California Pepper Commission
Research Report 2023-2024

I. IDENTIFICATION

A. California Pepper Commission
B. Insect Pest Management on Peppers
C. Proposal for the period beginning March 2023 and ending February 2024.
D. Principal Investigator:
Dr. Chow-Yang Lee
Department of Entomology
University of California, Riverside
E. Cooperating Personnel:
Greg Kund
Department of Entomology
Univ. of California, Riverside
F. Locations of Work:
Location #1: U.C. Riverside Agricultural Operations
Riverside, CA
Riverside County, CA
Location#2: McGrath Ranch
Santa Paula, CA
Ventura County, CA
G. Plants:
Location #1: BELL PEPPER: *Capsicum annuum* L. 'Double Up'
Location #2: ANAHEIM PEPPER: *Capsicum annuum* L.'Ventura'
H. Insects:

Bagrada bug; *Bagrada hilaris* (Burmeister)

Beet armyworm; *Spodoptera exigua* (Hübner)

Beet Leafhopper; *Circulifer tenellus* (Baker)

Green peach aphid; *Myzus persicae* (Sulzer)

Lygus bugs; *Lygus hesperus* (Knight)

Pepper weevil; *Anthonomus eugenii* Cano

Serpentine Leafminer; *Liriomyza trifoilii* (Burgess)

Silverleaf Whitefly; *Bemisia argentifolii* (Bellows and Perring)

Stink bugs; *Pentatomidae* spp.

Tomato/Potato Psyllid; *Bactericera cockerell*i (Sulc)

Tomato Fruitworm; *Helicoverpa zea* (Boddie)

Twospotted Spider Mite; *Tetranychus urticae* (Koch)

Vegetable Leafminer; *Liriomyza sativae* (Blanchard)

II. <u>Field Screening Trials for Identification of Effective Pesticides Location #1</u>

Seedlings were transplanted in a sandy loam-type soil on 25 May at the University of California Riverside's Agricultural Operations field #10F. Experimental plots were 3 rows wide (5-ft centers) by 40 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 randomized complete 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. The operating pressure was 100 psi, delivering 100 gpa. All treatments included an adjuvant except treatment #3, which consisted of Pyganic, Trilogy, and Entrust.

Table 1: Pepper Chemical Trial List of Treatments 2023

Treatment #	Compound	Rate-Product	Application Dates	Company Sponsor
1	Non-treated	-	-	-
2	Intrepid + Sequoia 2 SC Radiant SC Dyne-amic	10.0 oz 4.5 oz 7.0 oz 0.125%	7/27, 8/4, 8/11, 8/17, 8/25	-
3	Organic IPM Pyganic 5.0EC Trilogy EC Entrust SC	 15.0 oz 64.0 oz 8.0 oz	7/27, 8/4, 8/11, 8/17, 8/25	-
4	Sivanto Prime 200SL Drench	28.0 Fl oz	7/27	Bayer
5	Sivanto Prime 200SL Foliar	14.0 Fl oz	7/27	Bayer
6	Intrepid + Sequoia 2SC Exp. VST + Leprotec Dyne-amic	10.0 oz 4.5 oz 8 wt oz 1 pt 0.125%(v/v)	7/27, 8/4, 8/11, 8/17, 8/25	Vestaron
7	Exp. VST+ Leprotec Radiant SC Dyne-amic	8 wt oz 1 pt 7.0 oz 0.125%(v/v)	7/27, 8/4, 8/11, 8/17, 8/25	Vestaron
8	Mustang Maxx Avaunt eVO Exirel Dyne-amic	4.0 oz 6.0 oz 16.0 oz 0.25%	7/27, 8/4, 8/17,	FMC

9	Exp.	18.66 Fl oz	8/11,	Bayer
10	Chem Standard: Sequoia 2 SC Mustang Maxx Exirel Dyne-amic	 4.5 oz 4.0 oz 13.5 oz 0.25 %	7/27, 8/4, 8/11, 8/17, 8/25	

Figure 1. The field trial was composed of ten treatments with 4 replicates each for a total of 40 plots. The field was located at UCR Agricultural Operations.

