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California Pepper Commission
Research Report 2016-2017

I. IDENTIFICATION

A. California Pepper Commission.
B. Insect Pest Management on Peppers
C. Proposal for period beginning March 2016, ending February 2017.
D. Principal Investigator:
Dr. John T. Trumble
Department of Entomology
University of California, Riverside
E. Cooperating Personnel:
Greg Kund
Department of Entomology
Univ. of California, Riverside
F. Locations of Work:
U.C. Riverside Agricultural Operations
Riverside, CA
Riverside County, CA
G. Insects
Tomato/Potato Psyllid: *Bactericera cockerell*i (Sulc)
Beet armyworm (BAW): *Spodoptera exigua* (Hübner)
Tomato Fruitworm(TFW): *Helicoverpa zea* (Boddie)
Leafminer: *Liriomyza sativae* (Blanchard)
Leafminer: *Liriomyza trifoilii* (Burgess)
Lygus bugs: *Miridoa* spp.
Stink bugs (SB): *Pentatomidae* spp.
Pepper weevil (PW): *Anthonomus eugenii* Cano
Green peach aphid (GPA): *Myzus persicae* (Sulzer)

II. Field Screening Trials for Effective Pesticides

Seedlings were transplanted in a sandy loam type soil on 6 June at the University of California Riverside's Agricultural Operations field #5I. Experimental plots were 3 rows wide (5-ft centers) by 20 ft long and separated by a 3-ft buffer. The pepper transplants were drip irrigated (water pH 7.2 - 7.5). Treatments were replicated 4 times in a RCB block design. Application dates and a treatment list are shown in Table 1. All applications were made during working hours when wind conditions were mild. A tractor-mounted boom sprayer with 6 nozzles per row incorporated D-3 orifice disks, #25 cores, and 50 mesh screens. Operating pressure was 100 psi delivering 100 gpa. All treatments included Dyne-amic as an adjuvant at 0.25% vol/vol except treatment number six, which consisted of VST-06330 and BeetleGone!, and treatment 8, which used Pyganic, Trilogy, Mycotrol O, and Entrust.

Table 1: Pepper Chemical Trial List of Treatments 2016

Treatment #	Compound	Rate-Product	Application Dates	Company
1	Control	-	-	-
2	Minecto Pro Dyne-amic	7.0 Fl oz 0.25%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	Syngenta
3	Minecto Pro Dyne-amic	10.0 Fl oz 0.25%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	Syngenta
4	Radiant SC Dyne-amic	7.5 Fl oz 0.25%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	Dow
5	Radiant SC + Sequoia 2 SC Dyne-amic	7.0 Fl oz 4.5 Fl oz 0.25%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	Dow
6	VST-06330 + Bt BeetleGone! LI-700	0.25 lb 0.5 lb 0.125%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	Vestaron
7	IPM a-Verimark [a] b-Radiant SC c-Sequoia 2 SC Dyne-amic	 13.5 oz 7.5 oz 4.5 oz 0.25%	 8/8 8/1, 8/24, 9/9 8/17, 9/2	
8	Organic IPM a-Pyganic 5 EC b-Trilogy EC c-Mycotrol O d-Entrust SC	 17.0 oz 64.0 oz 32.0 oz 8.0 oz	 8/24 8/1, 8/24 8/8, 8/17, 9/2 8/8, 8/17, 9/2, 9/9	

9	Chem Standard: Asana XL Dyne-amic	 9 oz 0.25%	8/1, 8/8, 8/17, 8/24, 9/2, 9/9	

[a] Verimark was applied once on 8/8 as a soil drench

An early and mid-season field count of insect populations were taken by counting a single branch of four plants per replicated plot to determine what impact the treatments had on insect populations. On 14 Sep, 50 mature-green to ripe fruit were harvested from the center row of each replicate (200 per treatment) and examined for Lepidopterous internal damage (TFW), external damage (BAW), and hemipterous pests (SB). Fifty fruit were also inspected for damage from pepper weevils (PW), potato psyllid (PP), and aphids (GPA). Results are shown in Table 2.

Lepidopteran pressure was moderate to high in the category of 'external damage by BAW' (Figure 2). Internal damage by the pepper weevil was very low this year and could be a result of hot weather conditions. Potato psyllids were present in the field but we did not see significant numbers in our harvest assessment. Damage to the calyx by TFW, BAW, and PW feeding showed no differences between treatments (Figure 1). Harvest assessment of aphid infestation also showed no differences. However, field counts of psyllids revealed significant differences between the treatments. The control and treatment nine had the highest number of total psyllids (Figure 3). Pepper weevil populations were very low this year, which could be contributed to the high temperatures throughout the growing season.

Table 2.

