



Knockdown and Residual Control of Bagrada Bugs with Foliar Insecticides: Greenhouse Evaluations

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The objective of this study was to evaluate the efficacy of conventional and experimental insecticides applied as foliar sprays against Bagrada bug adults caged on broccoli seedlings grown under greenhouse conditions. Broccoli 'Emerald Crown' and cabbage 'Gazelle' were direct seeded into transplant trays in April 2011, and placed in a greenhouse at the Yuma Agricultural Center, Yuma, AZ. When plants reached the 2-leaf stage, the plants were sprayed with various insecticides and Bagrada bugs were caged on the treated plants. Adult mortality was measured daily, along with feeding damage and plant injury by adults over a 5 day period.

I. Greenhouse Trial - Knockdown Efficacy

On May 10, 2011, 2-leaf stage broccoli plants grown under greenhouse conditions were individually transplanted into 5" pots and held for 2-days. Following this period, potted plants were taken outside of the greenhouse and treated with a foliar spray of an insecticide using recommended field rates (see table below). Sprays were applied using a CO₂ operated back-pack sprayer delivering 21.5 GPA @ 40 psi similar to how small plots trials are treated. All sprays included an adjuvant, Dyne-Amic, @0.25 % v/v.

Insecticide	Rate/ac	Class	Anticipated activity	Anticipated damage
Brigade 2EC	5 oz	Pyrethroid	Quick knockdown	Little to none
Assail 30SG	4 oz	Neonicotinoid	Moderate knockdown	Light
Beleaf 50WG	2.8 oz	Anti-feedant	Slow knockdown	Moderate
Movento 2SC	5 oz	Ketoenol	Slow knockdown	Moderate to heavy
Cyazypyr 10SE	14 oz	Diamide	Unknown	Unknown
NNI-0101 20SC	3.2 oz	Unknown	Unknown	Unknown
Entrust 20 WP	3 oz	Spinosyn	Unknown	Unknown
Untreated control	-	-	None	Heavy

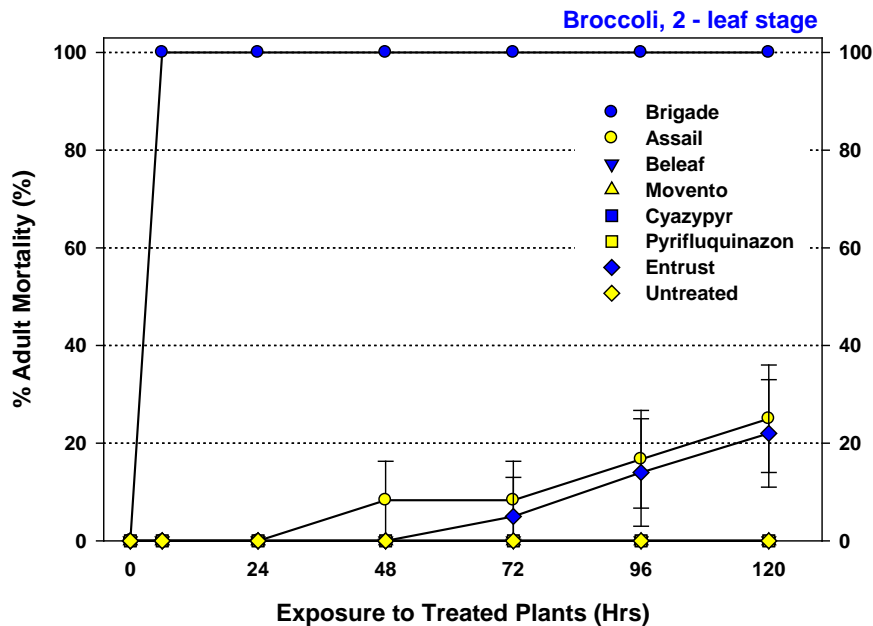
Each treatment was replicated 8 times (plants). After the insecticide sprays were allowed to air dry on plants outside of the greenhouse for 1 hour, plants were then placed inside of the greenhouse. Immediately thereafter, 2 field collected adult Bagrada bugs of unknown age were caged on each plant with a plastic container that had a screened lid to provide ventilation. Plants were arranged in a CRBD in the greenhouse. Plants were held in the greenhouse at average daytime temperatures of 90° F and nighttime temperatures of 76°F for the duration of the study.

