for the presence of each insect species. Bagrada bug control was evaluated by examining 20 plants per rep and counting the number of adults and damage on each plant at 1, 3 and 5 DAA. Beet armyworm (BAW), cabbage looper (CL) and diamondback moth (DBM) control was based on the examination of 10 whole plants for presence of small (newly hatched and 1st instar) and large (2nd instar or >) larvae at 6 DAA. The number of plants in each plot with fresh feeding tracks on plants was also recorded. Adult WF were estimated using a modified vacuum method that employed a 2- gallon portable vacuum (DeWALT, Baltimore, MD) which was fitted with cloth-screened 40 Dram containers to capture and retain vacuumed adults. At 1, 3 and 7 DAA, 5 individual plants from each replicate were sampled by vacuuming the terminal area of the plants for 3 s. Containers with adults were taken into the laboratory, placed in a freezer for 24 h after which the number of adults/ plant was recorded. Because of heterogeneity of mean variances, data were transformed using a log10 (x-1) function before analysis. Data for percentage of plants with fresh feeding damage on leaves 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.

Summary All the treatments significantly reduced Bagrada bug feeding damage relative to the untreated control, but none of the biopesticides provided control comparable to the conventional products. When averaged across all sample dates, only the Entrust combinations, Aza-Direct+Pyganic, and Azera provided significant control of whitefly adults. None of these treatments provided control comparable to the conventional standard. Similarly, only the Entrust treatments and the conventional standard insecticides significantly controlled Lepidopterous larvae.

Bagrada bug control with organically approved insecticides on broccoli

		Trial Average Bagrada bugs / 20 plants	
Treatment	**Rate**	**Adults**	**Fresh Damage**
Entrust	8 oz	0.4bcde	1.4bc
Entrust+M-Pede	8 oz+2 %	0.4bcde	1.0e
Entrust+Mantis	8 oz+1 pt	0.3cde	1.2e
Veratran-D	10 lbs	0.6bc	1.4cde
Grandivo	2 lbs	0.8ab	1.8b
Aza-Direct + Pyganic	2 pts + 17 oz	0.4bcde	1.0e
Azera	3 pts	0.4bcde	1.3cd
Oroboost	0.60%	0.7ab	1.9b
Brigade	6.2 oz	0.1de	0.2f
Brigade+Venom	6.2 + 3 oz	0.0e	0.1f
Untreated	-	1.2a	3.1a
	F value	*4.68*	*29.15*
	P > F	*0.0005*	*<.0001*

Efficacy of organically approved insecticides against whitefly adults in broccoli

		Whitefly Adults / Leaf						
Treatment	**Rate/ac**	**1-DAA-1**	**3-DAA-1**	**7-DAA-1**	**1-DAA-2**	**3-DAA-2**	**7-DAA-2**	**Avg**
Entrust	8 oz	18.5abc	20.9ab	12.3a	12.6ab	11.8a	17.1a	15.5abc
Entrust+M-Pede	8 oz+2 %	14.7bc	17.5ab	11.6a	8.9b	9.5a	12.5ab	12.4c
Entrust+Mantis	8 oz+1 pt	13.2c	14.5b	12.5a	12.4ab	9.8a	12.0b	12.4c
Veratran-D	10 lbs	17.7abc	20.9ab	12.4a	12.6ab	10.8a	14.8ab	14.9abc
Grandivo	2 lbs	19.7ab	20.3ab	13.9a	12.7ab	13.7a	14.1ab	15.7abc
Aza-Direct + Pyganic	2 pts + 17 oz	17.6abc	18.8ab	11.3a	9.8ab	8.8a	14.5ab	13.4bc
Azera	3 pts	18.2abc	18.7ab	11.1a	8.7b	10.3a	12.0b	13.2bc
Oroboost	0.60%	21.9a	21.1ab	15.3a	13.9ab	13.9a	13.6ab	16.6ab
Brigade	6.2 oz	16.2abc	14.5b	11.5a	11.1ab	9.6a	14.5ab	12.9bc
Brigade+Venom	6.2 + 3 oz	1.0d	1.1c	3.5b	0.4c	1.0b	1.6c	1.4d
Untreated	-	20.7ab	22.9a	14.4a	15.0a	13.8a	17.6a	17.4a
	F value	107.2	68.79	10.31	82	33.35	81.17	176.7
	P > F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Lep larvae control with organically approved insecticides on broccoli - 6 DAA-3

		Avg. Large Larvae / 10 Plants			
Treatment	**Rate/ac**	**BAW**	**CL**	**DBM**	**Total**
Entrust	8 oz	0.0c	0.4a	0.0c	0.4d
Entrust+M-Pede	8 oz+2 %	0.4bc	0.4a	0.0c	0.8cd
Entrust+Mantis	8 oz+1 pt	0.0c	0.0a	0.4bc	0.4d
Veratran-D	10 lbs	5.0a	4.6a	2.9abc	12.5a
Grandivo	2 lbs	6.7a	2.9a	2.5abc	12.1a
Aza-Direct + Pyganic	2 pts + 17 oz	2.1abc	3.3a	3.8abc	9.2ab
Azera	3 pts	4.2a	0.0a	5.4ab	9.6ab
Oroboost	0.60%	3.8a	0.9a	2.1abc	6.8ab
Brigade	6.2 oz	3.3ab	0.4a	0.8bc	4.6b
Brigade+Venom	6.2 + 3 oz	3.3ab	0.0a	0.4bc	3.7bc
Untreated	-	7.1	2.9a	5.8a	7.1a
	F value	*8.11*	*3.17*	*4.63*	*20.99*
	P>F	*<.0001*	*0.007*	*0.0005*	*<.0001*

Cross-spectrum Insect Control in Organic Broccoli, Fall 2016

Methods Broccoli "Emerald crown' was direct seeded on 6 Sep, 2016 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each treatment compound are provided in the tables. Three foliar spray applications were made on 19 and 27 Sep, and 7 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. An adjuvant, Silwet, was applied at 0.125% v/v with all treatments. The pH of the spray water in the Pyganic, and Azera treatments was lowered to a pH of 5.5-6 using Neutralizer at 0.1% v/v.

At various intervals after treatment, plants were randomly selected from each replicate and destructively sampled for the presence of each insect species. Bagrada bug and flea beetle damage were evaluated by examining 10 plants per rep and counting the number of adults and damage on each plant. Beet armyworm, cabbage looper and diamondback moth (DBM) control was based on the examination of whole plants for presence of small (newly hatched and 1st instar) and large (2^{nd} instar or >) larvae. The number of plants in each plot with fresh feeding tracks on plants was also recorded. Adult populations were assessed by counting all adults on the lower surface of a single leaf from 5 plants per replicate. Evaluations of SWF control was estimated by counting the number of eggs and immature lifestages on two, 2-cm^2 disk sections taken from 2 leaves collected from each of 5 plants per replicate at various days after application (DAA). WF immature densities on each leaf disk were estimated under magnification in the laboratory.