Treatment/ Formulation		Rate Amt/acre	Mean Number of Fruit Damaged/Replicate [b] Internal	External	All Leps	Pepper Weevil Internal	Calyx Damage	Psyllids
1	Control	-	0.75	4.75 a	5.5 a	0.25	12.00	0.00
2	Minecto Pro Dyne-amic	7.0 Fl oz 0.25%	0.50	0.50 b	1.00 b	0.00	8.25	0.00
3	Minecto Pro Dyne-amic	10.0 Fl oz 0.25%	0.25	1.50 b	1.75 b	0.00	4.50	0.00
4	Radiant SC Dyne-amic	7.5 Fl oz 0.25%	0.25	1.75 b	2.00 b	0.00	8.75	0.00
5	Radiant SC + Sequoia 2 SC Dyne-amic	7.0 Fl oz 4.5 Fl oz 0.25%	0.00	1.25 b	1.25 b	0.00	5.50	0.00
6	VST-06330 + Bt BeetleGone! LI-700	0.25 lb 0.5 lb 0.125%	0.50	1.50 b	2.00 b	0.00	11.00	0.00
7	IPM a-Verimark [a] b-Radiant SC c-Sequoia 2 SC Dyne-amic	 13.5 oz 7.5 oz 4.5 oz 0.25%	0.25	1.75 b	2.00 b	0.00	8.75	0.00
8	Organic IPM a-Pyganic 5 EC b-Trilogy EC c-Mycotrol O d-Entrust SC	 17.0 oz 64.0 oz 32.0 oz 8.0 oz	0.00	2.25 b	2.25 b	0.00	5.00	0.00
9	Chem Standard: Asana XL Dyne-amic	 9 oz 0.25%	0.25	2.25 b	2.50 b	0.00	7.50	0.00
ANOVA F value (by column)			1.109	3.027	2.776	--	1.457	--
ANOVA P value (by column)			0.388	0.015	0.022	--	0.219	--

[a] Verimark was applied once on 8/8 as a soil drench

[b] Means in columns followed by the same letter are not significantly different ($P<0.05$ level, Fisher's LSD Test). Internal damage due primarily to (TFW); external damage due primarily to (BAW). Bugs include *Lygus* and (SB). Calyx damage can be attributed to (TFW), (BAW), and (PW) feeding

