Knockdown and Residual Control of Bagrada Bug With Foliar Insecticides in Broccoli: *2013 Efficacy Report*

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Preventing adult Bagrada bugs, *Bagrada hilaris*, from feeding on plant terminals and small cotyledons is critical to establishing and maintaining a quality stand. Since Bagrada is a new pest in the southwestern United States, very little information is available for development of sustainable pest management approaches. Thus, management tactics for the Bagrada control in conventional cole crop production has consisted of intensive insecticide usage to protect emerging stands and developing crops.Although an action threshold has not yet been established, nominal observations thus far suggest that treating plants with a contact insecticide when populations exceed one adult per three row feet on seedlings or transplants can prevent stand losses and unacceptable plant damage. Consequently, with the devastating losses caused by high numbers of Bagrada bug in Arizona and southern California in 2010, growers have relied heavily on broad-spectrum insecticides to control large number of fall plantings. Surveys show that pyrethroids and neonicotinoids are the most commonly used insecticides. Since, 2010 it has been estimated that an average of four spray applications were made for Bagrada infestations in fall broccoli fields during stand establishment . http://ag.arizona.edu/crops/vegetables/advisories/more/insect59.html).

Previous research on insecticidal control of Bagrada bug from India and other countries where the Bagrada bug originated is not readily adaptable to cole crop production in the United States because many of the insecticides evaluated are either not currently registered in the U.S. or have been removed from the market. However, in general, pyrethroids have been shown to be the most commonly recommended insecticides for use on mustard crops in India, and older organophosphate products such as chlorpyrifos, malathion, prophenophos, and monocrotophos have also been shown to be effective. Preliminary research conducted in Arizona has demonstrated that foliar applications of pyrethroids (e.g., bifenthrin, lambda cyhalothrin, zeta-cypermethrin) and neonicotinoids (dinotefuron, clothianidin) did provide rapid knockdown control of adult Bagrada bug, but residual control was marginal.

Given the amount of pyrethroid insecticides historically applied to desert vegetable crops and the heavy reliance on neonicotinoids, alternative insecticide management programs will need to be developed if growers want to sustainably protect cole crops from Bagrada bug. In the short term, the current reliance on these two insecticide classes strongly suggests that additional active ingredients with different modes of action are needed to sustainably manage Bagrada on desert cole crops until other IPM alternatives can be developed. Several new reduced-risk classes of chemistry have been developed that have activity against piercing/sucking pests including the diamides, sulfoxamines, and ketoenols. To date however, preliminary studies have shown these new insecticides with novel modes of action do not have significant efficacy against Bagrada bug and likely will not be capable of providing cost-effective control once registered on cole crops .

This report provides the results of six efficacy trials conducted in 2012 at the Yuma Ag Center. The objective of the trials was to evaluate a number of insecticides against Bagrada bug in small broccoli plots under desert growing conditions. Conventional products (industry standards) were compared for efficacy along with a number of tank-mix combinations. Finally, several experimental and organically-approved insecticides were evaluated for efficacy compared with the local standards. All trials followed a similar experimental protocol which included an intense evaluation of adult control and feeding damage at 1, 3 and 5 days after application.

1. Conventional Insecticides

Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 6 Sep 2012. Plots were two beds wide by 35 ft long and bordered by a single untreated bed. 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. Two foliar sprays were applied on 26 Sep and 2 Oct as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments. Evaluations of *Bagrada bug* control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days after treatment (DAT). In addition, the number of plants in each sampled replicate that showed signs of recent feeding were recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where Bagrada bug adults prefer to feed. Insect and feeding data were subjected to ANOVA and means were separated using a *F*-protected LSD ($P \leq 0.05$).

The Bagrada bug population was moderate-high during the trial, and based on local experience, considered to be at economic injury levels. Plants were at the 2-leaf node stage when the first application was made. One day prior to the first application, pre-treatment counts estimated that plots were infested with an average of 7.0 adults per 20 plants. At 1-DAT1, all spray treatments significantly reduced adult numbers compared to the untreated check **(Table 1**). At 3-DAT1, differences in adult numbers varied among the spray treatments where numbers in the Belay and Orthene treatments did not differ from the untreated check. By 5-DAT1, adult numbers had increased in all the spray treatments and did not differ from the untreated check except for the Brigade treatment. Following the second application, *Bagrada bug* numbers were significantly reduced in all spray treatments at 1-DAT2. By 3-DAT2, adult numbers in the Lorsban and Belay treatments were not significantly different from the untreated check, and by 5-DAT2 differences in adult numbers were not detected among spray treatments and the untreated check. Averaged across samples, Brigade and Lannate provide the most consistent control among spray treatments. Similarly, evaluation of feeding signs following each application suggested that Brigade, Lannate, Orthene and Venom provided the most consistent plant protection **(Table 2).**