Adult mortality was assessed initially at 6 hr following infestation, and then at 24 hr intervals thereafter by recording the number of dead adults within the cage. Mortality was estimated over a 5 day exposure period following the spray treatment. Feeding damage to leaf tissue and terminal growing points was measured daily by estimating the percentage of leaf surface and terminal growth on each plant that had feeding lesions or was desiccated. After the 5 day infestation/exposure period was terminated, cages were removed, sprayed with Brigade at 5 oz (to eliminate the possibility of stray Bagrada bugs infesting the uncaged plants) and held in the greenhouse for 17 days weeks to determine impact of Bagrada feeding in each treatment on plant growth. Plant growth responses were estimated by measuring total plant leaf area ted for all leaves using a Li-Cor, LI-3100 leaf area meter, and measuring plant dry weights for all leaves, petioles and stems of each plant drying the plant parts at 70° C for 48 hrs in a forced draft oven.

Additionally, following the 5 day infestation period, all live adults that survived the exposure to the insecticide spray treatments were removed from plants and placed on fresh, untreated plants for 10 additional days to determine if delayed adult mortality would occur on the untreated plants. Note: No additional adult mortality was observed following this 10 day holding period. The results of the trial are shown below:

Results:

Adult Mortality



Brigade was clearly the most efficacious product in the trial where 100% adult knockdown mortality was observed at 6 hours following placement of adults on the treated plants/soil. None of the other treatments provided similar mortality. Among the other treatments, only Assail and Entrust provided any adult mortality at all, albeit significantly lower than Brigade and only slightly greater than the untreated control at 96 hours following infestation and provided slightly more than 20% mortality after 5 days of exposure to treated plants.

Plant Damage and Growth Responses

Treatment	Avg. Feeding Response (5 days after infestation)			Avg. Growth Response (17 d after cages removed)	
	% Feeding symptoms per leaf	% plants w/ desiccated leaves	% plants w/ damaged terminals	Total dry weight (g/plant)	Total leaf area (cm ² /plant)
Brigade	0.3 c	0.0 c	0.0 b	242.2 a	1.12 a
Assail	18.0 bc	25.0 bc	83.3 a	131.0 b	0.61 b
Beleaf	61.7 a	66.7 a	100 a	79.8 c	0.36 cd
Movento	51.7 a	50.0 ab	83.3 a	89.5 bc	0.41 bcd
Cyazypyr	62.3 a	66.7 a	100 a	61.6 c	0.30 d
NNI-0101	25.4 b	16.7 c	83.3 a	109.9 bc	0.54 bc
Entrust	61.7 a	50.0 ab	83.3 a	96.3 bc	0.41 bcd
Untreated	62.7 a	50.0 ab	66.7 a	72.5 c	0.34 cd

The quick adult knockdown provided by Brigade resulted in excellent plant protection, where treated plants had negligible feeding damage, and significantly greater growth than all other treatments. Assail and NNI-0101 (pyrifluquinazon) had less feeding damage on leaves than the untreated check, but none of the spray treatments, with the exception of Brigade, provided protection against terminal damage (blind or forked plants). With the exception of Assail and Brigade, all other treatments experienced feeding injury and reduced plant growth comparable to the untreated check.

Summary The results of this trial strongly suggest that insecticides with quick-acting contact activity (i.e., Brigade) appear to provide the good protection against *Bagrada* bugs under these experimental conditions. In comparison, many of the newer insecticide alternatives with translaminar and systemic activity against sucking insects evaluated in this trial appear to be poor candidates for *Bagrada* control on young broccoli plants.



Insecticide treated, 2-leaf broccoli plants with caged *Bagrada* bug adults in greenhouse.



Treated broccoli plants 5 days after exposure to *Bagrada* bugs and removal of cages