Figure 1. Calyx feeding damage

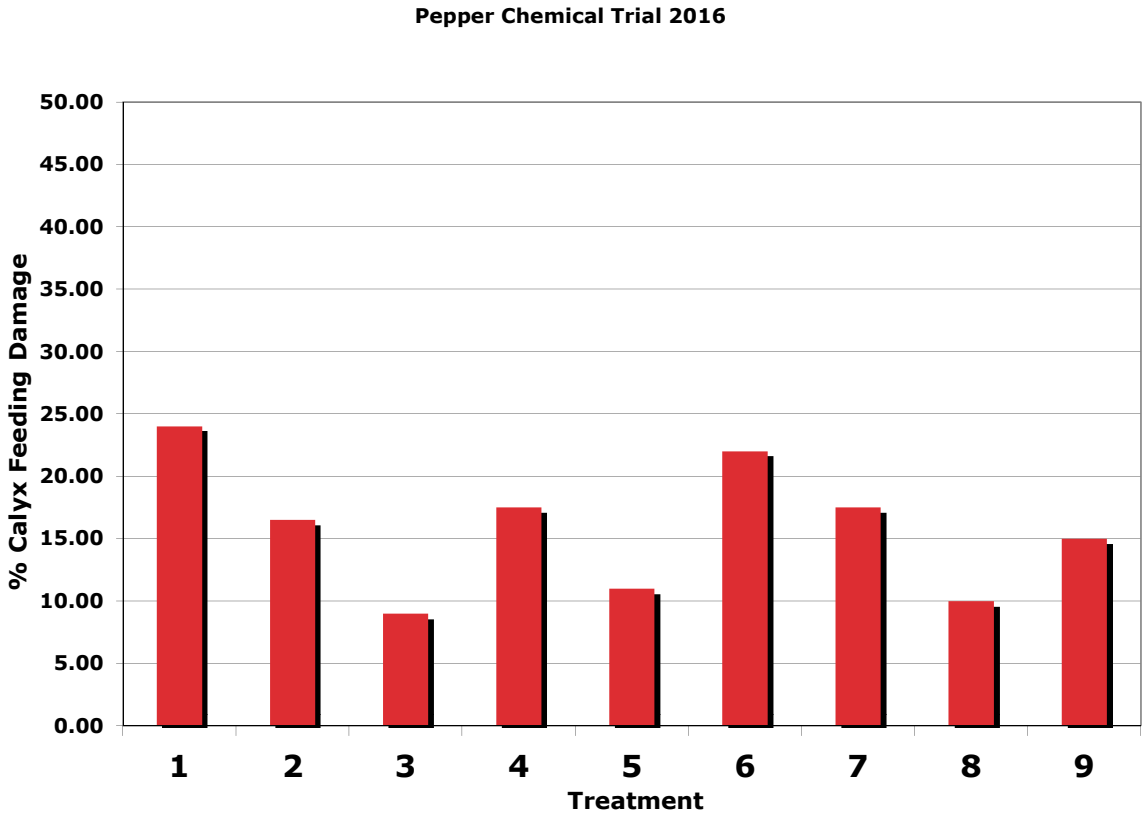


Figure 2. Lepidopteran damage

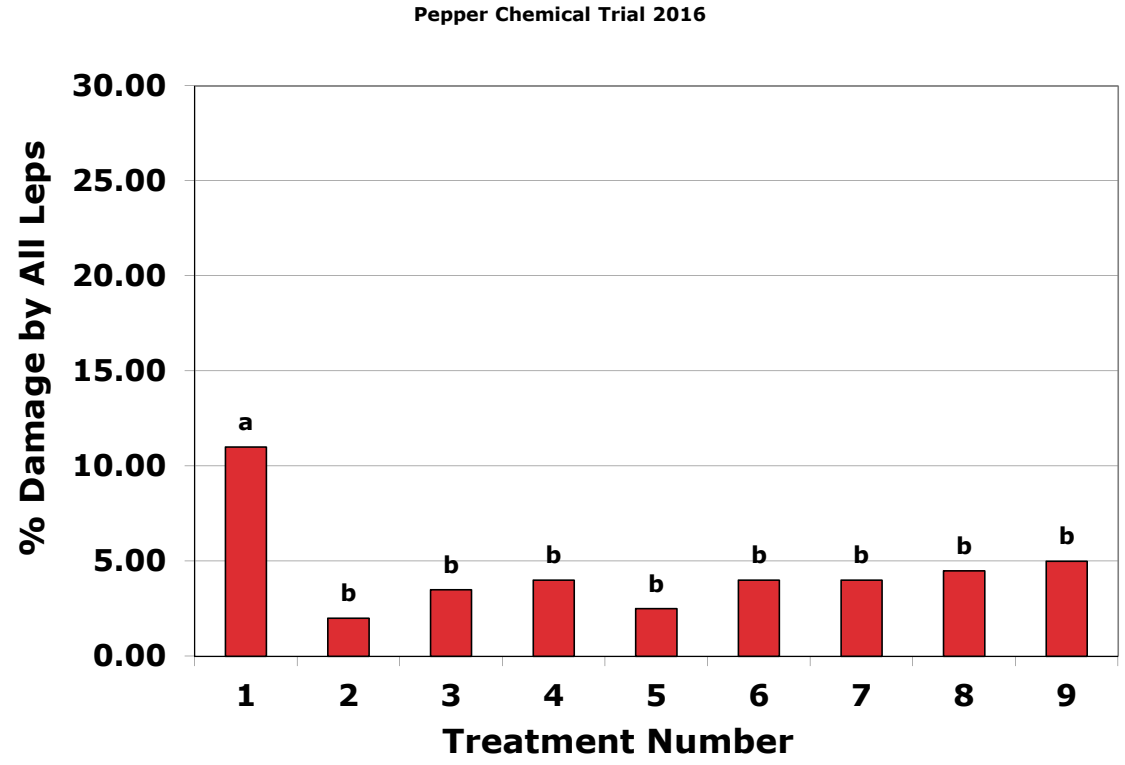
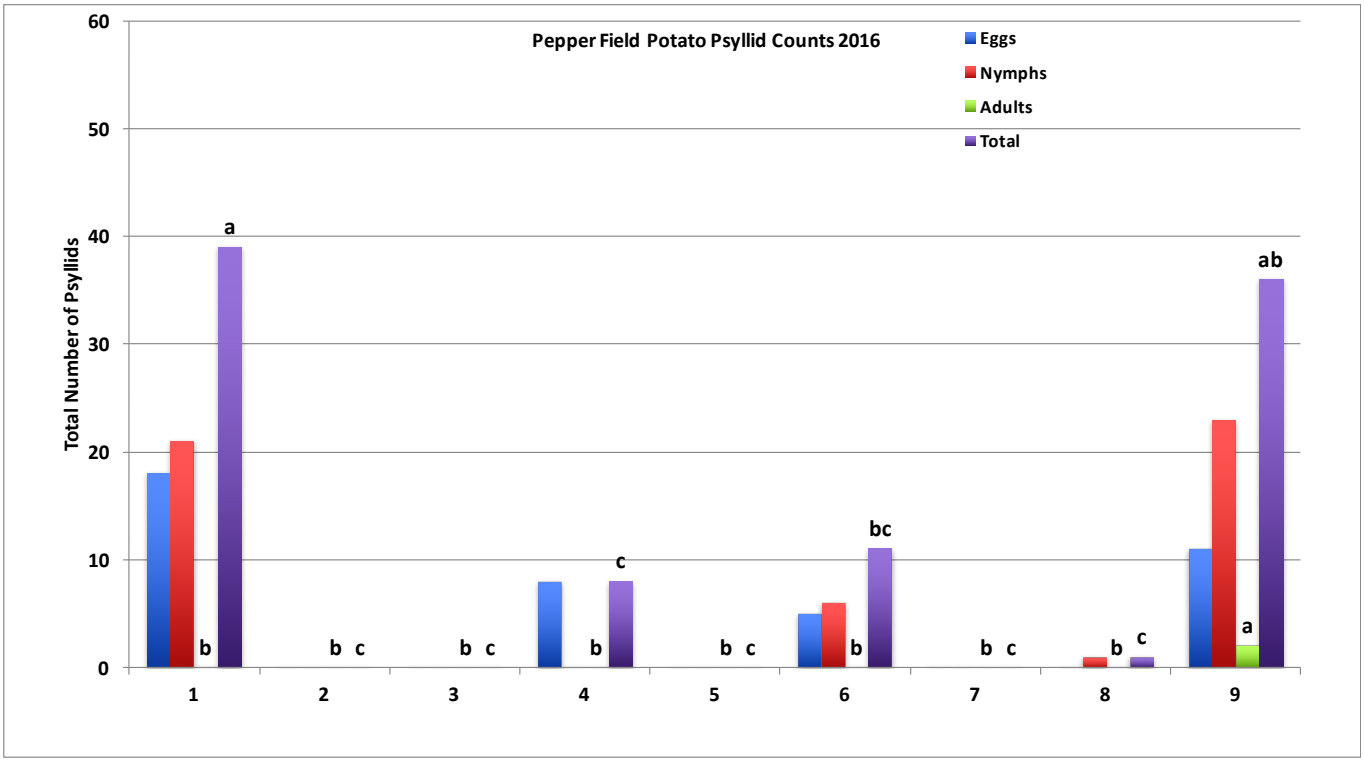