Because of heterogeneity of mean variances, data were transformed using a log10 (x-1) function before analysis. 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.

Summary Among the biopesticides, only the Entrust treatments significantly controlled all lepidopterous species present. Similarly, when averaged across all sample dates, only the Entrust treatments and Azera significantly reduced whitefly adults. Among biopesticides, Grandivo, Venerate, Pyganic and Botanigard +Xentrari did not provided significant control of whitefly nymphs. Bagrada bug damage was reduced with the Entrust treatments and flea beetle damage was reduced by Azera. The conventional insecticide (Exirel+Sniper) provided consistent control of all pests following each spray.

Efficacy of organically approved insecticides against Lep Larvae in broccoli

		Trial Average			
		Mean large larvae (2nd instar >) / 10 plants			
Treatment	**Rate/ac**	**BAW**	**CL**	**DBM**	**Total**
Exirel + Sniper	15 + 5 oz	0.1e	0.4c	0.0b	0.5c
Entrust + M-Pede	6 oz + 2 %	0.2de	0.9c	0.0b	1.1c
Entrust + Mantis	6 oz + 2 pts	0.4de	0.6c	0.0b	1.0c
Grandivo	2 lbs	1.9ab	5.9a	0.9a	8.7a
Venerate	2 qt	2.2a	6.4a	0.3ab	8.9a
Pyganic	17 oz	1.5abc	7.0a	0.5ab	9.0a
Azera	2 pts	1.4abc	3.1b	0.5ab	4.9b
Azera + Pyganic	2 pts + 17 oz	0.9bcd	2.2b	0.6ab	3.7b
Botanigard + Xentari	1 qt + 1 lb	0.7cde	2.9b	0.3ab	3.9b
Untreated		3.1a	7.9a	0.4ab	11.3a
	F value	*16.99*	*63.21*	*2.77*	*64.19*
	P<F	*<.0001*	*<.0001*	*0.02*	*<.0001*

Efficacy of organically approved insecticides against whitefly adults in broccoli

		Whitefly Adults / Leaf						
		1-DAA-1	3-DAA-1	7-DAA-1	1-DAA-2	4-DAA-2	7-DAA-2	**Trial Avg.**
Treatment	**Rate/ac**	**20-Sep**	**22-Sep**	**26-Sep**	**28-Sep**	**1-Oct**	**4-Oct**	
Exirel + Sniper	15 + 5 oz	0.6d	0.7c	7.6b	0.5d	1.3b	3.8b	2.4e
Entrust + M-Pede	6 oz + 2 %	4.0bc	4.3ab	16.3a	8.1bc	13.0a	13.8a	10.1cd
Entrust + Mantis	6 oz + 2 pts	3.2c	3.4b	15.3a	6.0c	10.3a	14.4a	8.7d
Grandivo	2 lbs	7.0ab	6.5a	20.3a	15.3ab	16.3a	20.4a	14.2ab
Venerate	2 qt	7.4a	6.2a	20.8a	15.9ab	17.6a	19.6a	14.6a
Pyganic	17 oz	5.8ab	5.2ab	15.0a	15.6ab	14.2a	17.4a	12.2abc
Azera	2 pts	6.3ab	4.7ab	15.9a	13.3ab	13.3a	12.0a	10.9bc
Azera + Pyganic	2 pts + 17 oz	5.6ab	5.2ab	22.0a	13.0ab	11.6a	15.1a	12.4abc
Botanigard + Xentari	1 qt + 1 lb	5.5ab	5.2ab	19.6a	16.4ab	17.4a	20.3a	12.9ab
Untreated		6.9ab	5.8a	22.4a	20.9a	16.4a	17.1a	14.5a
	F value	*38.33*	*29.94*	*7.67*	*42.33*	*33.22*	*9.63*	*135.71*
	P > F	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Efficacy of organically approved insecticides against whitefly immatures in broccoli

Treatment	Rate/ac	Trial Average: Mean Whitefly immatures / cm2 — Eggs	Small nymphs	Large nymphs	Total nymphs
Exirel + Sniper	15 + 5 oz	1.4c	1.2b	0.1e	1.2f
Entrust + M-Pede	6 oz + 2 %	7.0ab	5.6a	1.8abc	7.4bcde
Entrust + Mantis	6 oz + 2 pts	5.9b	5.4a	1.4bcd	6.8cde
Grandivo	2 lbs	9.6a	6.6a	2.2ab	8.8abcde
Venerate	2 qt	8.9ab	6.4a	3.8a	10.3abc
Pyganic	17 oz	7.6ab	8.1a	3.6a	11.7a
Azera	2 pts	9.0ab	6.1a	0.7cd	6.8de
Azera + Pyganic	2 pts + 17 oz	7.5ab	5.2a	0.4d	5.6e
Botanigard + Xentari	1 qt + 1 lb	10.1a	7.5a	3.1ab	10.6ab
Untreated		11.1a	6.4a	3.8a	10.2abcd
	F value	*16.43*	*7.82*	*9.82*	*6.51*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Efficacy of organically approved insecticides against bagrada bug and flea beetles in broccoli

Treatment	Rate/ac	Bagrada bug: Adults /10 plants	Bagrada bug: Damage (% plants)	Flea Beetles: Adults /10 plants	Flea Beetles: Damage (% plants)
Exirel + Sniper	15 + 5 oz	0.0b	0.0b	0.0a	7.5c
Entrust + M-Pede	6 oz + 2 %	0.3ab	0.0b	0.3a	37.5ab
Entrust + Mantis	6 oz + 2 pts	0.0b	2.5b	0.3a	55.0a
Grandivo	2 lbs	0.0b	7.5ab	0.3a	35.0ab
Venerate	2 qt	0.0b	12.5ab	0.3a	22.5ab
Pyganic	17 oz	0.3ab	7.5ab	0.5a	30.0ab
Azera	2 pts	1.0ab	10.0ab	0.0a	15.0b
Azera + Pyganic	2 pts + 17 oz	0.0b	7.5ab	0.3a	22.5ab
Botanigard + Xentari	1 qt + 1 lb	0.0b	5.0ab	0.0a	35.0ab
Untreated		1.5a	17.5a	0.3a	25.0ab
	F value	*3.03*	*3.37*	*0.39*	*2.96*
	P>F	*0.01*	*0.007*	*0.93*	*0.01*

Whitefly Control in Organic Broccoli, Fall 2017

Methods The objective of the study was to evaluate the efficacy of several bipoesticides against whiteflies on broccoli under fall desert growing conditions. Broccoli 'Emerald Crown' was transplanted on Aug 25, 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 are provided in the table. Two foliar sprays were applied on 5 and 16 Oct with a CO_2 operated boom sprayer at 40 psi and 20.5 GPA. A broadcast application was delivered through 2 TXVS-18 ConeJet nozzles per bed. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Ecoszin, Aza-Direct and Azera treatments to modify spray pH to ~5.5. An organic surfactant (Silwet) was applied to each treatment at 0.125% vol/vol.