To determine the impact of insecticides, a mid-season field assessment of insects was done on 26 July 2023 by counting all insects on five plants per replicated plot. On 31 August 2023, 50 mature-green to ripe fruit were harvested from the center row of each plot (200 fruit per treatment) and examined for the presence of potato psyllids, aphids, spider mites, and for damage caused by beet armyworm, bagrada bug, and other stinkbugs (external feeding), as well as tomato fruitworm (internal feeding). We also searched the calyx for damage caused by beet armyworm and tomato fruitworm. Furthermore, we opened 50 fruit per plot and inspected them for pepper weevil larvae (Figure 2).

Figure 2. Fifty harvested pepper fruit were picked for each tray and were subsequently evaluated for pepper weevil damage by cracking open each fruit. Damage was recorded when either larval feeding or adults were present inside the fruit.

Results

Field Sampling
Overall, the insect pressure was low to moderate this season, and there was variability within treatments. The insects of concern, except the pepper weevil, were present in the field.

For the field counts, there were no significant differences ($P > 0.05$) (Figure 3). The total psyllid numbers showed that the psyllid population was developing. Psyllid egg, nymph, and adult counts were five or fewer insects on average per treatment. The leafhopper counts were the highest across all treatments. There were low field counts of lepidopterans, thrips, aphids, whiteflies, and mites.

Harvest Evaluation
Our harvest assessment revealed low to moderate numbers of insects and damage in the various treatments, and there was no statistical separation except for the bagrada bug ($p=0.054$) (Table 2). Spider mite infestation and damage on the fruit was low, and only treatments 2, 4, and 7 sustained minimal damage of 0.5% (Figure 4).

Damage to the calyx caused by beet armyworm and tomato fruitworm was low and not significantly different ($P > 0.05$) between treatments (Figure 5). Treatment 7 had no damage to the calyx. Overall, lepidopteran pressure was moderate in this study, and there were no differences between treatments for total lepidopteran damage (Figure 6). The control sustained 6.5% damage, and treatment 7 had no damage. Over the past several pepper growing seasons, we have seen an increase in bagrada bug damage. The harvest assessment had significant differences ($P < 0.05$) between the treatments for bagrada bug damage (Figure 7). Bagrada bug damage is associated with star-shaped lesions under the fruit's skin, as shown in Figure 8.

Internal damage by the pepper weevil was not present this year and could result from hot weather conditions and a lack of good host plants to sustain populations throughout the year. Some pepper weevils were seen in the field, but no damage was seen in the harvested fruit. Additionally, good control of weed host plants such as “nightshade” can eliminate a potential source for reproduction of pepper weevils. Nightshade berries can provide a food source for developing pepper weevil larvae. Therefore, controlling nightshade plants near commercial pepper field operations is recommended. Potato psyllids were present in the field, as seen in our field counts, but we noticed very few in our harvest assessment.

Table 2.

	Treatment/ Formulation	Rate Amt/acre	Mean Number of Fruit Damaged/Replicate[a] Internal	External	All Leps	Bagrada Bug	Calyx Damage	Other
1	Non-treated	-	0.50	2.75	3.25	0.75 bc	1.00	2.00
2	Intrepid + Sequoia 2 SC Radiant SC Dyne-amic	10.0 oz 4.5 oz 7.0 oz 0.125%	0.00	2.00	2.00	0.25 c	0.25	5.00
3	Organic IPM Pyganic 5.0EC Trilogy EC Entrust SC	 15.0 oz 64.0 oz 8.0 oz	0.00	1.00	1.00	0.00 c	1.25	1.25
4	Sivanto Prime 200SL Drench	28.0 Fl oz	0.25	2.00	2.25	0.25 c	0.25	0.75
5	Sivanto Prime 200SL Foliar	14.0 Fl oz	0.25	1.50	1.75	5.75 a	0.25	2.75
6	Intrepid + Sequoia 2SC Exp. VST + Leprotec Dyne-amic	10.0 oz 4.5 oz 8 wt oz 1 pt 0.125%(v/v)	0.00	2.25	2.25	0.00 c	0.75	1.25
7	Exp. VST+ Leprotec Radiant SC Dyne-amic	8 wt oz 1 pt 7.0 oz 0.125%(v/v)	0.00	0.00	0.00	3.00 abc	0.00	2.00
8	Mustang Maxx Avaunt eVO Exirel Dyne-amic	4.0 oz 6.0 oz 16.0 oz 0.25%	0.25	1.25	1.50	1.00 bc	0.25	2.50
9	Exp.	18.66 Fl oz	0.50	1.75	2.25	0.00 c	0.50	0.50
10	Chem Standard: Sequoia 2 SC Mustang Maxx Exirel Dyne-amic	 4.5 oz 4.0 oz 13.5 oz 0.25 %(v/v)	0.00	1.75	1.75	4.50 ab	0.25	2.50
ANOVA F value (by column)			0.813	0.775	0.804	2.167	1.174	1.783
ANOVA P value (by column)			0.608	0.641	0.616	0.054	0.346	0.114