Figure 3. Pepper field Potato Psyllid counts.



IV. Laboratory Research
Objectives:

I. Test the efficacy of VST06330 on adult *Anthonomus eugenii*
II. Test the efficacy of VST06330 on *Bactericera cockerelli* nymphs
III. Test the efficacy of VST06330 on *Myzus persicae*
IV. Test the efficacy of VST06330 on *Tetranychus urticae*

Key Conclusions:

- VST06330 in the powder form applied at the high rate of 1 lb/Ac using a spray volume of 30 gal/Ac had a significant effect on the mortality of pepper weevils. This rate is the equivalent of 0.8 ppt. We would like to test the higher rates when pepper weevils are available.
- VST06330 also showed significant effects on potato psyllid nymphs at the rate of 5 ppt killing over 50%. A higher rate of kill was observed on smaller second instar nymphs than on the larger late third instars.
- Significant differences were seen between the controls and aphid treatments, but aphid survivorship remained substantial.
- VST06330 provided very good control of two spotted spider mites after 3 days when using the rate of 5 ppt. The lower rates of 1 ppt and 2 ppt did not provide good control.

Objective 1. Efficacy tests of VST06330 on adult *Anthonomus eugenii* pepper weevils
The goal of these tests were to determine if the rate of 1 lb/Ac of VST06330 @ 50 gal/Ac, and 30 gal/Ac would have an effect on the mortality of the pepper weevils.
Methods:
Adult pepper weevils were field collected from a research field at the South Coast Research and Extension Center in Irvine, CA. Treatments were replicated three times with five insects per replicate. Each replicate consisted of a petri dish with a filter paper disc in the bottom to absorb excess moisture from the spray application. A pepper leaf was placed into the petri dish along with 5 adult pepper weevils prior to the spray application. The petri dishes were chilled in a refrigerator to slow insect movement. An airbrush sprayer was used to apply the treatments in a uniform manner. The leaves were sprayed on both sides and the weevils were completely covered with the treatments. The untreated control was sprayed with water. Vintre was used as a surfactant to aid in coverage and penetration to improve efficacy.

We ran two tests with the pepper weevils. The first test we used an application volume of 50 gal/Ac, which is the equivalent of 0.5 ppt. There was no effect on the weevils in the first test so we ran a second test using 30 gal/Ac, which is the equivalent of 0.8 ppt, and the results showed a significant effect on mortality. See figures 1 and 2.

Test 1: Mixtures of the following treatments were prepared (50 gal/Ac):

1. Water
2. VST06330 5 ppt
3. VST06330 5 ppt + Vintre 0.25%

Test 2: Mixtures of the following treatments were prepared (30 gal/Ac):

1. Water
2. VST06330 5 ppt
3. VST06330 5 ppt + Vintre 0.25%

Daily mortality counts were recorded for a period of 4 days. Data were analyzed with 'R' statistical program using ANOVA and Fisher's Protected LSD test ($p<0.05$) packages.

Results:
The VST treatments did not have a significant effect on the mortality of pepper weevils in test 1 using the volume of 50 gal/Ac. However, we did see an effect using 30 gal/Ac in test 2 (Figures 4&5). Vintre did not provide any advantage when added to the VST treatment.

Figure 4. Pepper weevil mortality test (1 lb/Ac @ 50 gal/Ac).