Adult populations were assessed by counting all adults on the lower surface of a single leaf from 3-5 plants per replicate. Nymphs were assessed by making estimates of immature whiteflies at 7-d intervals following each spray application. Population densities were estimated by counting the number of small nymphs (1^{st} and 2^{nd} instars) and large nymphs (3^{rd} and 4^{th} instars) on two, 1-cm^2 disk discs taken from 2 leaves collected from each of 5 plants per replicate. Because of heterogeneity of mean variances, data were transformed using a log10 (x-1) function before analysis. All data were subjected to ANOVA; means were compared using Turkey's HSD test (P=0.05). Means from non-transformed data are presented in the tables.

Summary None of the biopesticide treatments significantly controlled whitefly adults compared with the untreated check. Only the conventional standard, Exirel, significantly reduced whitefly adults following each application.

Efficacy of organically approved insecticides against whitefly adults in broccoli

		Whitefly Adults / Leaf						
		6-Oct	8-Oct	12-Oct	17-Oct	20-Oct	23-Oct	Trial
Treatment	**Rate/ac**	**1-DAA1**	**3-DAA1**	**7-DAA1**	**1-DAA2**	**4-DAA2**	**7-DAA2**	**Avg.**
Ecozin	30 oz	9.0a	10.5a	9.6a	8.3a	8.0ab	13.3a	15.2a
Aza-Direct	3 pts	9.2a	9.1a	10.2a	10.5a	5.5ab	11.8a	14.1a
Azera	48 oz	10.5a	9.7a	13.6a	11.4a	7.0ab	10.8a	13.3a
Venerate XC	2 qts	9.7a	10.8a	11.4a	11.3a	11.0a	12.7a	15.3a
Exirel	16 oz	1.7b	0.9b	3.0b	2.0b	1.1b	1.6b	2.2b
Untreated	-	11.5a	11.5a	14.8a	12.2a	13.3a	13.8a	15.8a
	F value	*38.33*	*29.94*	*7.67*	*42.33*	*33.22*	*9.63*	*135.71*
	P > F	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Flea Beetle Control in Organic Broccoli, Fall 2016

Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 31 Aug. Plots were two beds wide by 25 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. A single foliar spray were applied on 9 Sep as a broadcast application delivered through 2 TXVS-18 ConeJet nozzles at 22.5 gpa and 40 psi. An adjuvant, Silwet, was applied at 0.125% vol/vol to all treatments. The pH of the spray water in the Pyganic treatments was lowered to a pH of 5.5-6 using neutralizer at 0.1% v/v.

Insect control evaluations were made 1, 2, 3 and 5 days after application (DAA). Flea beetle efficacy was measured by assessing seedling damage by counting the number of plants with evidence of flea beetle feeding present on true leaves and cotyledons in 6 row ft per plot. FB damage was rated as Light, when 1-2 small feeding sites (1-2 mm) on cotyledon or leaf; Moderate, when multiple feeding sites (3-4 mm) on at least 1 cotyledon or leaf; and Heavy, when cotyledons or leaves with multiple feeding sites (>5 mm) with holes chewed through cotyledons/leaves. 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). Actual non-transformed means are presented in the tables.

Summary Averaged across each sampling dates, feeding damage from flea beetles did not differ among the biopesticide treatments and the untreated control. Only the conventional standard pyrethroid (Discipline) significantly reduced feeding damage.

Flea Beetle control with organically approved insecticides in lettuce

		Trial Average Flea beetle Feeding Damage (%)			
Treatment	**Rate/ac**	**Light**	**Moderate**	**Heavy**	**Total**
Entrust	8 oz	7.2ab	3.5a	2.9a	13.5a
Entrust + M-Pede	8 oz + 2%	6.3ab	3.2a	3.2a	12.7a
Pyganic	17 oz	9.7a	2.8a	2.3a	14.7a
Discipline	5 oz	3.5b	0.3b	0.0b	3.8b
Untreated	-	10.8a	4.1a	3.2a	18.2a
	F value	4.51	6.49	10.18	10.02
	P > F	0.02	0.005	0.0008	0.0008

Flea Beetle Control in Organic Broccoli-II, Fall 2016

Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 8 Sep. Plots were two beds wide by 15 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. A single foliar spray were applied on 18 Sep as a broadcast application delivered through 2 TXVS-18 ConeJet nozzles at 22.5 gpa and 40 psi. An adjuvant, Silwet, was applied at 0.125% vol/vol to all treatments. The pH of the spray water in the Pyganic and Azera treatments was lowered to a pH of 5.5-6 using neutralizer at 0.1% v/v.

Insect control evaluations were made 1, 2, 3 and 5 days after application (DAA). Flea beetle efficacy was measured by assessing seedling damage by counting the number of plants with evidence of flea beetle feeding present on true leaves and cotyledons in 6 row ft. FB damage was rated as Light, when 1-2 small feeding sites (1-2 mm) on cotyledon or leaf; Moderate, when multiple feeding sites (3-4 mm) on at least 1 cotyledon or leaf; and Heavy, when cotyledons or leaves with multiple feeding sites (>5 mm) with holes chewed through cotyledons/leaves. 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). Actual non-transformed means are presented in the tables.

Summary Averaged across each sampling dates, total feeding damage from flea beetles did not differ among the biopesticide treatments and the untreated control. Only the conventional insecticide, Endigo, significantly reduced feeding damage.

Flea Beetle control with organically approved insecticides in lettuce

		Trial Average Flea beetle Feeding Damage (%)			
Treatment	**Rate/ac**	**Light**	**Moderate**	**Heavy**	**Total**
Entrust	8 oz	2.5a	3.8a	3.8a	10.0ab
Entrust + Pyganic	8 + 17 oz	2.5a	6.3a	2.5a	11.3a
Pyganic	17 oz	2.5a	2.5a	0.0b	5.0ab
Azera+Pyganic	32 + 17 oz	3.8a	5.0a	2.5a	11.3a
Endigo	4.5 oz	0.0a	0.0a	0.0a	0.0b
Untreated	-	3.8a	3.8a	2.5a	10.0a
	F value	0.89	2.2	0.9	3.22
	P > F	0.51	0.11	0.51	0.04

Lepidopterous Control in Organic Head Lettuce, Fall 2015

Methods Head lettuce 'El Guapo' was direct seeded on 18 Sep, 2015 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 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 and adjuvant are provided in the tables. Four foliar applications were made on 6, 16 Oct and 2, 18 Nov 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.