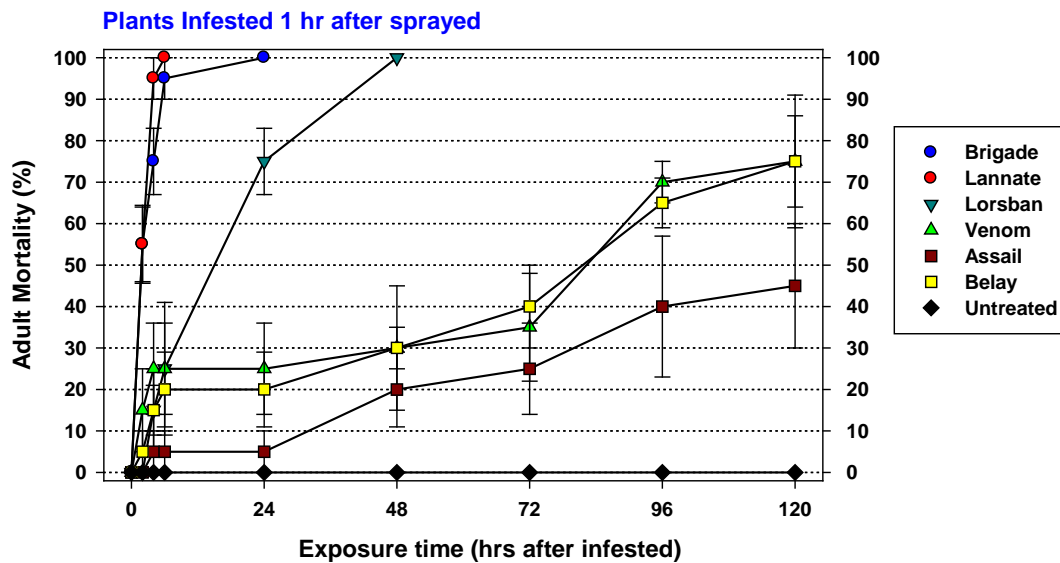
II. Greenhouse Trial - Knockdown and Residual Efficacy

On May 25, 2011, 2-leaf stage cabbage plants grown under greenhouse conditions were individually transplanted into 5" pots and held for 1-day. Following this period, potted plants were treated outside of the greenhouse with a foliar spray of an insecticide similar to Trial I (see table below). Trial II differed from the above trial in that plants were infested with adult *Bagrada* bugs at 3 infestation intervals (1 hour, 3 days and 5 days following the spray treatments) in an attempt to measure both knockdown and residual control of the insecticides. All adults were exposed to plants for a 5 day interval following infestation.

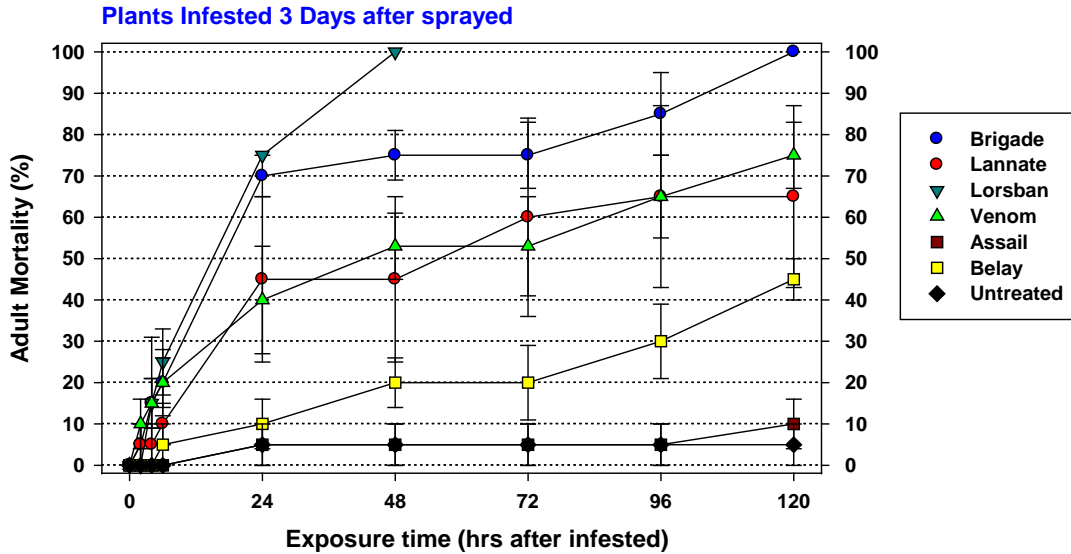
Insecticide	Rate/ac	Class
Brigade 2EC	5 oz	Pyrethroid
Lannate SP	1 lb	Carbamate
Lorsban 50WP	1.33 lb	Organophosphate
Venom 70WG	4 oz	Neonicotinoid
Assail 40SG	4 oz	Neonicotinoid
Belay 2.13SC	4 oz	Neonicotinoid
Untreated control	--	
Un-infested control	--	

