Comparing Physical Barriers and Organic Pesticides for Controlling Cabbage Webworm on Daikon

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Cabbage Webworm in Hawaii

The cabbage webworm (*Hellula undalis*) is an economically important pest on brassica crops such as white stem cabbage (pak choy), mustard cabbage (kai choy), napa cabbage (won bok), radishes, broccoli, cabbage, and other crucifers. Brassica crop production has increased in Hawaii from 2007 to 2012. The 2012 Census of Agriculture documented that 368 farms harvested 1,204 acres of brassica crops, as compared to 247 farms and 1,029 acres in 2007.

Cabbage webworm caterpillar on daikon with webbing and frass

The cabbage webworm can cause damage throughout the growing period of crops. However, primary damage occurs on young, developing plants as caterpillars feed on growing terminals (apical meristems). This feeding causes the development of multiple shoots, resulting in unmarketable product, or even plant death. Other symptoms include webbing, folding of young leaves, feeding damage on developing leaves, and frass.

Leaf folding due to cabbage webworm

A replicated field trial to study the control of cabbage webworm was established at the Waimanalo Research Station on September 27, 2016.

Webworm leaf tip damage and symptoms on daikon

Feeding damage and frass

The objectives of the field trial were to: 1) control the cabbage webworm (*Hellula undalis*) on daikon radish using organic insecticides and physical barriers and 2) determine efficacy of organic insecticides on webworm control, as compared to a conventional, commercially available insecticide.

Table 1 Insecticides Used

Product Name	**Active Ingredient**	**Label Rate Applied**	**Rate per Label**
Neemix 4.5	Azadirachtin	10 fl. oz./acre	4-10 fl. oz./acre
Crymax WDG	*Bacillus thuringiensis (Bt) kurstaki*	2.0 pounds/acre	0.5-2.0 pounds/acre
Entrust SC	Spinosad	6 fl. oz./acre	3-6 fl. oz. /acre
Pyganic 5%	Pyrethrin	17 fl. oz./acre	4.5-17 fl. oz./acre
Coragen (conventional)	Chlorantraniliprole (RynaXypyr)	3.5 fl. oz./ac	3.5-7.5 fl. oz./acre

* For additional information about the organic products, please refer to *Appendix* section of this article

Table 2 Physical Barriers Used

Product Name	**Specifications**	**Price**
Screen	17 mesh	\$0.12/ ft^2
Proteknet “Biothrips" Insect Netting	0.35mm x 0.35mm; 89% light transmission; 62% porosity	\$0.14/ft^2

The trial consisted of seven treatments, each replicated three times: four organic insecticides, one conventional insecticide, and two physical barriers (Tables 1, 2). An untreated control was also included in the field design and replicated four times. Double rows of daikon were 80 feet long and spaced 8 feet apart. There were five treatment plots per double row of daikon. Treatment blocks measured 15 feet long with 1 foot allotted between each treatment. To protect the direct seeded daikon from early bird and pest damage, a screen was installed over the plots for 10 days to give each plot a uniform and successful start.

Two weeks after seeding, organic insecticides were treated weekly at the highest labeled rate using a CO_2 sprayer with a boom attachment. Spray volume yielded 70-100 gallons per acre. The non-organic insecticide, Coragen, was sprayed every other week at the lowest labeled rate.

Screen and row covers were installed over the designated treatment plots ten days after initial seeding. The screen was installed using hoops to provide structure. Floating row covers were placed loosely over the top of the beds and secured by rocks and soil around the perimeter. Both the screen and floating row cover used in this trial are available commercially in greenhouse catalogs.

We utilized the modified *Kermerait et al* scale of 0-5 where 0= no damage, 1= trace to 5% damage, 2=6% to 15%, 3=16% to 35%, 4=36% to 67%, and 5=68% to 100% to assess webworm infestation damage (see Table 3).