[a] 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 tomato fruitworm; external damage due primarily to beet armyworm. Calyx damage can be attributed to tomato fruitworm and beet armyworm.

Figure 3. Pepper field insect counts 7-26-2023.

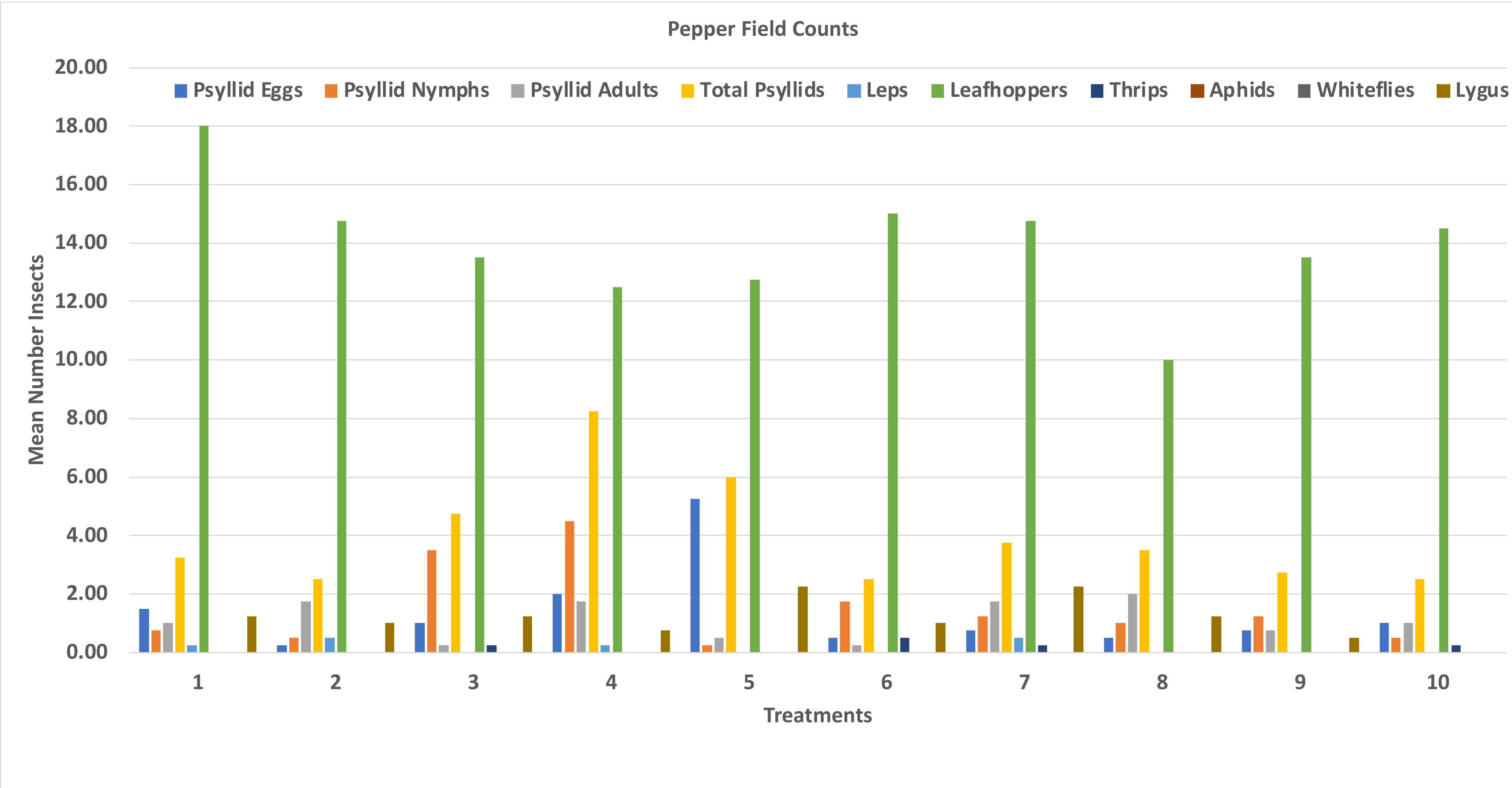


Figure 4. Spider mite infestation and damage on pepper fruit at harvest.