Table 1. Adult Bagrada bug Knockdown and Residual Control

		Mean Adults / 20 plants						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**5-DAT1**	**1-DAT2**	**3-DAT2**	**5-DAT2**	**Avg**
Brigade 2EC	6.2 oz	0.0b	0.5d	2.3b	0.0b	1.3bc	1.5a	0.9d
Lannate SP	1.0 lb	1.8b	2.5bcd	4.0ab	0.0b	1.0c	4.0a	2.2c
Lorsban 50W	1.33 lb	1.5b	1.5cd	3.0ab	0.8b	5.0ab	4.0a	2.6bc
Belay 2.13SC	4 oz	0.5b	4.0ab	5.0a	0.8b	4.3abc	5.5a	3.5b
Venom 70WG	4 oz	0.5b	2.0bcd	6.8a	0.3b	1.3bc	4.0a	2.5bc
Orthene 97SG	1 lb	0.5b	3.5abc	4.0ab	0.8b	1.5bc	5.5a	2.6bc
Untreated control	-	7.3a	5.8a	6.8a	5.0a	6.8a	6.5a	6.3a

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

Table 2. Feeding Damage on Plants

Treatment	Rate /acre	Mean Plants with Fresh Feeding Signs						
		1-DAT1	3-DAT1	5-DAT1	1-DAT2	3-DAT2	5-DAT2	Avg
Brigade 2EC	6.2 oz	0.3cd	0.0d	3.8c	0.3b	2.3c	1.5c	1.3d
Lannate SP	1.0 lb	0.3cd	2.5bc	6.5bc	0.5c	3.0c	4.8ab	2.9c
Lorsban 50W	1.33 lb	1.0bc	1.5c	6.5bc	2.0b	7.0b	5.5a	3.9bc
Belay 2.13SC	4 oz	1.8b	3.3b	8.3ab	1.0bc	6.8b	6.0a	4.5b
Venom 70WG	4 oz	0.0d	2.3bc	9.0ab	1.0bc	3.0c	3.3b	3.1c
Orthene 97SG	1 lb	0.5cd	2.8bc	6.8bc	0.8bc	3.3c	5.0ab	3.2c
Untreated control	-	5.8a	6.5a	11.3a	6.3a	12.3a	6.5a	8.1a

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

2. Pyrethroids

Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 6 Sep 2012. 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. Two foliar sprays were applied on 15 and 19 Sep as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments. Evaluations of *Bagrada bug* control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days after treatment (DAT). In addition, the number of plants in each sampled replicate that showed signs of recent feeding was recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where *Bagrada bug* adults prefer to feed. Insect and feeding data were subjected to ANOVA and means were separated using a *F*-protected LSD ($P \leq 0.05$).

Plants were at the 1-leaf node stage when the first application was made. The Bagrada bug population was moderate-high during the trial, and considered to be at economic injury levels. At 1-DAT1, all pyrethroid spray treatments significantly reduced adult numbers compared to the untreated check **(Table 1),** but by 3-DAT1, no differences in adult numbers were detected among the spray treatments and the untreated check. A second application was made immediately thereafter, and at 1- and 3-DAT2, there were significantly fewer adult Bagrada bug in the pyrethroid treated plots than in the untreated check. By 5-DAT2, no significant differences in adult numbers were detected among the treatments and the untreated. Averaged across samples, Danitol and Asana appeared to provide the most consistent control among spray treatments. Evaluation of feeding signs following each application followed a trend similar to treatment differences for adult numbers **(Table 2).** The results of this trial are consistent with previous trials that suggest: (a) pyrethroids can provide good knockdown control of Bagrada bug adults on broccoli seedlings, but in general lack residual efficacy, and (b) there appears to be a close relationship between adult numbers and fresh feeding signs estimated from samples on treated and untreated broccoli plants. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1. Adult Bagrada bug Knockdown and Residual Control