Each spray treatment was applied to a total of 18 plants (6 plants replicated in each of the 3 infestation periods). After the insecticide sprays were allowed to air dry on plants outside of the greenhouse, all the plants were placed inside of the greenhouse and covered with a cage. At 1-hour following spray treatments, 4 field collected adult *Bagrada* bugs of unknown age were placed on 6 treated plants/treatment and held in the greenhouse similar to Trial I. This procedure was repeated at 3 days and 5 days after the plants were sprayed. In each infestation period, adult mortality was assessed at 2, 4 and 6 hr initially following infestation, and then at 24 hr intervals thereafter. Feeding damage to leaf tissue and terminal growing points was measured similar to trial I. After the 5 day infestation period was terminated for each set of infestations, cages were removed and all plants were held in the greenhouse for 15 days to determine the impact of *Bagrada* feeding and insecticide treatments on plant growth responses. Leaf area and Dry weights were estimated similar to the first trial.

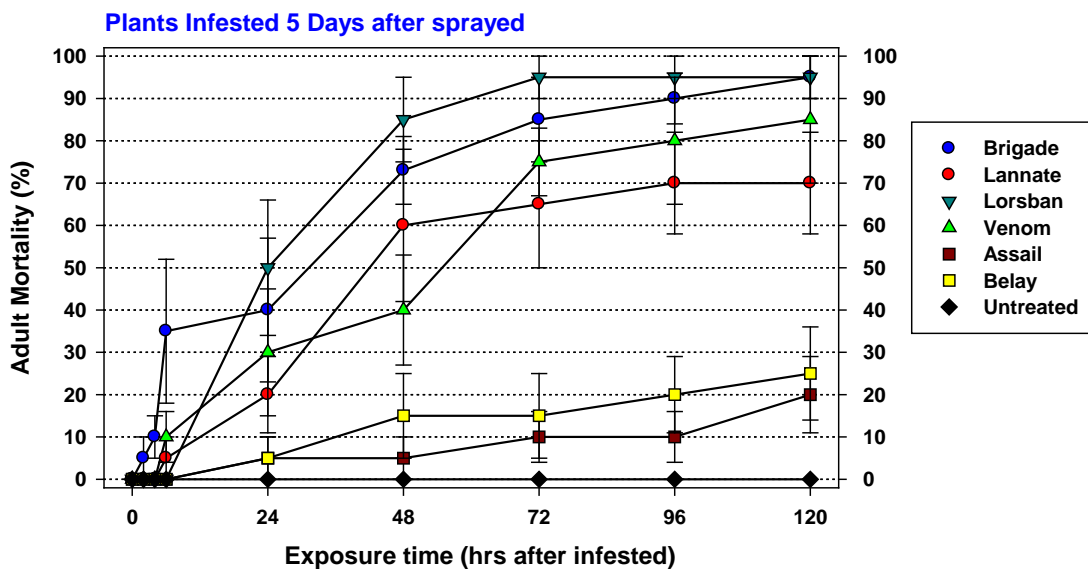
Adult Mortality



When cabbage plants were infested 1 hour following spray treatment, Lannate and Brigade provided the quickest adult knockdown mortality. After only 6 hours exposure to treated plants, adult mortality was 100% in the Lannate treatment and 95% in the Brigade treatment. Lorsban eventually provided 100% mortality after 2 days of exposure to treated plants. The neonicotinoids overall did not provide good knockdown mortality of adults. Venom and Belay provided 75% mortality after 5 days exposure and Assail provide about 45% mortality.



None of the insecticides provided relatively quick knockdown of *Bagrada* adults on cabbage plants infested 3 days following spray treatment. However, the most efficacious product appeared to be Lorsban which provided 75% and 100% mortality after 24 and 48 hours of exposure, respectively. Brigade initially provided about 70% mortality after 24 hours, but complete mortality did not occur until day 5. Lannate had much less residual efficacy and did not provide efficacy different from Venom. Belay provided even less residual efficacy than the 1 hr infestation period above. Adult mortality on Assail treated plants did not differ from the untreated control.



Residual efficacy of the insecticides was further diminished on cabbage plants infested 5 days following spray treatments, and none of the treatments provided 100% mortality following 5 days of exposure to the treated plants. However, Lorsban and Brigade provided > 70-80% mortality after 2 days on the treated plants and reached levels exceeding 90% mortality after 4 days of exposure. Venom and Lannate appeared to have no increase in residual activity against adults relative to the previous exposures. Neither Belay or Assail provided mortality comparable to the other spray treatments, although they were significantly better than the untreated control.