Beet armyworm (BAW), cabbage looper (CL) and corn earworm (CEW) control was based on the examination of 10 whole plant at 3, 7, 10 and 14 days following the first three applications (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. At harvest, (7 DAA-4), 10 plants from each plot were harvested and assessed for damage and larval contamination. 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.

Summary All of the biopesticides significantly reduced % damage, BAW and Total large larvae numbers compared to the untreated control. Only the Entrust combinations provided significant control of CL, and overall provided the most consistent control of BAW. Entrust activity was not enhanced by the use of any one adjuvant. Harvest evaluations showed that the Entrust treatments provided the best protection, whereas head contamination from feeding damage, frass and BAW in the Grandivo treatment was not significantly different from the untreated control.

Lep larvae control with organically approved insecticides in lettuce

			Trial Average		
		Damage	Mean Large Larvae/10 plants		
Treatment	Rate	(% plants)	CL	BAW	Total
Entrust+Oroboost	5 oz+0.25%	11.1c	0.2b	0.4c	0.6c
Entrust+M-Pede	5 + 2%	10.6c	0.2b	0.3c	0.5c
Entrust+Mantis	5 +1 pt	9.7c	0.2b	0.2c	0.4c
Entrust+Nufilm-P	5 oz+0.25%	8.2c	0.1b	0.2c	0.3c
Dipel+NufilmP	2 lb+0.25%	24.5b	0.5ab	1.7b	2.2b
Xentari+NuFilm P	2 lb+0.25%	27.8b	0.4ab	1.5b	2.0b
Grandivo+NuFilm P	3 lbs+0.25%	33.7b	0.8ab	2.1b	2.9b
Untreated	-	58.0a	1.1a	3.7a	4.8a
	F value	*43.53*	*5.18*	*17.59*	*39.47*
	P>F	*<.0001*	*0.002*	*<.0001*	*<.0001*

Lep larvae control with organically approved insecticides in lettuce at harvest *(7 DAA-4)*

Treatment	Rate/ac	*% Contaminated Heads* Damage	Frass	CL	BAW	CEW	Total larvae
Entrust+Oroboost	5 oz+0.25%	5.0bc	10.0bc	0.0b	2.5b	0.0a	2.5cd
Entrust+M-Pede	5 + 2%	2.5c	0.0c	0.0b	0.0b	0.0a	0.0d
Entrust+Mantis	5 +1 pt	0.0c	2.5c	0.0 b	0.0b	0.0a	0.0d
Entrust+Nufilm-P	5 oz+0.25%	2.5c	2.5c	0.0 b	0.0b	0.0a	0.0d
Dipel+NufilmP	2 lb+0.25%	15.0bc	10.0bc	5.0b	2.5b	2.5a	10.0b
Xentari+NuFilm P	2 lb+0.25%	8.0bc	10.0bc	2.5b	5.0ab	0.0a	7.5bc
Grandivo+NuFilm P	3 lbs+0.25%	30.0ab	22.5ab	0.0b	15.0a	0.0a	15.0b
Untreated	-	65.0a	52.5a	22.5a	15.0a	2.5a	40.0a
	F	*14.08*	*10.72*	*10.97*	*8.33*	*0.82*	*26.84*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.58*	*<.0001*

Lepidopterous Control in Organic Head Lettuce, Fall 2016

Methods Head lettuce 'El Guapo' was direct seeded on 7 Sep, 2016 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. Three foliar applications were made on 1, 8, and 23 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, Nufilm P, was applied @ 0.125% vol/vol with each treatment on applications 1 and 3, Silwet was applied as an adjuvant @ 0.125% for application 2. The pH of the spray water in the AzaGuard treatments was lowered to a pH of 5.5using 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, 7, and 10 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.

Summary When averaged across all sample dates, Grandivo and Venerate did not significantly control BAW or CL, whereas AzaGuard and Dipel did not control BAW. The Entrust and Xentari treatments significantly reduced both CL and BAW larvae, and had significantly less feeding damage than the untreated check. No differences in control were observed between the 3 and 5 oz Entrust rates.

Lep larvae control with organically approved insecticides in lettuce

			Trial Average		
		Damage	Mean Large Larvae/10 plants		
Treatment	**Rate**	**(% plants)**	**CL**	**BAW**	**Total**
Entrust	5 oz	6.4d	0.1d	0.2d	0.3c
Entrust	3 oz	12.1cd	0.6d	0.3cd	0.9c
AzaGaurd	16 oz	47.9ab	3.7bc	2.1ab	5.7ab
Dipel	2 lbs	43.1ab	3.2c	2.2abc	5.4ab
Xentari	2 lbs	33.3bc	3.2c	0.5bcd	3.7b
Grandivo	2 lbs	60.4ab	6.1ab	3.0a	9.1a
Venerate	2 qts	61.9a	6.6ab	3.0a	9.6a
Untreated	-	69.0a	7.1a	3.0a	10.1a
	F value	*21.64*	*36.31*	*9.91*	*34.64*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Lepidopterous Control in Organic Head Lettuce Fall 2017

Methods 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 (2nd 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.

Summary 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, and Venerate and Xentari significantly reduced BAW numbers relative to the untreated check. Aza-Direct, Azera, Dipel, and Grandivo did not provide significant BAW control.

Lep larvae control with organically approved insecticides in lettuce

		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
	F	*1.86*	*11.67*	*13.24*
	P>F	*0.13*	*<.0001*	*<.0001*

Lepidopterous Control in Organic Broccoli, Fall 2017

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Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers 7 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. Three foliar sprays were applied on 20 Sep, 1 and 12 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 23.5 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 various intervals following each spray application during the trial. For diamondback moth, beet armyworm, and cabbage looper, whole plants were destructively sampled for the presence of large (2^{nd} or > instar) larvae.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 CL and BAW population levels were light, and DBM were light-moderate. Against CL, BAW and DBM, Entrust provided control comparable to the local standards Radiant and Proclaim. Xentari only provided significant control against DBM. Overall Entrust was a much more effective biopesticide against Lep larvae than Xentari.

Lep larvae control with organically approved insecticides in broccoli.