Treatment	Rate /acre	Mean Adults / 20 plants					
		1-DAT1	3-DAT1	1-DAT2	3-DAT2	5-DAT2	Avg
Brigade 2EC	6.2 oz	0.0b	2.8a	0.0c	0.8b	3.3a	1.4bcd
Mustang Max	4.0 oz	0.0b	2.5a	1.3b	1.0b	2.8a	1.5bc
Warrior II	1.9 oz	0.3b	2.3a	0.3c	1.0b	2.0a	1.2bcd
Danitol 2.4EC	16 oz	0.0b	1.8a	0.0c	0.3b	1.5a	0.7d
Perm-Up 25DF	12.8 oz	0.5b	3.8a	0.0c	1.0b	4.8a	2.0b
Asana XL	9.6 oz	0.0b	2.5a	0.0c	0.5b	1.8a	1.0cd
Untreated control	-	1.3a	2.8a	4.3a	3.0a	3.5a	3.0a

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

Table 2. Feeding Damage on Plants

Treatment	Rate /acre	Mean Plants with fresh feeding signs					
		1-DAT1	3-DAT1	1-DAT2	3-DAT2	5-DAT2	Avg
Brigade 2EC	6.2 oz	0.0b	2.3a	0.0c	0.8bc	2.8a	1.2bc
Mustang Max	4.0 oz	0.0b	2.5a	0.0c	1.5b	3.3a	1.5b
Warrior II	1.9 oz	0.0b	2.8a	0.5b	0.3c	2.3a	1.2bc
Danitol 2.4EC	16 oz	0.0b	2.8a	0.0c	0.3c	1.5a	1.0c
Perm-Up 25DF	12.8 oz	0.3b	2.8a	0.0c	1.0bc	3.5a	1.5b
Asana XL	9.6 oz	0.0b	3.0a	0.0c	0.3c	2.0a	1.1c
Untreated control	-	1.8a	3.8a	3.3a	3.8a	3.3a	3.2a

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

3. <u>Neonicotinoids</u>

The objective of this study was to evaluate the efficacy of several conventional insecticides against a new invasive pest, *Bagrada hilaris,* in broccoli under desert growing conditions. Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 18 Sep 2012. 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. Two foliar sprays were applied on 16 and 23 Oct as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments. Evaluations of Bagrada bug control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days (DAT; 1st application only). In addition, the number of plants in each sampled replicate that showed signs of recent feeding was recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where Bagrada *bug* adults prefer to feed. Adult SLWF were evaluated at 1, 3 and 7 DAT following both applications. Populations were estimated using a modified vacuum method that employed a 2- gallon portable vacuum (DeWALT, Baltimore, MD) which was fitted with cloth-screened 40 Dram containers to capture and retain vacuumed adults. On each sample date, 5 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. Because of heterogeneity of mean variances, data were log transform (mean+1) and subjected to ANOVA; means were separated using an *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

Plants were at the 4-leaf node stage when the first application was made. The Bagrada bug population was moderate during the trial, and SLWF adult numbers were moderate-heavy. At 1-DAT1, all spray treatments except Assail at the 4.0 oz/ac rate significantly reduced Bagrada adult numbers compared to the untreated check (**Table 1).** At 3-DAT1, differences in adult numbers varied among the spray treatments where numbers in the Assail (4.0 oz/ac) and Exirel treatments did not differ from the untreated check. By 5-DAT1, adult numbers had increased in the spray treatments and did not differ from the untreated check except for the Venom, Endigo and Leverage treatments. Futhermore, evaluation of feeding signs following at each sampling interval suggested that these same treatments provided the most consistent plant protection. SLWF control was most consistent in the Venom, Assail (both rates) and Exirel treatments **(Table 2).**When considering control for both insect pests, Venom was clearly the most efficacious insecticide. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1. Adult Bagrada bug Knockdown and Residual Control