Plant Damage and Growth Responses

Plants Infested 1-Hour After Sprays Applied

Treatment	Avg. Feeding Response (5 days after infestation)			Avg. Growth Response (15 d after cages removed)	
	% Feeding symptoms per leaf	% plants w/ desiccated leaves	% plants w/ damaged terminals	Total dry weight (g/plant)	Total leaf area (cm ² /plant)
Un-infested	0 c	0 c	0 b	0.60 a	173.5 a
Brigade	0 c	0 c	0 b	0.51 ab	150.7 ab
Lannate	0 c	0 c	0 b	0.50 ab	128.1 bc
Lorsban	6.8 c	0 c	60 a	0.63 a	151.9 ab
Venom	0 c	0 c	0 b	0.54 ab	134.7 b
Assail	37.0 b	33.4 b	80 a	0.32 c	69.8 de
Belay	11.8 c	5.0 c	60 a	0.41 bc	91.5 cd
Untreated	93.3 a	88.4 a	100 a	0.14 d	35.4 e

Similar to the first greenhouse trial, the quick adult knockdown provided by the contact insecticides (Brigade, Lannate, Lorsban) on plants infested 1-hour after treatment resulted in excellent plant protection, where treated plants had negligible leaf damage, and had growth responses similar to the un-infested plants. However, Lorsban treated plants had a significantly greater percentage of plants with damaged terminals relative to the other contact materials and likely resulted from the slower knockdown mortality observed. Although Venom did not provide the same level of adult mortality as Lannate and Brigade, plant protection and growth responses were comparable. Both Belay and Assail had significantly more feeding / terminal damage than the contact insecticides and Venom.

Plants Infested 3-Days After Sprays Applied

Treatment	Avg. Feeding Response (5 days after infestation)			Avg. Growth Response (15 d after cages removed)	
	% Feeding symptoms per leaf	% plants w/ desiccated leaves	% plants w/ damaged terminals	Total dry weight (g/plant)	Total leaf area (cm ² /plant)
Un-infested	0 d	0 d	0 c	0.58 a	165.5 a
Brigade	0 d	0 d	0 c	0.59 a	142.3 ab
Lannate	37.8 bc	35.0 bc	60 ab	0.43 ab	99.7 bc
Lorsban	5.8 d	5.0 cd	60 ab	0.44 ab	105.4 bc
Venom	0.4 d	0 d	40 bc	0.56 a	133.2 abc
Assail	62.5 ab	65.0 ab	100 a	0.25 bc	49.1 de
Belay	10.3 cd	5.0 cd	80 ab	0.40 ab	88.2 cd
Untreated	75.3 a	70.0 a	100 a	0.14 c	30.2 e

On plants infested 3 days after spray treatment, only Brigade, Lannate, Venom and Belay had negligible feeding damage on leaves, whereas feeding damage on the Assail treated plants was not different from the untreated control plants. However, only Brigade-treated plants sustained no damage to the terminal growing points. Growth responses for most the treatments were significantly greater than the untreated control with the exception of the Assail treated plants. Plant growth in both these treatments was significantly reduced, and only the Brigade- and Venom-treated plants had dry weight and leaf area measurements comparable to the un-infested plants.