		Trial Average Mean Large Larvae / 10 plants			
Treatment	**Rate**	**CL**	**BAW**	**DBM**	**Total**
Radiant	5 oz	0.9bc	0.02b	0.6c	1.5c
Proclaim	4.8 oz	1.7bc	0.2b	0.9c	2.9c
Entrust	5 oz	0.7c	0.1b	0.5c	1.3c
Xentari	1.5 lb	2.2ab	0.7ab	3.4b	6.2b
Untreated		2.0ab	1.0a	8.3a	11.2a
	F value	*6.58*	*8.86*	*28.86*	*25.87*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Lepidopterous Control in Organic Broccoli-II, Fall 2017

Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers 7 Sep, 2017. Plots were two beds wide by 35 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 1 and 11 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 23.5 gpa. An adjuvant, Silwet (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments. The pH of the spray water in the Pyganic, Aza-Direct and Azera treatments was lowered to a pH of 5.5-6 using Neutralizer at 0.1% v/v.

For assessment of Lepidopterous larvae , 10 plants were randomly selected from each replicate at various intervals following each spray application during the trial. For beet armyworm and cabbage looper, whole plants were destructively sampled for the presence of large (2^{nd} or > instar) larvae. For diamondback moth, the presence of all large (1st - 4th instar) 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 (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 CL and BAW population levels were light, and DBM were moderate. Entrust was the only treatment that significantly reduced the numbers of all three Lep species relative to the untreated. Dipel significantly reduced BAW and DBM numbers, and Aza-Direct reduced DBM numbers. Larvae numbers in the Pyganic+Azera and Venerate treatments were not significantly different from the untreated control. Overall, Entrust provided the most consistent control of BAW, CL and DBM larvae in this broccoli trial.

Lep larvae control with organically approved insecticides in broccoli.

		Trial Average Mean Larvae / 10 plants			
Treatment	**Rate**	**BAW**	**CL**	**DBM**	**Total**
Entrust	**5 oz**	0.0b	0.5b	1.0d	1.5e
Pyganic+Azera	**17+48 oz**	0.8ab	2.1a	10.8ab	13.7bc
Venerate	**2 qts**	0.9ab	3.4a	12.6ab	16.9ab
Aza-Direct	**3 pts**	0.7ab	1.7ab	8.8bc	11.2cd
Dipel	**1.5 lbs**	0.2b	2.6a	6.4c	9.1d
Untreated	**-**	1.6a	3.0a	15.4a	20.1a
	F value	*4.35*	*8.65*	*57.15*	*100.69*
	P>F	*0.01*	*0.005*	*<.0001*	*<.0001*

Diamondback Moth Control in Broccoli, Fall 2017

Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers 27 Oct, 2017. Plots were two beds wide by 35 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. A single foliar spray was applied on 25 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 23.5 gpa. An adjuvant, Silwet (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments.

For assessment of diamondback moth larvae, 10 plants were randomly selected from each replicate at various intervals. Whole plants were destructively sampled for the presence of all (1st - 4th instar) 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 (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 DBM populations level were light. Among the biopesticides only Entrust provided DBM control comparable to the conventional standards (Radiant, Proclaim). When averaged across all samples, all of the treatments significantly reduced DBM compared to the untreated control.

Diamondback moth larvae control with organically approved insecticides in broccoli.

		Mean DBM larvae / 10 plants at DAA						
Treatment	**Rate/ac**	**3**	**6**	**10**	**14**	**17**	**21**	**Trial Avg.**
Radiant	5 oz	0.0b	0.0c	0.5bc	0.5b	0.4bc	0.4c	0.3d
Proclaim	4.8 oz	0.2b	1.3bc	1.3abc	2.0ab	0.8bc	1.3abc	1.1bcd
Entrust	5 oz	0.0b	0.0c	1.0abc	0.3b	0.4bc	0.8bc	0.4cd
Dipel	1.5 lb	1.7ab	0.8bc	1.8abc	1.0ab	0.4bc	2.1abc	1.3bc
Xentari	1.5 lb	1.3ab	1.0bc	3.3ab	1.0ab	2.5abc	2.1abc	1.8b
Untreated	-	4.4a	4.5a	5.5a	4.3a	6.7a	3.8a	4.8a
	F	*3.28*	*6.62*	*4.99*	*2.98*	*4.95*	*5.63*	*20.16*
	P>F	*0.004*	*<.0001*	*0.0002*	*0.007*	*0.0002*	*<.0001*	*<.0001*

Diamondback Moth Control in Broccoli, Spring 2017

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Yuma Agricultural Center

Methods Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers 27 Oct, 2017. Plots were two beds wide by 35 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. Three foliar sprays were applied on 17 and 31 Jan and 8 Feb with a CO_2 pressurized boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 23.5 gpa. An adjuvant, Silwet (Helena Chemical Co.), was applied at 0.125% vol/vol with these spray treatments.

For assessment of diamondback moth larvae, 10 plants were randomly selected from each replicate 6 days following each application. Whole plants were destructively sampled for the presence of all (1st - 4th instar) 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 (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 DBM populations were moderate to heavy in this trial. All of the treatments provided significant control of DBM larvae at 6 DAA for each application. Both biopesticides Entrust and Xentari provided DBM control comparable to the conventional standards.

Diamondback moth larvae control with organically approved insecticides in broccoli.

		Avg DBM larvae / 10 plants			
Treatment	**Rate/ac**	**6 DAA-1**	**6 DAA-2**	**6 DAA-3**	**Trial Avg.**
Radiant	6 oz	2.0b	12.5b	11.3b	8.0b
Proclaim	4.8 oz	4.0b	12.9b	6.3b	7.5b
Entrust	6 oz	4.0b	13.3b	7.1b	7.8b
Xentari	1.5 lb	0.6b	10.8b	10.4b	8.5b
Untreated		16.0a	36.7a	43.3a	25.4a
	F value	*4.91*	*2.41*	*6.03*	*12.44*
	P > F	*0.0002*	*0.03*	*<.0001*	*<.0001*

Diamondback Moth Control in Cabbage, Spring 2018

Methods Cabbage 'Gazzelle' was direct seeded into double row beds on 42 inch centers 17 Jan, 2018. Plots were two beds wide by 35 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. Three foliar sprays were applied on 3, 14, and 24 April with a CO_2 pressurized boom sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 40 psi and 23.5 gpa. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol with these spray treatments**.**

For assessment of diamondback moth(DBM) larvae , 10 plants were randomly selected from each replicate at 6 days following each spray application (DAA) during the trial. Whole plants were destructively sampled for the presence of all larval instars. 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 DBM populations were heavy in this trial. Similar to the 2017 broccoli trial, all of the treatments provided significant control of DBM larvae at 6 DAA for each application. Both biopesticides, Entrust and Xentari, provided DBM control comparable to the conventional standards Radiant and Proclaim.