		Bagrada Adults / 20 plants			Plants with fresh feeding signs		
Treatment	**Rate /acre**	**1-DAT**	**3-DAT**	**5-DAT**	**1-DAT**	**3-DAT**	**5-DAT**
Venom 70WG	4 oz	0.3 cd	0.8 cde	0.5 b	0.0 d	0.5 de	1.3 b
Endigo ZC	4.5 oz	0.5 de	0.0 e	0.8 b	0.0 d	0.0 e	1.5 b
Assail 30SG	4 oz	2.8 ab	2.0 ab	3.0 a	2.5 ab	2.5 ab	5.8 a
Assail 30SG	5.3 oz	1.0 d	1.5 bc	3.3 a	0.8 c	1.5 bc	4.5 a
Closer 2SC	5.7 oz	2.5 bc	0.3 de	2.8 a	2.5 ab	0.8 cd	3.5 a
Exirel 10SC	20.5 oz	1.8 de	1.8 ab	4.3 a	1.8 b	1.5 bc	5.8 a
Leverage 360	3 oz	0.0 e	1.0 bcd	0.5 b	0.0 d	0.5 de	1.0 b
Untreated control	-	5.3 a	3.8 a	3.3 a	3.8 a	3.3 a	6.0 a

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

Table 2. Whitefly Adult Knockdown

		Mean Whitefly Adults / Sample						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**7-DAT1**	**1-DAT2**	**3-DAT2**	**7-DAT2**	**Avg**
Venom 70WG	4 oz	26.2 d	10.4 e	9.5 c	5.5 c	0.8 cd	5.3 bc	5.5 e
Endigo ZC	4.5 oz	63.7 ab	68.9 a	20.6 ab	15.8 b	6.0 a	15.1 a	15.8 b
Assail 30SG	4 oz	41.4 c	17.9 c	10.1 c	4.8 cd	1.6 bc	6.6 bc	4.8 d
Assail 30SG	5.3 oz	29.6 d	10.9 de	8.1 cd	4.6 cd	0.9 cd	5.2 c	4.6 e
Closer 2SC	5.7 oz	44.2 bc	42.8 b	20.8 b	10. b	3.9 a	9.9 ab	10.3 c
Exirel 10SC	20.5 oz	61.7 ab	15.1 cd	6.0 d	2.6 d	0.5 d	2.4 d	2.6 e
Leverage 360	3 oz	63.3 ab	62.2 ab	23.8 ab	11.8 b	2.4 ab	14.8 a	11.8 bc
Untreated control	-	87.0 a	90.8 a	31.4 a	27.5 a	5.2 a	16.7 a	27.5 bc

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

4. Pyrethroid and Neonicotinoid Mixtures

The objective of this study was to evaluate the efficacy of several mixtures (tank mixtures and formulated, in-can mixtures) of pyrethroid and neonicotinoid insecticides against *Bagrada* and whiteflies in broccoli under desert growing conditions. Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 6 Sep 2012. 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. Two foliar sprays were applied on 25 Sep and 1 Oct as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments. Evaluations of Bagrada control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days after treatment (DAT). In addition, the number of plants in each sampled replicate that showed signs of recent feeding was recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where Bagrada adults prefer to feed. Evaluations of whitefly (SWF) control was estimated by counting the number of eggs and nymphs on two, 2-cm^2 disk sections taken from the leaves on the 2nd and 3rd leaves nodes collected from each of 10 plants per replicate at 11-DAT2. SWF nymph densities on each leaf disk were estimated under magnification in the laboratory. Because of heterogeneity of mean variances, data were log transform (mean+1) and subjected to ANOVA; means were separated using an *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

The Bagrada population was high during the trial, and based on local experience, considered to be at economic injury levels. Plants were at the 2-leaf node stage when the first application was made. One day prior to the first application, pre-treatment counts estimated that plots were infested with an average of 5.6 adults per 20 plants. All the mixtures provided significant knockdown control of Bagrada adults compared to the untreated check at 1and 3 day following each application, except the Belay +Danitol tank mixture (**Table 1**). Fewer mixtures provide significant residual control at 5 DAT, where among the pyrethroids and neonicotinoid mixtures, only the Venom+Brigade, Assail+Brigade and Endigo treatments had fewer adults than the untreated check. Averaged across all samples, the Venom+Brigade and Endigo treatments provide the most consistent knockdown and residual control. Similarly, evaluation of feeding signs following each application showed that these same treatments provided the most consistent plant protection **(Table 2).** Pyrethroid and neonicotinoid mixtures are important treatments in desert broccoli production because of their efficacy against SWF. In this trial, all of the mixtures provided significant reduction of SWF nymphs compared to the untreated, but the Venom+Brigade combination provided the most significant control of both SWF eggs and nymphs **(Table 3).** The results of this trial suggest that the Venom+Brigade mixture is a good candidate for Bagrada control in desert broccoli crops when SWF populations are also heavy. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1. Adult Bagrada bug Knockdown and Residual Control