Plants Infested 5-Days After Sprays Applied

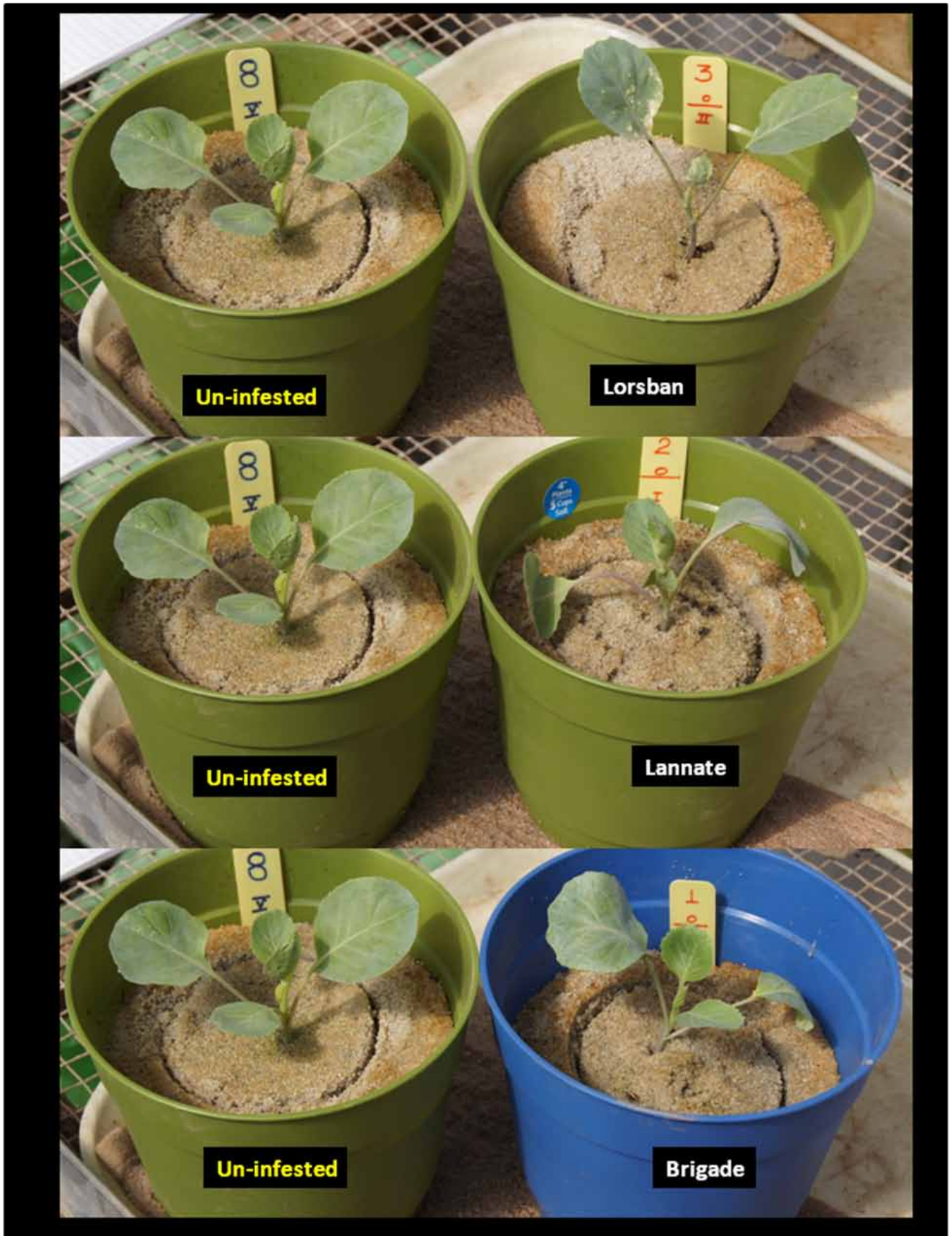
Treatment	Avg. Feeding Response (5 days after infestation)			Avg. Growth Response (15 d after cages removed)	
	% Feeding symptoms per leaf	% plants w/ desiccated leaves	% plants w/ damaged terminals	Total dry weight (g/plant)	Total leaf area (cm ² /plant)
Un-infested	0 d	0 c	0 b	0.69 ab	170.3 a
Brigade	5.2 d	0 c	20 b	0.58 bc	135.8 b
Lannate	26.6 bc	14.0 bc	80 a	0.52 cd	122.3 b
Lorsban	16.6 cd	10 bc	100 a	0.51 cd	123.1 b
Venom	0.3 d	0 c	10 b	0.72 a	170.4 a
Assail	43.4 ab	40.0 a	100 a	0.40 e	75.1 cd
Belay	31.7 bc	28.0 ab	100 a	0.42 de	89.5 c
Untreated	60.2 a	43.0 a	80 a	0.23 f	44.5 d

A similar response was observed on plants infested 5 days after spray treatment, where among all treatments, Venom and Brigade appeared to provide the best residual plant protection against *Bagrada* feeding. Growth responses for Venom were greatest for Venom and was the only treatment comparable to the un-infested plants. Again Assail did not provide much protection and showed reduction in plant growth similar to the untreated control.