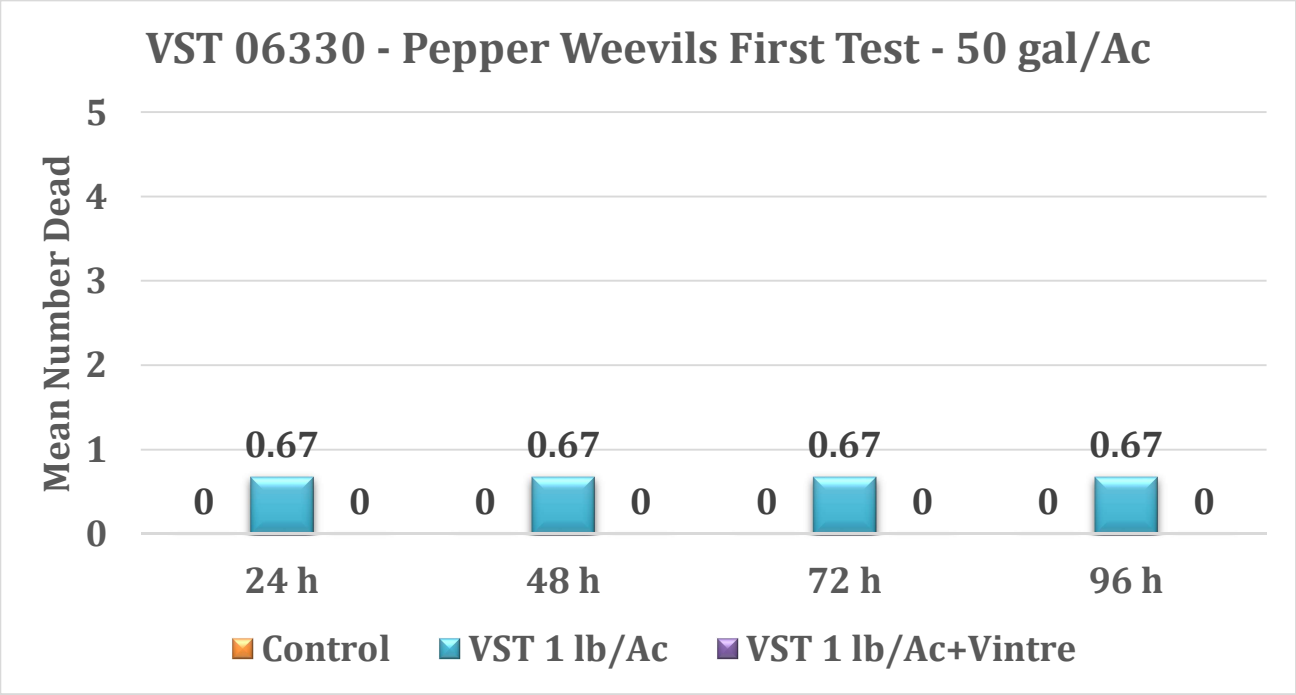
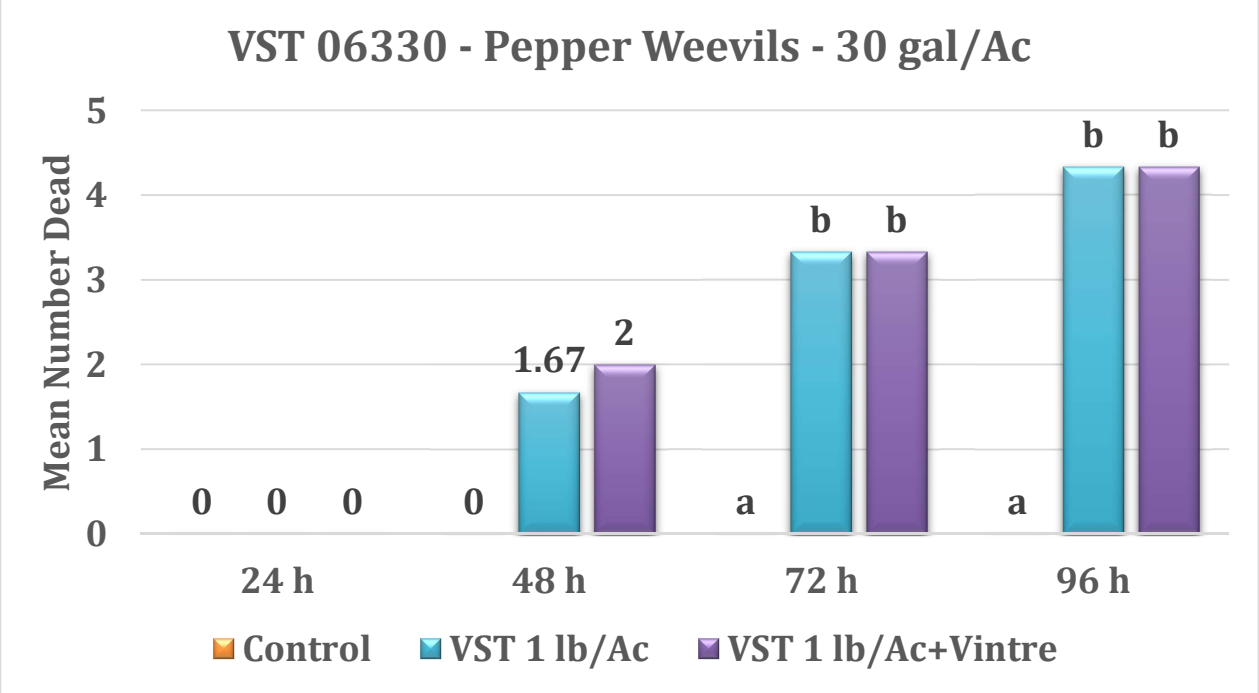