Physical barrier used to ensure uniform germination (left) and established treatment plots (right)

CO_2 sprayer set up

CO_2 boom sprayer attachment

Cabbage Webworm Organic Insecticide Trial
Field Layout

Screen	Control	Neemix 4.5	Coragen	Entrust SC
Crymax WDG	Coragen	Pyganic 5%	Row Cover	Crymax WDG
Row Cover	Entrust SC	Screen	Pyganic 5%	Control
Neemix 4.5	Pyganic 5%	Control	Entrust SC	Neemix 4.5
Coragen	Crymax WDG	Row Cover	Control	Screen

Table 3. Damage Ratings Based on Visual Plant Damage Using Modified Kermerait et al. Method

Rating	Visual Damage Percentage
0	None
1	Trace to 5%
2	6% to 15%
3	16% to 35%
4	36% to 67%
5	68% to 100%

Results and Implications

Final webworm damage data collected on November 25, 2016 showed there were significant differences among the control, organic insecticides, and physical barriers (Figure 1). Control plots resulted in visual webworm damage levels between 16 to 35 percent. Entrust SC resulted in the lowest average damage rating of the organic treatments. Webworm control with Entrust SC was comparable to Crymax WDG, the 17 mesh screen, as well as the non-organic insecticide, Coragen. Crymax WDG was comparable to Entrust SC, the

Rating cabbage webworm damage on daikon

17 mesh screen and Neemix 4.5. Of the two physical barriers tested, the 17 mesh screen resulted in significantly less average damage than the floating row cover. Coragen (non-organic), Entrust SC, the 17 mesh screen, and Crymax WDG out performed Neemix 4.5, Pyganic 5% and the floating row cover.