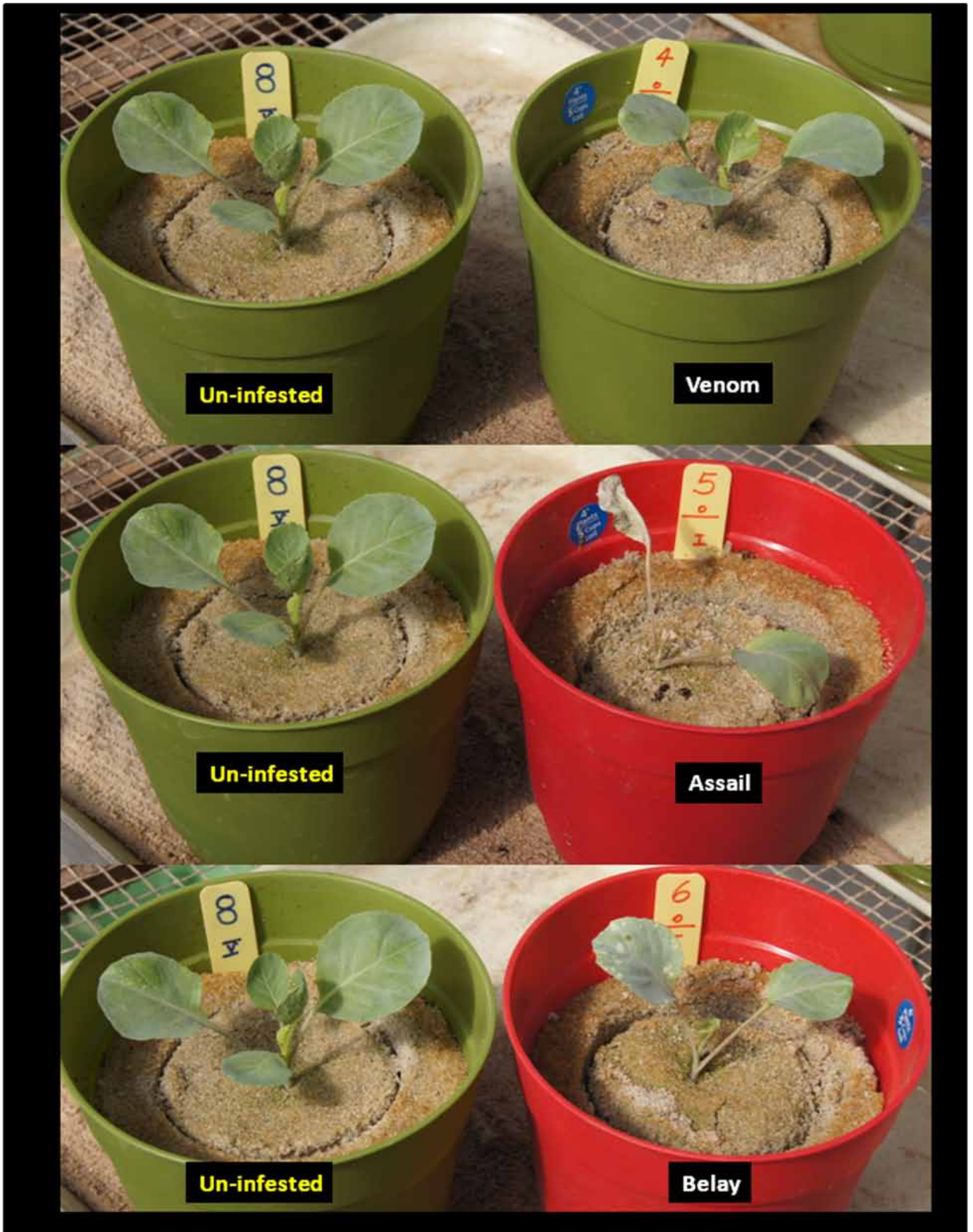
Summary The results of this trial corroborate the results of the first trial strongly suggesting that insecticides with quick-acting contact activity (i.e., Brigade, Lannate, Lorsban) appear to provide good short-term protection against *Bagrada* bug feeding under experimental conditions. However, residual mortality appeared to be limited to about 3 days. Although, Venom, a translaminar neonicotinoid, did not provide comparable levels of adult mortality, the insecticide spray did provide good residual plant protection for up to 5 days, comparable to Brigade. In addition, these preliminary studies also suggest that in the presence of heavy *Bagrada* bug numbers, young broccoli and cabbage plants left unprotected for as little as 2-3 days can sustain significant damage to growing points and suffer reductions in plant growth.

In conclusion, these results suggest that under intense *Bagrada* bug pressure, pest management programs on cole crops should consider alternating contact materials (i.e., Pyrethroids and OP/carbamates) during stand establishment (cotyledon-2 leaf stage) when the plants are developing rapidly, and then rotating to Venom (dinotefuron) on established plants to provide residual protection. This study also illustrates the importance of monitoring for *Bagrada* feeding symptoms on cotyledons (A), and young leaf tissue (B), as well as for adults.