Figure 5. Pepper weevil mortality test (1 lb/Ac @ 30 gal/Ac).



Objective 2. Efficacy test of VST06330 on *Bactericera cockerelli* nymphs
The goal of this test was to determine if the VST treatments alone and in combination with "Distance" had an effect on the mortality of potato psyllid nymphs in the second and third instar life stages.

Methods:
Yellow Pear tomato plants 8 inches in height were used as the host for the potato psyllid nymphs. Each treatment was replicated five times with ten 2nd to 3rd instar nymphs transferred to each leaf as the replicate. The nymphs were transferred with a camel hair brush from tomato leaves that came from our Texas strain potato psyllid colony. Hand held spray bottles were used to apply each treatment. The untreated control was sprayed with water. Each plant was sprayed just prior to runoff of the material to maximize the amount of active ingredient remaining on the plants.

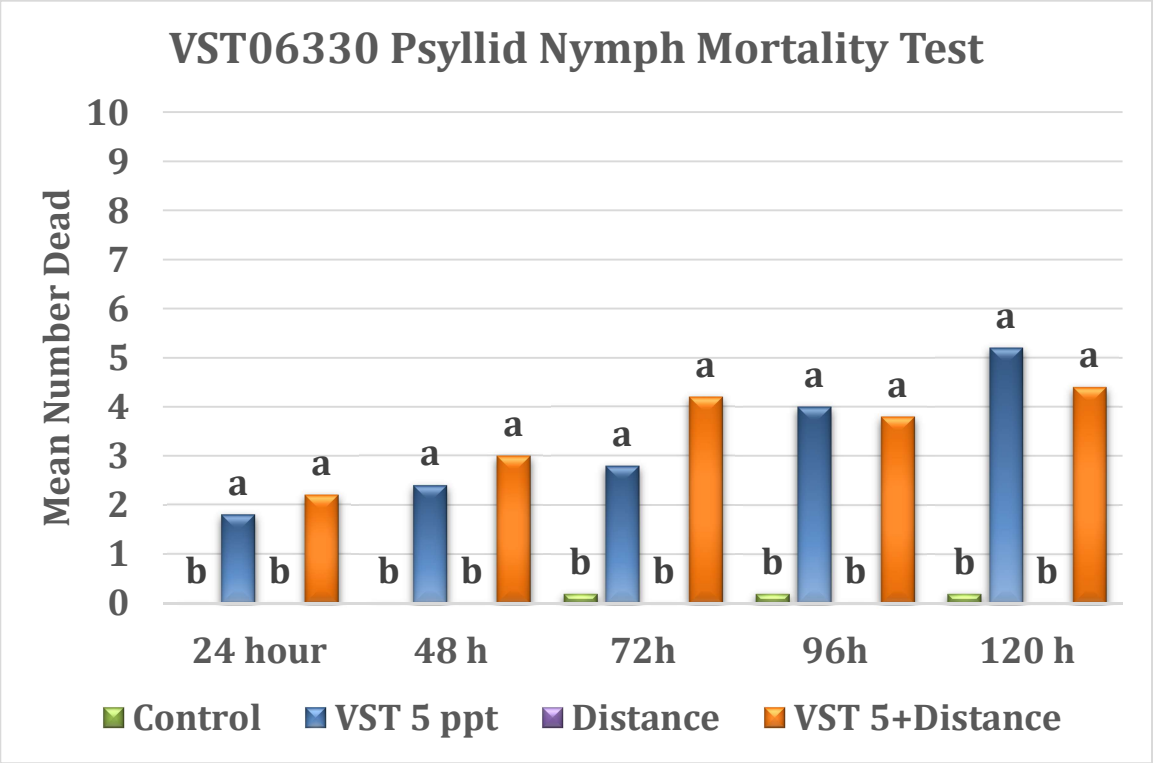
Mixtures of the following treatments were prepared:

1. Water
2. VST06330 5 ppt
3. Distance 10 oz./ 100 gal
4. VST 06330 5 ppt + Distance

Daily mortality counts were recorded for a period of 5 days. Data were analyzed with 'R' statistical program using ANOVA and Fisher's Protected LSD test ($p<0.05$) packages.