		Avg DBM larvae / 10 plants			
Treatment	**Rate/ac**	**6-DAA1**	**6-DAA2**	**6-DAA3**	**Trial Avg**
Radiant	5 oz	1.0b	0.0b	0.0b	0.3b
Proclaim	4.8 oz	0.0b	0.0b	0.8b	0.3b
Xentari	2 lb	1.0b	0.8b	2.5b	1.4b
Entrust	5.0 oz	1.5b	0.0b	0.8b	0.8b
Untreated	-	20.5a	15.8a	153.3a	63.2a
	F value	*9.49*	*11.12*	*11.73*	*19.76*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Thrips Control in Organic Romaine, Fall 2016

Methods Romaine 'Del Sol' was direct seeded on 29 Sep, 2016 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 were made 1 and 11 Nov 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. No adjuvants were applied with any of the sprays. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Pyganic, AzaGaurd, Aza-Direct and Azera treatments to modify spray pH to ~5.5.

Numbers of Western flower thrips (WFT) and Bean thrips (BT) from 5 plants per replicate were recorded at 3, 7, and 10 days following each application. 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. The Entrust treatments provided the most effective BT and WFT control compared to the other biopesticides. Addition of M-Pede with Entrust, 5 oz enhanced overall WFT control better than Entrust, 7 oz alone. Among the other biopesticides, only Veratran-D significantly reduced WFT adults and larvae compared with the untreated control.

Thrips control with organically approved insecticides in romaine.

		Trial Average Mean Thrips/Plant			
Treatment	**Rate/ac**	**BT adults**	**WFT Adults**	**WFT Larvae**	**WFT Total**
Entrust	7 oz	4.5b	5.5bc	4.9cd	10.4c
Entrust+M-Pede	5 oz + 2%	2.9b	2.9c	3.0d	5.9d
Entrust+Mantis	5 oz + 1 pt	6.3b	6.3bc	5.9c	12.2c
Aza-Direct	3.5 pts	21.1a	9.6ab	30.8ab	40.4ab
AzaGuard	16 oz	20.6a	10.1ab	28.4ab	38.4ab
Azera	3 pts	19.6a	8.8ab	33.3ab	42.0ab
Azera+Pyganic	3 pts + 17 oz	20.1a	11.2a	26.5ab	37.6ab
Pyganic	17 oz	17.7a	10.5ab	37.8a	48.3a
Veratrand-D	10 lbs	18.5a	6.0bc	19.7b	25.6b
Untreated	-	23.3a	11.0ab	48.6a	59.7a
	F value	*58.84*	*9.81*	*62.23*	*58.45*
	P>F	*<.0001*	*<.0001*	*<.0001*	*<.0001*

Thrips Control in Organic Head Lettuce, Spring 2016

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Yuma Agricultural Center

Methods Head Lettuce 'Domingos 67' was direct seeded on 3 Dec, 2015 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42-inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Four foliar sprays were applied 31 Jan, 10, 16, and 26 Feb. The Entrust +M-Pede treatment only received M-Pede (2%) on the 3rd spray date. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 25 gpa through 2 TXVS-18 ConeJet nozzles per bed. An adjuvant, Silwet, was applied at 0.125% to all treatments.

Aphid populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sampling date, 5-8 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. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at 3 and 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 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:

Averaged across all sample evaluations, only the Entrust+M-Pede and the Aza-Direct treatments had significantly fewer total thrips than the untreated control. None of the insecticide treatments provided aphid control (data not shown), although aphid numbers were low.

Thrips control with organically approved insecticides in head lettuce.

		Trial Average Western Flower Thrips / Plant		
Treatment	**Rate**	**Adults**	**Larvae**	**Total**
Entrust+M-Pede	5 oz+2 %	4.3b	0.8d	5.1c
Aza-Direct	3.5 pts	8.1a	3.6c	11.7b
Pyganic	17 oz	7.1a	10.1abc	17.2ab
Azera	3 pts	8.3a	4.9bc	13.2ab
PFR-97	2 lbs	8.0a	9.2ab	17.2ab
Grandivo	3 lbs	7.8a	9.5ab	17.3ab
Untreated	-	7.8a	13.3a	21.1a
	F value	*16.51*	*43.63*	*53.94*
	P>F	*<.0001*	*<.0001*	*<.0001*

Thrips Control with Entrust and Adjuvants in Organic Head Lettuce, Spring 2016

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Arizona Experiment Station
Yuma Agricultural Center

Methods Head lettuce 'S7735LD' was direct seeded on 5 Nov, 2015 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 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 18 and 26 Jan. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Several adjuvants were applied to Entrust at different rates (% vol/vol).

Numbers of WFT from 5 plants per replicate were recorded at 3 and 7 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 were transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary WFT populations levels were light. All the Entrust treatments, regardless of adjuvant used, significantly provided WFT control when averaged across all sample dates. Among adjuvants, M-Pede, Silwet, and Mantis provided the most consistent WFT control compared to Entrust allied without an adjuvant.

Thrips Control with Entrust and Adjuvants in Head Lettuce

Treatment	Adjuvant Rate	Trial Average Western Flower Thrips / Plant Adults	Larvae	Total
Entrust, 7 oz + NuFilm P	0.25%	1.5b	6.4b	7.8b
Entrust, 7 oz + NanoBS	5%	1.3b	4.7bc	6.0bc
Entrust, 7 oz + M-Pede	2%	1.2b	3.7c	4.9c
Entrust, 7 oz + Oroboost	0.25%	0.9b	6.0bc	6.9bc
Entrust, 7 oz + Silwet	0.25%	1.0b	3.2c	4.2c
Entrust, 7 oz + Mantis	1 pt	1.2b	3.1c	4.3c
Entrust, 7 oz	-	1.2b	6.9b	8.1b
Untreated	-	3.9a	15.1a	19.0a

Thrips Control with Entrust and Adjuvants in Organic Romaine, Spring 2016

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Arizona Experiment Station
Yuma Agricultural Center

Methods Romaine' Solid King' was direct seeded on 3 Dec, 2015 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Two foliar sprays were applied 12 and 27 Feb. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Various adjuvant was applied to the treatments at various rates.

Numbers of WFT from 5 plants per replicate were recorded at 3, 7 and 11 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 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 As opposed to the previous head lettuce trial, WFT populations in this romaine trial were much heavier. All the Entrust treatments significantly reduced WFT numbers compared to the untreated check, and the M-Pede+Entrust, 5 oz treatment provided the better control compared to Entrust, 7 oz applied alone.

Thrips Control with Entrust and Adjuvants in Romaine.