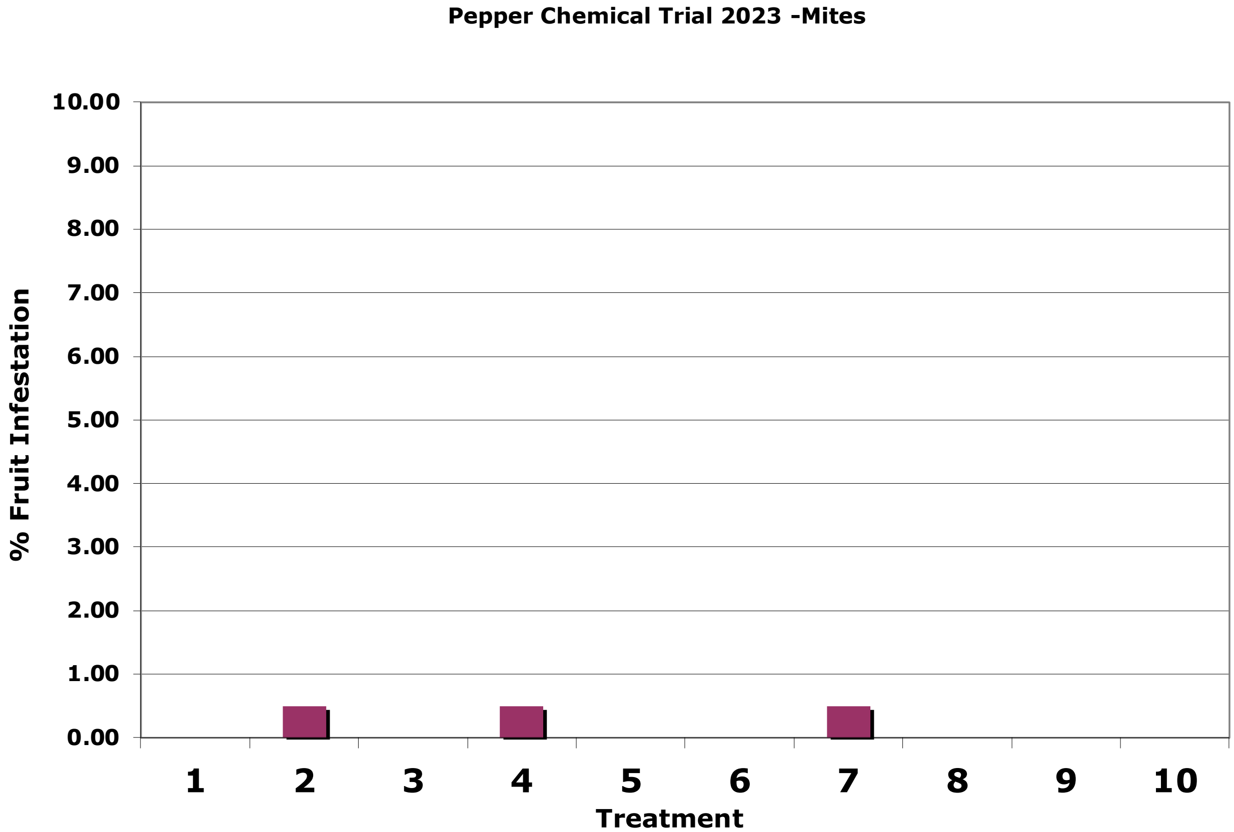


Figure 5. Calyx feeding damage

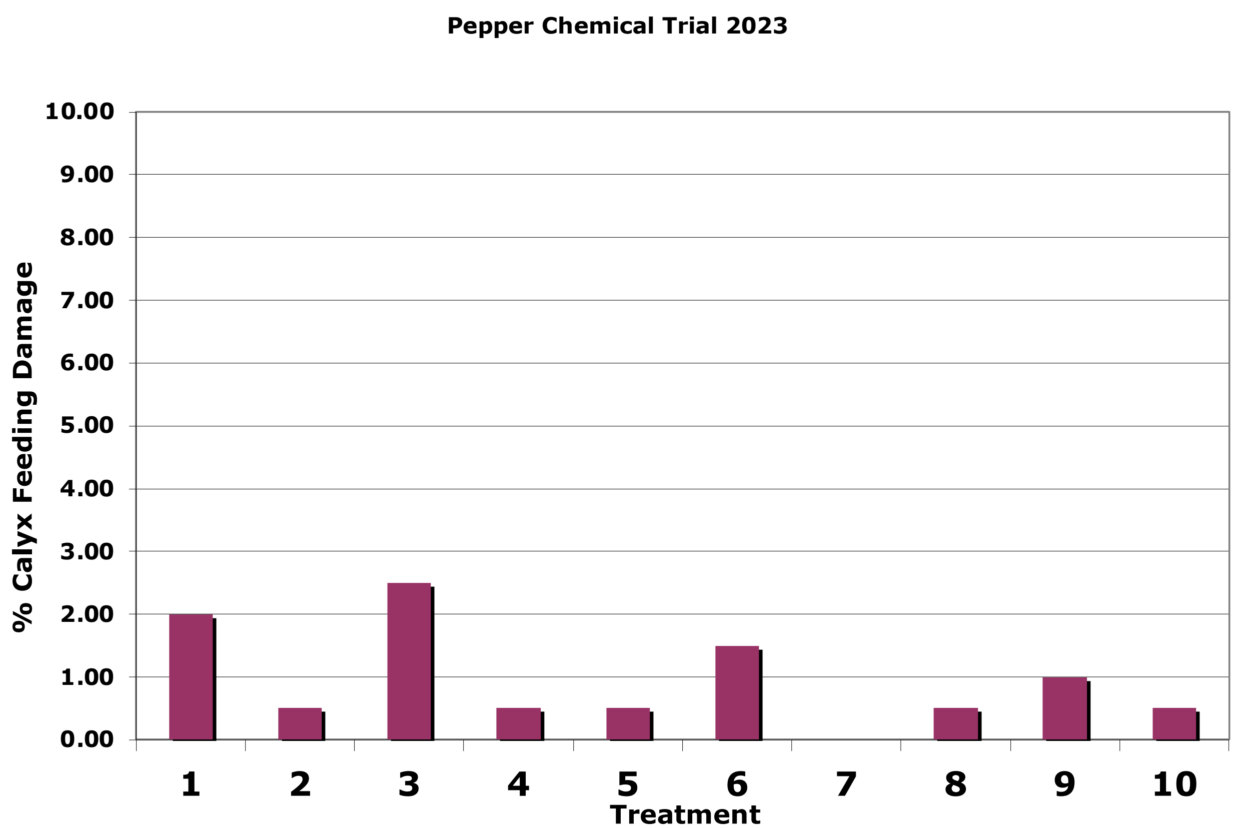


Figure 6. All Lepidopteran damage combined

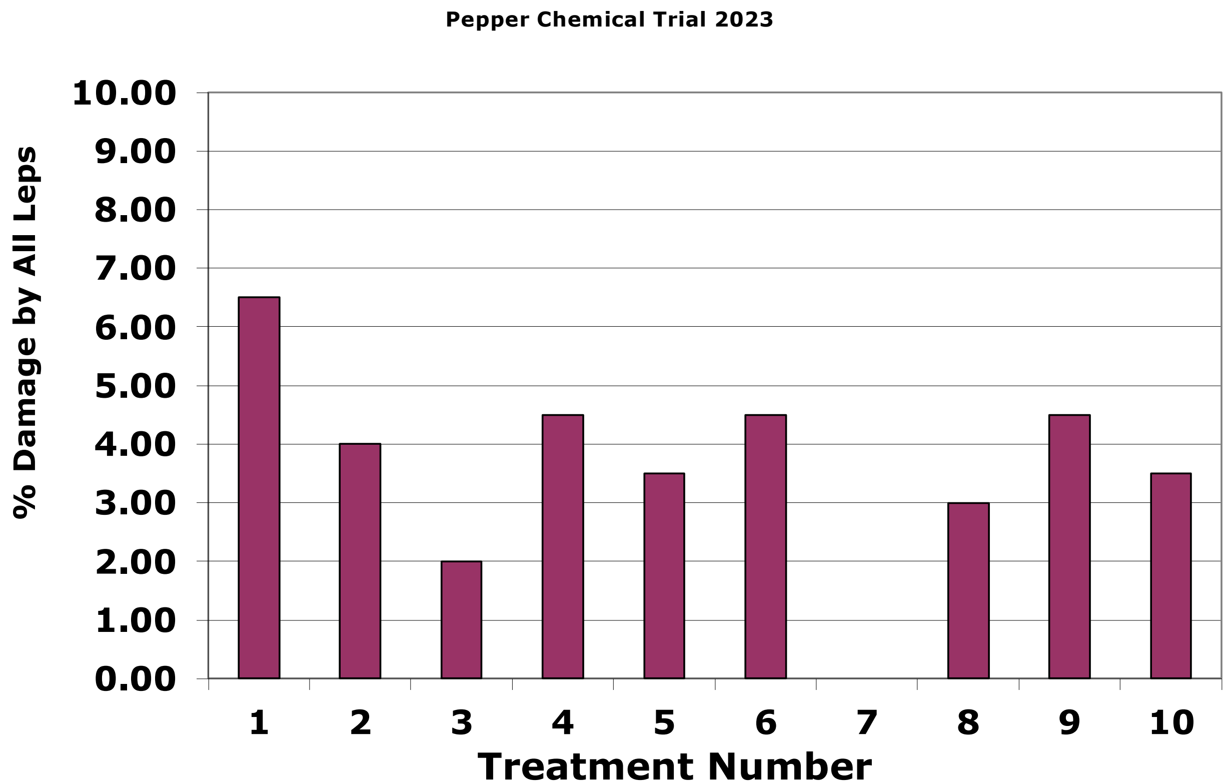


Figure 7. Damage by bagrada bug

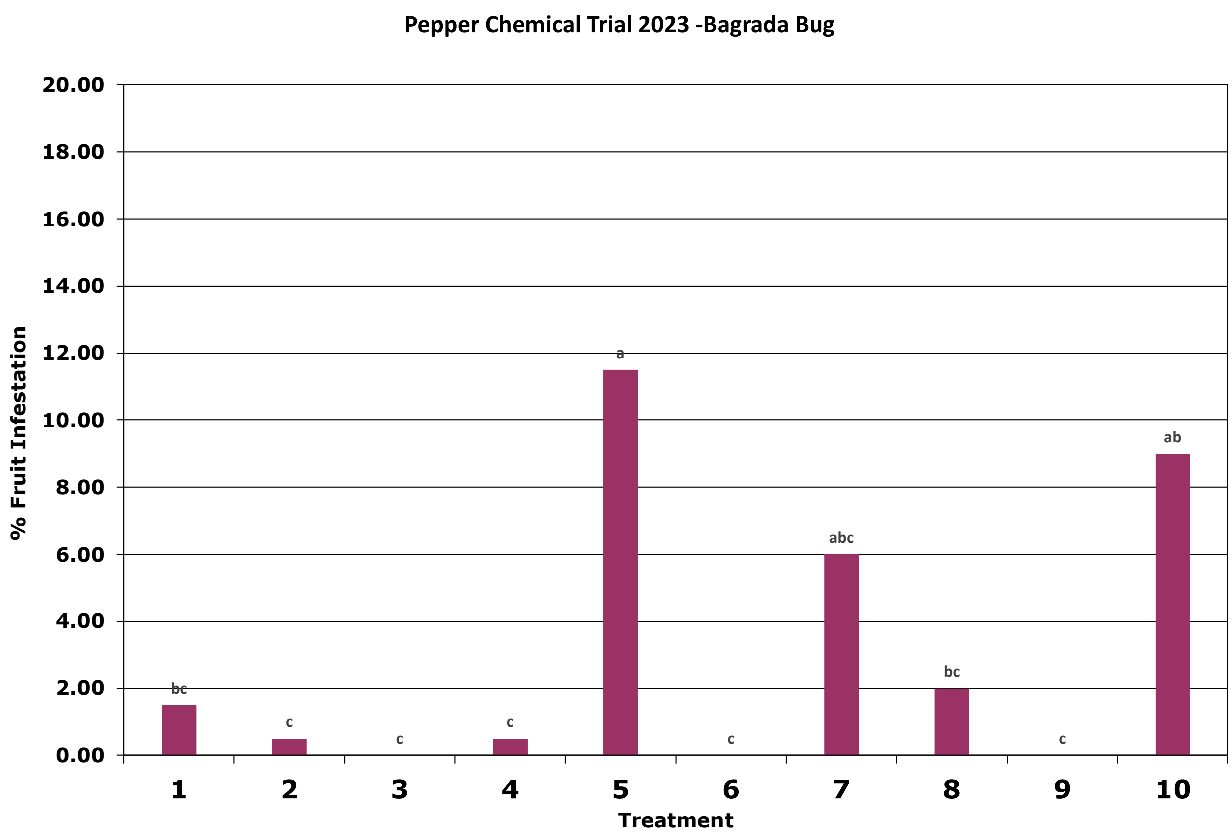


Figure 8. Bagrada bugs cause damage by feeding with their needle-like mouthparts. Multiple insertions of their mouthparts at each feeding site causes cell wall damage to the pepper fruit resulting in the visible star shaped patterns.

III. Pepper weevil trial Location #2

ANAHEIM PEPPER: *Capsicum anuum* L. 'Ventura'

EFFECT OF INSECTICIDES ON PEPPER INSECTS IN SANTA PAULA, CA, 2023