Results:
There were significant differences between the treatments, and the VST06330 product showed approximately 50% mortality of the psyllid nymphs. The Distance material had no effect on the psyllid nymphs and did not provide any additional kill when combined with the VST 06630 treatment (Figure 6). As an observation, we saw higher mortality on the smaller instar nymphs than on the later third instar life stages.

Figure 6. *Bactericera cockerelli* 2nd to 3rd instar nymph mortality



Objective 3. Efficacy test of VST06330 on *Myzus persicae* nymphs
The goal of this test was to determine if the VST treatments alone and in combination with "Enstar" had an effect on the mortality of green peach aphids.

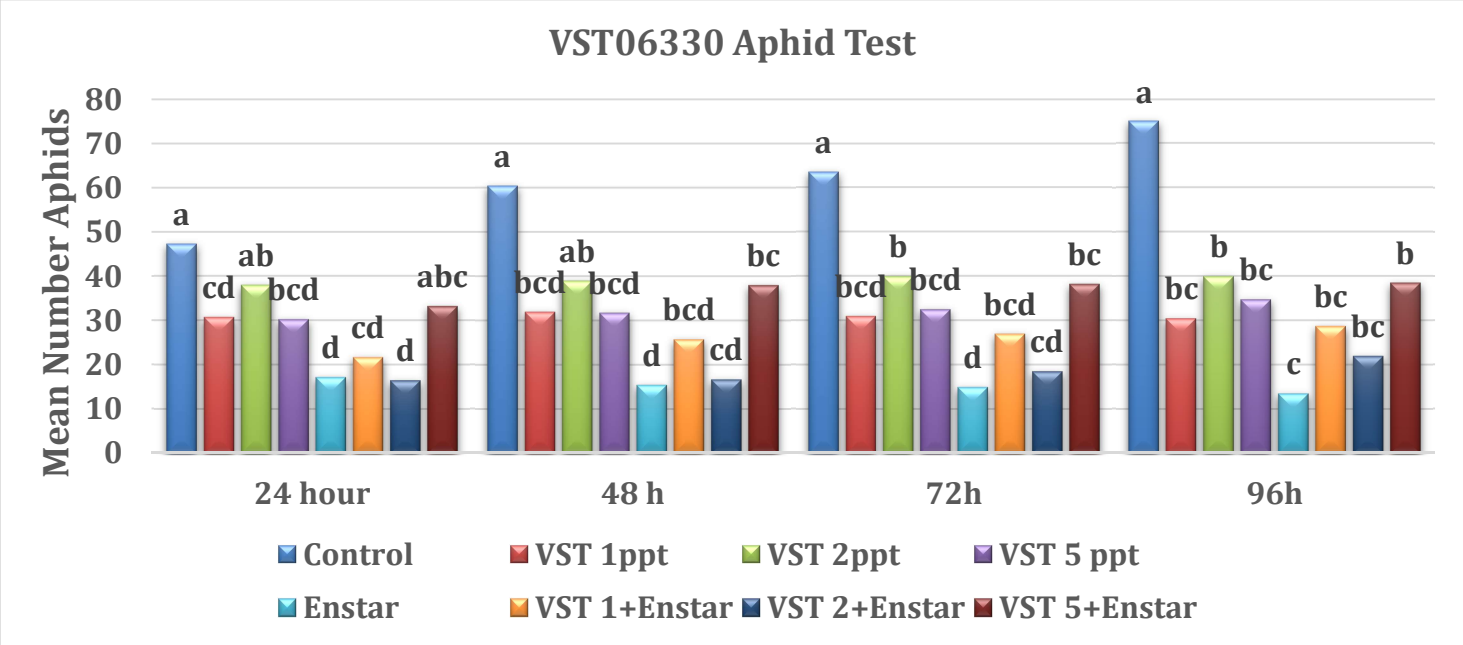
Methods:
Bell pepper plants 8 inches in height were used as the host for the green peach aphids. Each treatment was replicated four times with twenty aphids transferred to each leaf as the replicate. The nymphs were transferred with a camel hair brush from pepper leaves that came from our laboratory green peach aphid colony. Hand held spray bottles were used to apply each treatment. The untreated control was sprayed with water. Each plant was sprayed just prior to runoff of the material to maximize the amount of active ingredient remaining on the plants.

Mixtures of the following treatments were prepared:

1. Water
2. VST06330 1 ppt
3. VST06330 2 ppt
4. VST06330 5 ppt
5. Enstar 5 oz/Ac @ 100 ga/Ac
6. VST06330 1 ppt + Enstar
7. VST06330 2 ppt + Enstar
8. VST06330 5 ppt + Enstar

Daily mortality counts were recorded for a period of 4 days. Data were analyzed with 'R' statistical program using ANOVA and Fisher's Protected LSD test ($p<0.05$) packages.