Treatment	Adjuvant Rate	Trial Average Western Flower Thrips / Plant		
		Adults	Larvae	Total
Entrust, 5 oz + NuFilm P	0.25%	8.5b	11.3b	19.9b
Entrust, 5 oz + M-Pede	2%	5.7c	2.8d	8.4d
Entrust, 5 oz + Oroboost	0.25%	8.4b	4.8c	13.2bc
Entrust, 5 oz + Silwet	0.25%	7.6bc	5.3c	13.0c
Entrust, 5 oz + Mantis	1 pt	7.6bc	5.7c	13.4bc
Entrust, 7 oz	-	8.3b	7.4bc	15.9bc
Untreated	-	16.8a	61.4a	78.2a

Thrips Control with Entrust in Organic Romaine, Spring 2016

Methods Romaine' Solid King' was direct seeded on 3 Dec, 2015 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Formulations and rates for each compound are provided in the tables. Two foliar sprays were applied on 2 and 16 Feb. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 22.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. No adjuvant was applied to the 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 were transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Summary WFT populations in this romaine trial were light-moderate. All the Entrust treatments significantly reduced adult and larval WFT numbers compared to the untreated check, and M-Pede enhanced insecticidal activity when combined rate for rate with Entrust, over Entrust applied alone.

Thrips Control with Entrust in Romaine.

		Trial Average		
		Western Flower Thrips / Plant		
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Total**
Entrust	3	4.0ab	4.2b	8.2b
Entrust	5	3.7bc	2.5bc	6.3bc
Entrust	7	3.4bc	2.4bc	5.8bc
Entrust +M-Pede	3+2%	3.1bc	1.4cde	4.5cd
Entrust +M-Pede	5+2%	3.0bc	1.2de	4.2cd
Entrust +M-Pede	7+2%	2.7c	1.0e	3.6d
Untreated	-	7.5a	18.8a	26.3a
	F value	*9.91*	*28.31*	*27.29*
	P>F	*<.0001*	*<.0001*	*<.0001*

Thrips Control in Organic Romaine, Fall 2017

COLLEGE OF AGRICULTURE & LIFE SCIENCES
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Yuma Agricultural Center

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, 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 were made 22 Oct and 3 Nov 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 at 0.125% vol/vol to all treatments. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the DeBug Turbo, Neemix, Aza-Direct and Azera treatments to modify spray pH to ~5.5.

Numbers of Western flower thrips (WFT) and Bean thrips (BT) from 5 plants per replicate were recorded at 3, 7, and 10 days following each application. 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 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.

Thrips control with organically approved insecticides in romaine.

Treatment	Rate/ac	Mean Bean Thrips / Plant	Mean WFT / Plant		
			Adult	Larvae	Total WFT
Entrust	7 oz	3.9b	6.5a	4.2c	10.7c
Veratran-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
	F value	*2.43*	*1.24*	*24.08*	*14.51*
	P>F	*0.04*	*0.31*	*<.0001*	*<.0001*

Thrips Control in Organic Head Lettuce, Spring 2017

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Arizona Experiment Station
Yuma Agricultural Center

Methods Head lettuce 'Gazelle' was direct seeded on 25 Jan, 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 6, 14 and 24 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 DeBug Turbo, AzaGuard, and Aza-Direct treatments to 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 and 7 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 population levels were light-moderate. Among the biopesticides, only Entrust+M-Pede provided significant control of adults and larvae in this trial.

Thrips control with organically approved insecticides in head lettuce.

		Trial Average Mean WFT /Plant		
Treatment	**Rate/ac**	**Adult**	**Larvae**	**Total**
DeBug Turbo	**32 oz**	13.7a	27.0a	40.7a
AZA-Direct	**3 pts**	15.0a	21.3 a	36.3a
AZAGuard	**16 oz**	14.3a	23.1a	37.4a
Entrust+M-Pede	**7 oz + 2 %**	7.9b	3.4b	11.3b
Untreated	**-**	12.1a	34.4a	46.5a
	F value	*10.73*	*41.12*	*32.51*
	P>F	*<.0001*	*<.0001*	*<.0001*

Thrips Control in Organic Romaine, Spring 2018

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.

Thrips control with organically approved insecticides in romaine.

		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
	F value	*8.06*	*72.48*	*47.81*
	P>F	*<.0001*	*<.0001*	*<.0001*

Aphid Control in Organic Head Lettuce, Spring 2015

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Arizona Experiment Station
Yuma Agricultural Center

Methods The objective of this study was to evaluate the efficacy of several organically-approved insecticides against green peach and foxglove aphids in lettuce under desert growing conditions. Lettuce' Navajo'' was direct seeded into double row beds on 42 inch centers on 2 Dec 2014. Plots were two beds wide by 35 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 28 Jan, 4 and 12 Feb as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 29.5 gpa and 60 psi. No adjuvants were applied to any of the treatments. Where instructed by the label, the pH of the spray water was lowered to 5.5 using Buffer X as the acidifier.

Evaluations of green peach and foxglove aphid populations were assessed by estimating the number of aphids / plant in whole plant, destructive samples. On each sample date, six or eight 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 log transformed (mean+1) and subjected to ANOVA; means were separated using Tukeys ($P = 0.05$). Actual non-transformed means are presented in the tables.

Summary

Aphid populations were light in the trial. None of the spray treatments significantly reduced aphid populations relative the untreated control on any sample date with the exception of AZA-Direct at 6 DAA1. No phytotoxicity was observed in any of the treatments.

		Avg. Total aphids/ plant				
Treatment	**Rate (oz/ac)**	**6 DAA1**	**6 DAA2**	**6 DAA3**	**12 DAA3**	**Avg.**
AzaGuard	16 oz	6.3ab	3.7a	2.7a	4.9a	4.4a
AzaDirect	3 pts	3.6b	2.8a	2.3a	5.3a	3.7a
Pyganic	17 oz	5.9ab	5.0a	5.8a	9.8a	6.6a
M-Pede	2%	7.2ab	3.9a	5.2a	5.5a	5.5a
AzaDirect+M-Pede	3 pts + 2%	5.3ab	2.7a	11.7a	14.5a	8.6a
AzaDirect+Pyganic	3 pts + 17 oz	5.5ab	1.5a	2.8a	6.3a	4.0a
Pyganic+M-Pede	17 oz + 2%	6.0ab	4.2a	1.4a	3.1a	3.7a
Untreated	-	10.3a	5.5a	5.9a	6.3a	7.0a
	F value	*2.36*	*2.33*	*0.75*	*0.38*	*0.87*
	P> F	*0.06*	*0.06*	*0.63*	*0.91*	*0.54*

Aphid Control in Organic Cabbage, Spring 2016

COLLEGE OF AGRICULTURE & LIFE SCIENCES Arizona Experiment Station Yuma Agricultural Center

Methods Cabbage 'Primo vantage' was direct seeded was direct seeded on 28 Jan, 2016 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. Four applications were made on 3, 10, 17, 25 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

Green peach aphid (GPA) populations were assessed 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 was light-moderate. No significant differences in aphid numbers were detected among the biopesticide treatments and the untreated control on each sample date. Averaged across all four sample evaluations (6 DAA), only the Aza-Direct and Azera treatments had significantly fewer aphids than the untreated control.