		Mean Adults / 20 plants						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**5-DAT1**	**1-DAT2**	**3-DAT2**	**5-DAT2**	**Avg**
Brigadier	5.5 oz	0.3 c	1.0 b	3.0 bc	0.0 b	2.3 b	6.5 abc	2.2 c
Venom +Brigade	4 oz + 6 oz	0.0 c	0.8 b	0.3 d	0.3 b	0.5 b	1.0 d	0.6 e
Assail +Brigade	5.3 oz + 6 oz	0.8 c	0.5 b	2.5 c	0.5 b	0.5 b	5.0 bcd	1.6 cd
Belay + Danitol	4 oz + 14 oz	2.0 b	4.0 a	4.3 ab	0.5 b	1.8 b	6.5 abc	3.2 b
Endigo ZC	4.5 oz	0.3 c	0.8 b	1.8 c	0.0 b	1.3 b	2.5 cd	1.1 de
Leverage 360	3.0 oz	0.3 c	1.0 b	4.5 ab	0.0 b	1.0 b	7.0 ab	2.3 c
Untreated check	-	6.0 a	4.8 a	5.3 a	4.0 a	8.0 a	10.3 a	6.4 a

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

Table 2. Feeding Damage on Plants

Treatment	Rate /acre	Mean Plants with Fresh Feeding Signs						
		1-DAT1	3-DAT1	5-DAT1	1-DAT2	3-DAT2	5-DAT2	Avg
Brigadier	5.5 oz	0.3 c	2.0 b	4.8 c	4.8 b	4.8 b	7.3 ab	4.0 c
Venom +Brigade	4 oz + 6 oz	0.0 c	0.5 c	2.5 d	2.3 bc	2.0 c	2.0 c	1.6 e
Assail +Brigade	5.3 oz + 6 oz	0.8 bc	1.3 bc	4.5 c	2.3 bc	4.5 b	4.5 bc	3.0 cd
Belay + Danitol	4 oz + 14 oz	1.3 b	7.0 a	8.0 ab	2.3 bc	6.3 ab	7.8 ab	5.5 b
Endigo ZC	4.5 oz	0.3 c	0.8 c	4.8 c	1.3 c	3.8 bc	3.5 bc	2.4 de
Leverage 360	3.0 oz	0.0 c	1.5 bc	5.5 bc	0.3 d	3.3 bc	8.0 ab	3.1 d
Untreated check	-	4.0 a	7.0 a	10.8 a	10.3 a	11.3 a	12.3 a	9.3 a

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

Table 3. Control of Whitefly immatures

Treatment	Rate /acre	Whitefly Immature Densities (mean / cm^2)	
		Eggs	Nymphs
Brigadier	5.5 oz	3.8 ab	5.2 bc
Venom +Brigade	4 oz + 6 oz	0.4 d	1.1 d
Assail +Brigade	5.3 oz + 6 oz	1.3 bc	3.2 c
Belay + Danitol	4 oz + 14 oz	3.5 ab	6.2 b
Endigo ZC	4.5 oz	3.0 b	6.6 b
Leverage 360	3.0 oz	0.9 cd	5.9 b
Untreated check	-	7.9 a	14.7 a

5. Experimental Insecticides

The objective of this study was to evaluate the efficacy of several experimental l insecticides relative to the industry standard against *Bagrada hilaris* under desert growing conditions. Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 6 Sep 2012. 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. Two foliar sprays were applied on 20 and 26 Sep as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. An adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments. Evaluations of Bagrada bug control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days after treatment (DAT). In addition, the number of plants in each sampled replicate that showed signs of recent feeding were recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where Bagrada bug adults prefer to feed. Insect and feeding data were subjected to ANOVA and means were separated using a *F*-protected LSD ($P \leq 0.05$).