Results:
There were significant differences between the treatments, but the VST06330 product did not provide a high level of control (Figure 7). The Enstar treatment provided the best level of control and it was only a 32% reduction.
Figure 7. *Myzus persicae* mortality



Objective 4. Efficacy test of VST06330 on *Tetranychus urticae*
The goal of this test was to determine if the VST treatments alone and in combination with "Agrimek" had an effect on the mortality of two spotted spider mites.

Methods:
Celery plants 12 inches in height were used as the host for the spider mites. Each treatment was replicated four times with forty mites transferred to each leaf as the replicate. The stem of the celery petiole was covered with a layer of petroleum jelly to keep the mites from moving around the plant. The mites were transferred with a camel hair brush from celery leaves that came from our laboratory mite colony. Hand held spray bottles were used to apply each treatment. The untreated control was sprayed with water. Each plant was sprayed just prior to runoff of the material to maximize the amount of active ingredient remaining on the plants.

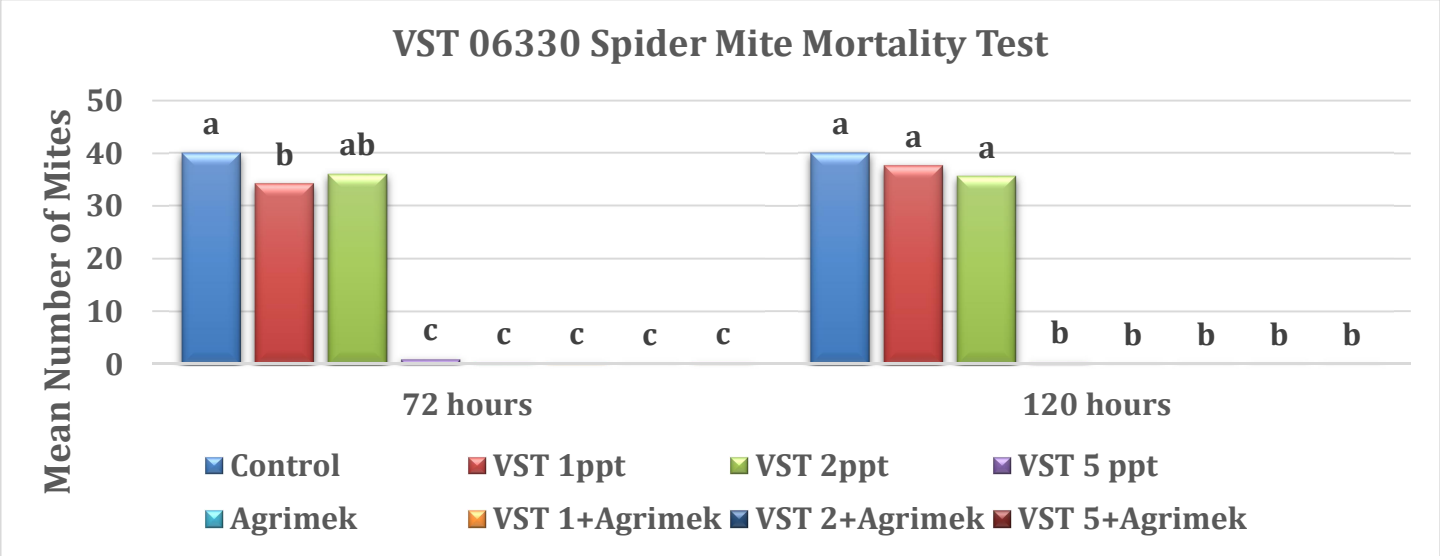
Mixtures of the following treatments were prepared:

1. Water
2. VST06330 1 ppt
3. VST06330 2 ppt
4. VST06330 5 ppt
5. Agrimek 16 oz/Ac @ 100 gal/Ac
6. VST06330 1 ppt + Agrimek
7. VST06330 2 ppt + Agrimek
8. VST06330 5 ppt + Agrimek

Mortality counts were recorded for a period of 5 days. Data were analyzed with 'R' statistical program using ANOVA and Fisher's Protected LSD test ($p<0.05$) packages.

Results:
There were significant differences between the treatments, and the VST06330 product with a rate of 5 ppt provided a 99% reduction of the mite populations. The Agrimek treatment also provided 100% control by itself and in combination with the VST06330 material (Figure 8).

Figure 8. *Tetranychus urticae* mortality



The product VST06330 has been assigned a trade name "Spear T ™" of Vestaron Corporation. The product has not been released, but is expected to be on the market within the year.

IV. Additional Research
We are testing alternative strategies and chemicals for psyllid control such as repellents to disrupt insect behaviors. Successful repellents and insecticides will be incorporated into an IPM program. We are continuing to study pepper weevil control and have attempted to acquire grant funding to support this research.

V. Additional Funding Support
Funding from the Pepper Commission has been leveraged by acquiring additional financial support for our pepper research. We have received monetary awards to study and develop pepper IPM program strategies, as well as chemical industry support.