This trial aimed to test registered and experimental products against pepper pests, specifically targeting pepper weevils. The growing region had been known to have good pepper weevil pressure, and we saw pepper weevil damage on the harvested fruit. No field counts were done in this trial, and the harvest assessment results were the measure of the treatments.

Seedlings were transplanted in sandy loam-type soil on 1 July 2023 at the McGrath Ranch field location (34.321636, -119.093478). Experimental plots were 12 rows wide (5-ft centers) by 40 ft long. The pepper transplants were drip irrigated (water pH 7.2–7.5). Treatments were replicated 4 times within each treatment block. Application dates and a treatment list for the experimental treatments are shown in Table 3. The "Grower treatment" was a standard pesticide application rotation commonly used by commercial pepper growers. All applications were made during working hours when wind conditions were mild. A tractor-mounted boom sprayer was employed by "Nutrien Ag Solutions" to apply the commercial treatments. The experimental plots were sprayed with a handheld CO2 backpack sprayer using 4 nozzles per row at a pressure of 40 psi. Commercial tractor application was not possible since experimental products were used, and commercial applicators can not use experimental products in the spray tanks for regulatory reasons. As a note, the "Grower treatment" was inadvertently applied over all plots. The grower could not convince the commercial agricultural pesticide application company to avoid applications in our designated plots, even though they were marked. These companies and their personnel are not accustomed to doing research plot work. In essence, the research treatments 1–3 became incorporated into the "Grower treatment" program. We could not have an untreated control plot since this was a commercial pepper production operation. Despite these complications, we were able to see some interesting results.