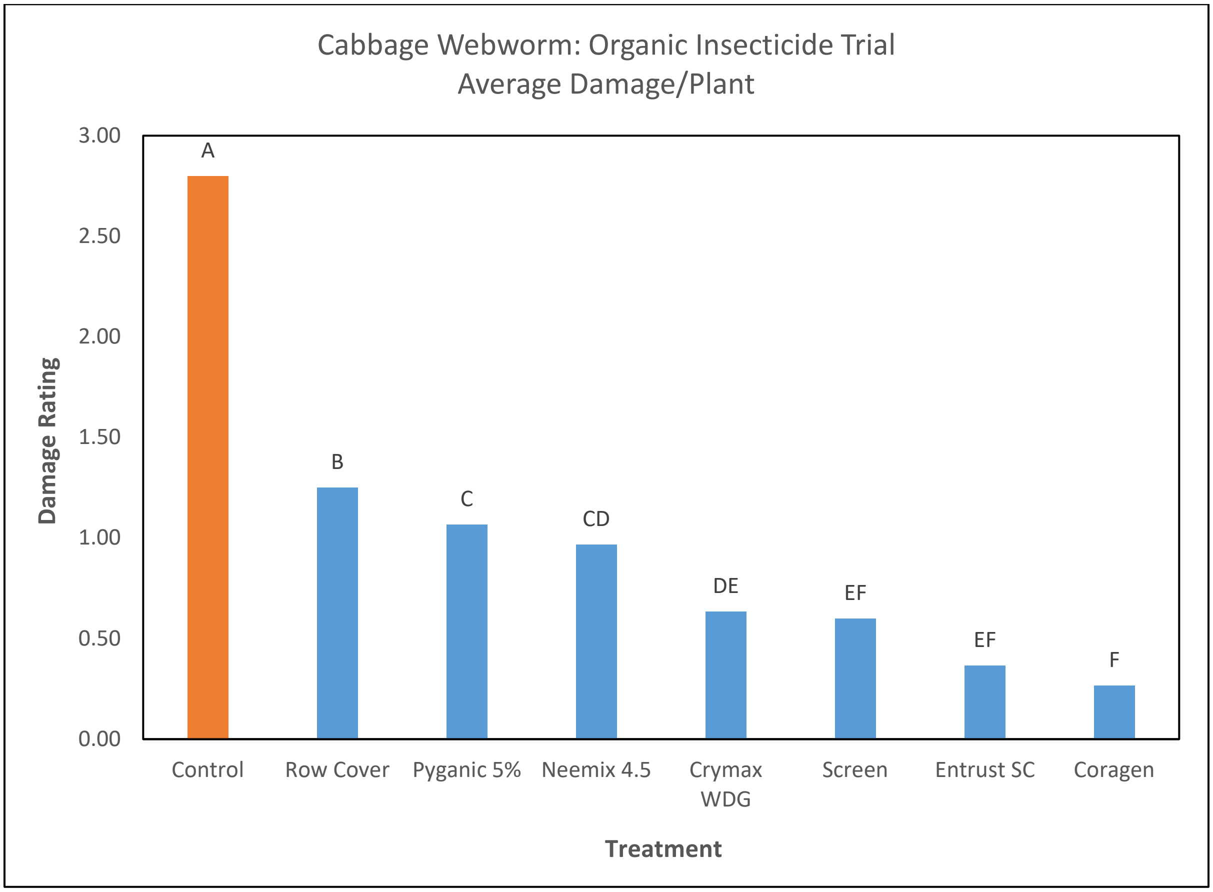

Figure 1. Average webworm damage ratings for organic, physical barrier, and non-organic treatments. Ratings were based on a 5-point rating scale (Table 3), and average ratings were taken from 10 random plants per plot. *Averages that do not share a letter are significantly different (Tukey Multiple Comparison ANOVA).

Feeding damage of webworm at daikon growing terminal

Lepidoptera pests are highly susceptible to insecticide resistance issues. Resistance can be minimized with proper rotation of approved insecticides in different chemical classes, utilization of recommended rates and spray intervals, and achieving optimum spray coverage to reduce persistence of resistant populations. The results from this trial may help agricultural producers develop and expand on its resistance management program against *Lepidoptera* pests to combat webworm in brassica cropping systems.

The 17 mesh, non-chemical, pest exclusion barrier outperformed the floating row cover and was comparable to Coragen, Entrust SC and Crymax WDG in its ability to suppress webworm populations. Observational field data indicated that target and non-target pests which enter the screened units (possibly via transplanting, weeding, crop maintenance, etc.) may get trapped inadvertently inside the screened area and create additional problems. Installing hoops for support when using screen materials may be worth the additional labor to provide structural support. Row covers fail mainly due to improperly securing the material to the ground. More time is needed to evaluate the application and installation of screen systems for *Lepidoptera* pest control in brassica systems.

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Appendix

Neemix 4.5

Neemix 4.5 is an OMRI-listed pesticide that is approved for various tropical fruits and vegetables, including crucifers, and insects, like moths, thrips, and worms. The active ingredient is Azadirachtin, a key ingredient in neem products. Azadirachtin acts as an insect growth regulator when ingested by blocking hormones that facilitate metamorphosis, preventing further insect growth and reproduction. Azadirachtin also can repel insects or reduce insect appetite upon ingestion. Azadirachtin breaks down rapidly with sunlight, reduced to half its amount in 1-2 days. This compound has little to no effect on wildlife or nectar-feeding insects, but can be slightly toxic to aquatic life.

Crymax WDG

Crymax Water Dispersible Granule (WDG) Bioinsecticide is an OMRI-listed pesticide that is approved for various tropical fruits and vegetables, including crucifers, and insects, like moths and worms. The active ingredient is *Bacillus thuringiensis* (Bt) kurstaki strain of soil bacterium, which produces toxins specific to lepidopteran insects. Bt is effective only upon ingestion by immature larvae, where the toxins produced destroy the gut and result in reduced feeding and death within a few hours to weeks. Bt breaks down rapidly in sunlight, reduced to half in about 4 hours, but can last for months or years in soil. This is not known to be toxic to wildlife or aquatic life.

Entrust SC

Entrust SC is an OMRI-listed pesticide that is approved for various tropical fruits and vegetables, including crucifers, and insects, like moths, thrips, and worms. The active ingredient is Spinosad, a compound made from spinosyn A and D, two natural chemicals produced by a soil bacterium. Upon ingestion or contact, Spinosad attacks the nervous system of insects, causing paralysis and death within 1-2 days. Spinosad breaks down with sunlight, reduced to half its amount in 2 days to 2 weeks on plants and soil. Can be highly toxic to honey bees and aquatic life.

Pyganic 5.0

Pyganic 5.0 is an OMRI-listed pesticide that is approved for various tropical fruits and vegetables, including crucifers, and insects, like moths, thrips, and worms. The active ingredients are Pyrethrins, a mixture of six naturally occurring compounds found in certain chrysanthemum flowers. Upon ingestion or contact, Pyrethrins attack the nervous system of insects, causing paralysis and death. Some of the compounds in Pyrethrins break down with sunlight, reduced to half its amount in about 12 hours. Can be highly toxic to honey bees and aquatic life.