Aphid control with organically approved insecticides in cabbage.

		Avg. Green Peach Aphids per Plant				
Treatment	**Rate/ac**	*6 DAA-1* **9-Mar**	*6 DAA-2* **16-Mar**	*6 DAA-3* **22-Mar**	*6 DAA-4* **31-Mar**	**Trial Avg**
Aza-Direct	3.5 pts	5.1a	21.3a	14.1b	18.3a	17.9b
Pyganic 5.0	17 oz	1.0a	32.6a	29.0a	16.6a	19.8ab
Azera	3.5 pts	8.3a	35.2a	13.6b	13.6a	17.7b
Mantis	2 pts	12.5a	34.2a	27.2a	14.9a	22.2ab
M-Pede	2%	12.8a	33.0a	26.9a	29.9a	25.6ab
PFR-97	2 lbs	16.1a	30.8a	24.2a	30.3a	25.3ab
Gandivo	3 lbs	21.1a	33.3a	30.8a	20.6a	26.5ab
BugBomb	2.3%	14.3a	34.8a	28.9a	30.4a	27.1ab
Untreated	-	18.4a	54.1a	37.9a	38.8a	37.3a
	F	*2.12*	*0.88*	*4.62*	*3.57*	*3.42*
	P>F	*0.1*	*0.55*	*0.01*	*0.01*	*0.02*

Aphid Control in Organic Cabbage, Spring 2018

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 6 DAA3, only Aza-Direct had fewer aphids than the untreated control. Averaged across all four sample evaluations (6 DAA), Aza-Direct had significantly fewer aphids than the untreated 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
	F	*3.21*	*5.31*	*19.58*	*32.74*
	P>F	*0.01*	*0.0007*	*<.0001*	*<.0001*

Aphid Control in Organic Spinach, Spring 2016

Methods Spinach 'Cello' was planted on 84 inch beds in a plant density of 18 seedlines per bed on 27 Jan, 2016. Stands were established with sprinkler irrigation and irrigated with sprinklers thereafter. Plots for each trial consisted of a single 84" bed , 35' long with a 5 ft buffer within rows and a 1 bed untreated buffer between plots. Plots were arranged in a randomized complete block design with 4 replications. Formulations and rates for each compound are provided in the tables. Three applications were made on 3, 14 and 20 March. Beleaf was only applied on 3 and 20 Mar. The foliar sprays were applied with a CO_2 operated boom sprayer at 50 psi and 25 gpa. A broadcast application was delivered through 4 TX-18 ConeJet nozzles per bed. No adjuvants were applied to any of the treatments. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the Pyganic, PFR-97, 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 by estimating the number of aphids / plants in whole plant, destructive samples. On each sampling date, 10 plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous (non-winged) aphids present. Because of heterogeneity of mean variances, data were transformed using a $\log_{10}(x + 1)$ function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the table.

Summary Following three applications and averaged across all sample evaluations, all of the insecticide treatments had significantly fewer aphids then the untreated control. Aphid numbers were lowest in the conventional standard (Beleaf), and aphid numbers did not differ significantly among the biopesticide treatments.

Aphid control with organically approved insecticides in spinach.

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

Aphid / Thrips Control in Organic Head Lettuce, Spring 2017

COLLEGE OF AGRICULTURE & LIFE SCIENCES
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Methods Head lettuce 'Gazelle' was direct seeded on 25 Jan, 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. Four foliar application was made on 5, 11, 17 and 24 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. An acidifier (Neutralizer) was applied at 0.1% vol/vol to the DeBug Turbo, Neemix, AzaGuard, 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 / plant in whole plant, destructive samples at 5 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 5 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-moderate. Averaged across all sample dates, all of the biopesticide treatments except Neemix had significantly fewer aphids than the untreated control. Following 4 spray applications, only ~50% control of the aphids was achieved. Furthermore, none of the biopesticide treatments significantly reduced numbers of WFT adults and larvae relative to the untreated control.

Aphid control with organically approved insecticides in head lettuce.

		Mean Green Peach Aphids / Plant				
Treatment	**Rate/ac**	**5 DAA1**	**5 DAA2**	**5 DAA3**	**5 DAA4**	**Trial Avg**
Aza-Direct	3 pts	33.8a	9.7a	2.6b	0.3a	11.6b
AzaGuard	16 oz	26.0a	9.4a	2.5b	0.2a	9.5b
PFR 97	2 lbs	24.5a	12.4a	3.0ab	0.2a	10.0b
Azera	2 pts	21.6a	12.6a	2.5b	0.3a	9.2b
DeBug Turbo	32 oz	27.7a	10.1a	1.7b	0.1a	9.9b
Neemix 4.5	10 oz	46.0a	13.7a	2.4b	0.3a	15.6ab
Trilogy	2%	25.3a	10.0a	1.7b	0.2a	9.3b
M-Pede	2%	25.5a	11.2a	2.3b	0.2a	9.8b
Untreated	-	50.1a	21.7a	6.1a	0.5a	19.6a
	F value	*1.44*	*1.52*	*5.02*	*0.61*	*4.07*
	P>F	*0.23*	*0.21*	*0.0009*	*0.77*	*0.004*

Thrips control with organically approved insecticides in head lettuce.

		Trial Average Mean Thrips / Plant		
Treatment	**Rate/ac**	**Adults**	**Larvae**	**Total**
Aza-Direct	3 pts	13.2a	14.4a	27.6a
AzaGuard	16 oz	10.8a	16.2a	27.0a
PFR 97	2 lbs	11.6a	23.9a	35.5a
Azera	2 pts	9.8a	21.4a	31.2a
DeBug Turbo	32 oz	9.8a	14.5a	24.3a
Neemix 4.5	10 oz	9.6a	20.7a	30.3a
Trilogy	2%	10.5a	27.2a	37.7a
M-Pede	2%	9.1a	17.8a	26.9a
Untreated	-	10.8a	26.7a	37.5a
	F value	*1.15*	*2.41*	*2.24*
	P>F	*0.36*	*0.05*	*0.06*

Aphid / Thrips Control in Organic Head Lettuce, Spring 2018

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 / plant 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.

Aphid control with organically approved insecticides in head lettuce.

		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
	F value	*4.05*	*3.59*	*5.15*	*9.58*
	P>F	*0.004*	*0.007*	*0.0008*	*<.0001*

Thrips control with organically approved insecticides in head lettuce.

		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
	F value	*4.05*	*3.59*	*5.15*
	P>F	*0.004*	*0.007*	*0.0008*