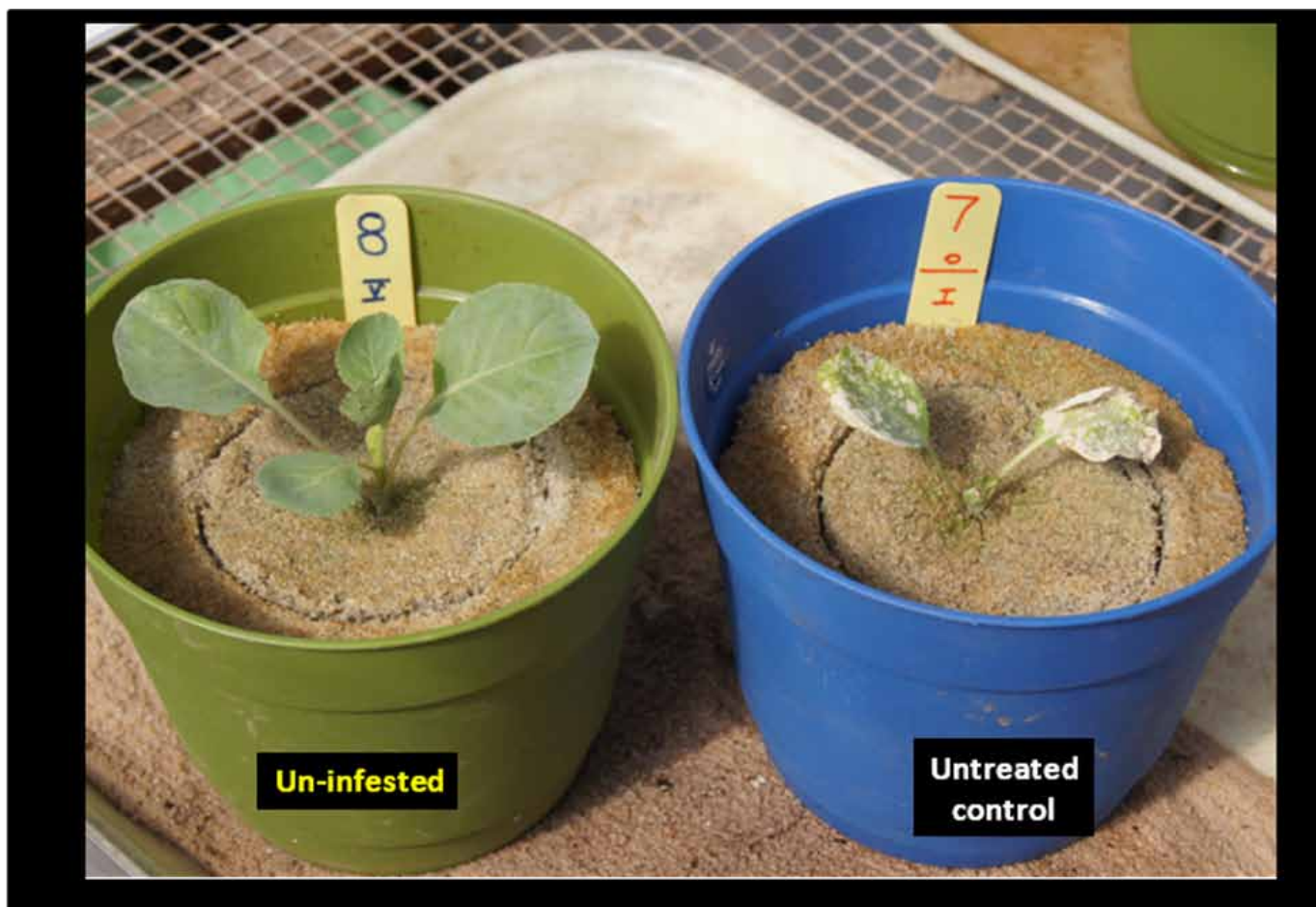




Insecticide treated cabbage plants following a 5 days exposure to 4 *Bagrada* adults caged on plants one hour after spray was applied. Compared with caged plants not infested.



Insecticide treated cabbage plants following a 5 days exposure to 4 *Bagrada* adults caged on plants one hour after spray was applied. Compared with caged plants not infested.



Untreated cabbage plants following a 5 days exposure to 4 *Bagrada* adults caged on plants. Compared with caged plants not infested.