Plants were at the 2-leaf node stage when the first application was made. The Bagrada bug population was moderate-high during the trial, and based on local experience, considered to be at economic injury levels. Compared to the industry standard (Brigade+Venom), none of the experimental compounds provided consistent control of Bagrada bug adults following either application **(Table 1).** Further, none of the experimental compounds significantly reduced adult numbers relative to the untreated control after either application. Averaged across samples, adult numbers measured in the experimental treatments were 2-3 fold higher or more than the Brigade+Venom treatments. Similar post-treatment differences in feeding signs were observed among the industry standard, experimental compounds and untreated control **(Table 2).** These results are consistent with previous trials that suggest that insecticides with little known contact toxicity (Exirel, Rimon, Movento) do not provide adequate control of adults or suppression of feeding damage. Although Closer, Sivanto and NNI-0101 have shown contact activity against other sucking pests (e.g., aphids and whiteflies) in other trials, these compounds appear to have marginal activity against Bagrada bug. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1. Adult Bagrada bug Knockdown and Residual Control

		Mean Adults / 20 plants						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**5-DAT1**	**1-DAT2**	**3-DAT2**	**5-DAT2**	**Avg**
Brigade + Venom	6 + 4 oz	0.8 de	0.5 c	3.8 a	0.8 b	0.8 b	2.5 c	1.5 d
Sivanto 20SL	10 oz	0.8 de	1.8 bc	6.5 a	4.3 a	5.3 a	5.0 ab	3.9 c
NNI-0101, 20SC	3.2 oz	1.3 cde	3.0 ab	5.8 a	4.8 a	5.0 a	5.0 ab	4.1 bc
Rimon 0.83EC	2.8 oz	2.3 abc	3.8 ab	7.8 a	8.3 a	3.5 a	4.5 b	4.9 ab
Closer 2SC	5.7 oz	0.5 e	3.0 ab	8.0 a	4.5 a	5.3 a	4.8 b	4.3 bc
Movento 2SC	5 oz	3.3 ab	2.0 abc	7.8 a	8.3 a	4.3 a	4.8 b	5.0 bc
Exirel 10SC	20.5 oz	2.0 bcd	2.5 abc	7.5 a	4.5 a	5.0 a	6.3 ab	4.6 bc
Untreated control	-	5.0 a	4.8 a	8.0 a	6.0 a	6.3 a	7.0 a	6.2 a

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

Table 2. Feeding Damage on Plants

		Mean Plants with Fresh Feeding Signs						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**5-DAT1**	**1-DAT2**	**3-DAT2**	**5-DAT2**	**Avg**
Brigade + Venom	6 + 4 oz	0.0 e	0.3 c	4.0 b	0.0 c	0.5 c	2.5 c	1.2 d
Sivanto 20SL	10 oz	1.8 cd	2.0 b	10.3 a	4.5 ab	7.8 ab	7.3 ab	5.6 bc
NNI-0101, 20SC	3.2 oz	2.0 bcd	3.0 ab	8.8 a	3.8 ab	6.0 b	6.8 ab	5.0 c
Rimon 0.83EC	2.8 oz	3.3 a	3.5 a	9.0 a	6.0 a	8.8 ab	7.0 ab	6.3 ab
Closer 2SC	5.7 oz	1.0 d	4.3 a	9.8 a	3.0 b	7.8 b	5.8 b	5.3 c
Movento 2SC	5 oz	4.0 a	3.5 a	8.0 a	6.3 a	7.8 b	7.0 ab	6.1 ab
Exirel 10SC	20.5 oz	2.8 abc	3.3 a	10.0 a	5.8 a	8.3 ab	7.8 a	6.3 ab
Untreated control	-	5.8a	6.5a	11.3a	6.3a	12.3a	6.5a	8.1a

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

6. Organically-Approved Insecticides

The objective of this study was to evaluate the efficacy of several organically-approved insecticides against a new invasive pest, *Bagrada hilaris,* in broccoli under desert growing conditions. Broccoli 'Emerald Crown' was direct seeded into double row beds on 42 inch centers on 12 Sep 2012. 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. Two foliar sprays were applied on 1 and 7 Oct as broadcast applications delivered through 2 TXVS-18 ConeJet nozzles at 25 gpa and 40 psi. A conventional adjuvant, Dyne-Amic (Helena Chemical Co.), was applied at 0.25% vol/vol to all treatments except M-Pede+Entrust. Evaluations of Bagrada bug control was estimated by carefully examining whole plants (20 per replicate) for the presence of live adults on leaves, petioles and stems, as well as on the soil surface beneath each plant at 1, 3 and 5 days after treatment (DAT). In addition, the number of plants in each sampled replicate that showed signs of recent feeding was recorded by inspecting the terminal growth and young leaves on each plant for fresh feeding signs that appeared as pale, starburst-shaped lesions on foliage where Bagrada bug adults prefer to feed. Because of heterogeneity of mean variances, data were log transform (mean+1) and subjected to ANOVA; means were separated using an *F*-protected LSD ($P \leq 0.05$). Actual non-transformed means are presented in the tables.

The Bagrada bug population was high during the trial, and based on local experience, considered to be at economic injury levels. Plants were at the 2-leaf node stage when the first application was made. The Brigade+Venom mixture was included as the industry standard used in conventional broccoli production. At 1-DAT1, none of the organic spray treatments provided control comparable to the commercial Brigade +Venom treatment, and only the M-Pede+Entrust combination had significantly fewer adults than the untreated check **(Table 1).** At 3-DAT1, only the AZA-Direct treatment had fewer adults than the untreated check, and by 5-DAT1 only adult numbers in the Aza-Direct and M-Pede+Entrust treatments were significantly different from the untreated check. Results following the 2nd applications were quite variable. Bagrada bug numbers were significantly reduced in all spray treatments at 1-DAT2, except in the Garlic Barrier and Surround treated plots, but at 3-DAT2, only the Venom+Brigade treatment had significantly fewer adults than the untreated check. At 5-DAT2 adult numbers were significantly lower in all spray treatments. Averaged across all samples, the Aza-Direct and M-Pede+Entrust treatments provided the most consistent control among the organic spray treatments. Similarly, evaluation of feeding signs following each application suggested showed that these two treatments provided the most consistent protection from Bagrada bug feeding **(Table 2).** However, none of the organically-approved insecticide treatments evaluated in this trial provided control of Bagrada bug adults or suppression of feeding comparable to the Venom+Brigade conventional standard. No phytotoxicity symptoms were observed following any of the insecticide treatments.

Table 1. Adult Bagrada bug Knockdown and Residual Control

		Mean Adults / 20 plants						
Treatment	**Rate /acre**	**1-DAT1**	**3-DAT1**	**5-DAT1**	**1-DAT2**	**3-DAT2**	**5-DAT2**	**Avg**
Brigade +Venom	6 + 4 oz	0.0d	2.0c	1.3c	0.0d	0.0b	0.3c	0.6f
Pyganic 5EC	18 oz	4.3ab	9.3ab	10.3ab	3.5bc	4.3a	3.0b	5.8d
Aza-Direct	3 pts	4.8ab	3.5c	11.5ab	5.5b	2.8a	3.0b	5.2de
GWN-9996	36 oz	3.0bc	9.0ab	12.8ab	5.5b	3.0a	2.5b	6.0cd
Garlic Barrier AG	15%	4.3ab	6.8b	16.5a	16.5a	2.8a	3.8b	8.4ab
M-Pede + Entrust SC	2%+8 oz	1.8c	6.8b	8.3b	2.0c	3.8a	3.3b	4.3e
Surround WP	25 lbs	6.0a	10.3a	9.8ab	12.8a	4.5a	4.5b	8.0abc
Untreated check	-	5.5ab	9.0ab	15.5a	17.0a	4.0a	7.5a	9.8a

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

Table 2. Feeding Damage on Plants

Treatment	Rate /acre	Mean Plants with Fresh Feeding Signs						
		1-DAT1	3-DAT1	5-DAT1	1-DAT2	3-DAT2	5-DAT2	Avg
Brigade +Venom	6 + 4 oz	0.5c	4.3c	3.3c	0.3c	0.8c	3.3c	2.0e
Pyganic	18 oz	5.0ab	13.8ab	12.3ab	6.0b	6.3ab	9.5ab	8.8bc
Aza-Direct	3 pts	4.5ab	11.3b	13.0ab	5.5b	3.0bc	7.3b	7.5cd
GWN-9996	36 oz	4.5ab	14.5ab	13.8ab	5.0b	5.5ab	8.8ab	8.7bc
Garlic Barrier AG	15%	5.0ab	13.8ab	16.0a	14.5a	3.3ab	12.5a	10.8ab
M-Pede + Entrust SC	2%+8 oz	3.3b	14.3ab	11.0b	2.8b	3.3ab	9.0ab	7.3d
Surround WP	25 lbs	4.5ab	14.5ab	12.5ab	12.0a	3.8ab	12.5a	10.0b
Untreated check	-	6.5a	17.8a	16.0a	14.0a	7.0a	13.0a	12.4a

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

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