On 3 October 2023, 50 mature-green to ripe fruit were harvested from four random sections of each plot (200 fruit per treatment), weighed, and examined for damage. The field setup and stage of fruit development before assessment can be seen in Figure 9. We first inspected the calyx for damage caused by beet armyworm and tomato fruitworm. Subsequently, we examined the fruit for damage caused by beet armyworms, stinkbugs (external feeding), tomato fruitworms, and pepper weevils (internal feeding). Every fruit was cut open and inspected for pepper weevil larvae. Fruit was also examined for potato psyllids, aphids, and spider mites.

Results

The harvest assessment weights for each treatment did show some differences. Treatments 2 and 3 yielded 6.5 kg/tray and 7.1 kg/tray, respectively. These treatments significantly differed from treatments 1 and 4, which weighed 5.0 kg/tray and 5.5 kg/tray, respectively (Figure 10).

Insect pest damage was seen as damage to the calyx, lepidopteran feeding, lygus bug feeding scars, pepper weevil exit holes, and pepper weevil larval feeding inside the fruit. A summary of insect pest damage is shown in Table 4. Calyx damage, which can be attributed to beet armyworm, tomato fruitworm, and pepper weevil feeding, was not significantly different, but we did see damage ranging from 0% in Treatment 1 to the highest level of 4.5% in Treatment 4 (Figure 11). Lepidopteran damage results showed that treatment 1 had the lowest damage of 1.5% and Treatment 4 had the highest damage at 7% (Figure 12). Lygus and stink bug damage was low throughout the field, but we saw significant differences between the treatments. Treatments 1–3 had no damage, and Treatment 4 had 2.5% damage (Figure 13). Pepper weevil pressure was evident in the harvest assessment, although there were no significant differences between treatments due to variability. Treatment 1 and Treatment 4 sustained 15.0% and 10.5% damage, the two poorest performing rotations. Treatments 2 and 3 performed better with 4.5% and 5.5% pepper weevil damage, respectively (Figure 14). Examples of pepper weevil pest damage can be seen in Figure 15.

Table 3.

Treatment #	Compound	Rate-Product	Application Dates	Company Sponsor
1	Plinazolin Dyne-amic	4.1 fl oz 0.25%	8/30, 9/12	Syngenta
2	Plinazolin Dyne-amic	5.2 fl oz 0.25%	8/30, 9/12	Syngenta
3	Mustang Maxx Avaunt eVO Dyne-amic	4.0 oz 6.0 oz 0.25%	8/30, 9/12	FMC
4	Grower treatment	-	-	

Table 4.

			Mean Number of Fruits Damaged/Replicate [a]					
Treatment/ Formulation		Rate Amt/acre	Internal	External	All Leps	Pepper Weevil	Calyx Damage	Other
1	Plinazolin Dyne-amic	4.1 fl oz 0.25%	0.00	0.75	0.75	7.5	0.00	0.00 b
2	Plinazolin Dyne-amic	5.2 fl oz 0.25%	0.00	3.00	3.00	2.25	2.00	0.00 b
3	Mustang Maxx Avaunt eVO Dyne-amic	4.0 oz 6.0 oz 0.25%	0.00	2.75	2.75	2.75	1.25	0.00 b
4	Grower treatment	-	0.00	3.50	3.50	5.25	2.25	1.25 a

[a] 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). Calyx damage can be attributed to (TFW) and (BAW) feeding. Other refers to lygus and stink bug damage.

Figure 9. Yield assessment and field photos

Figure 10. Pepper harvest yield results.

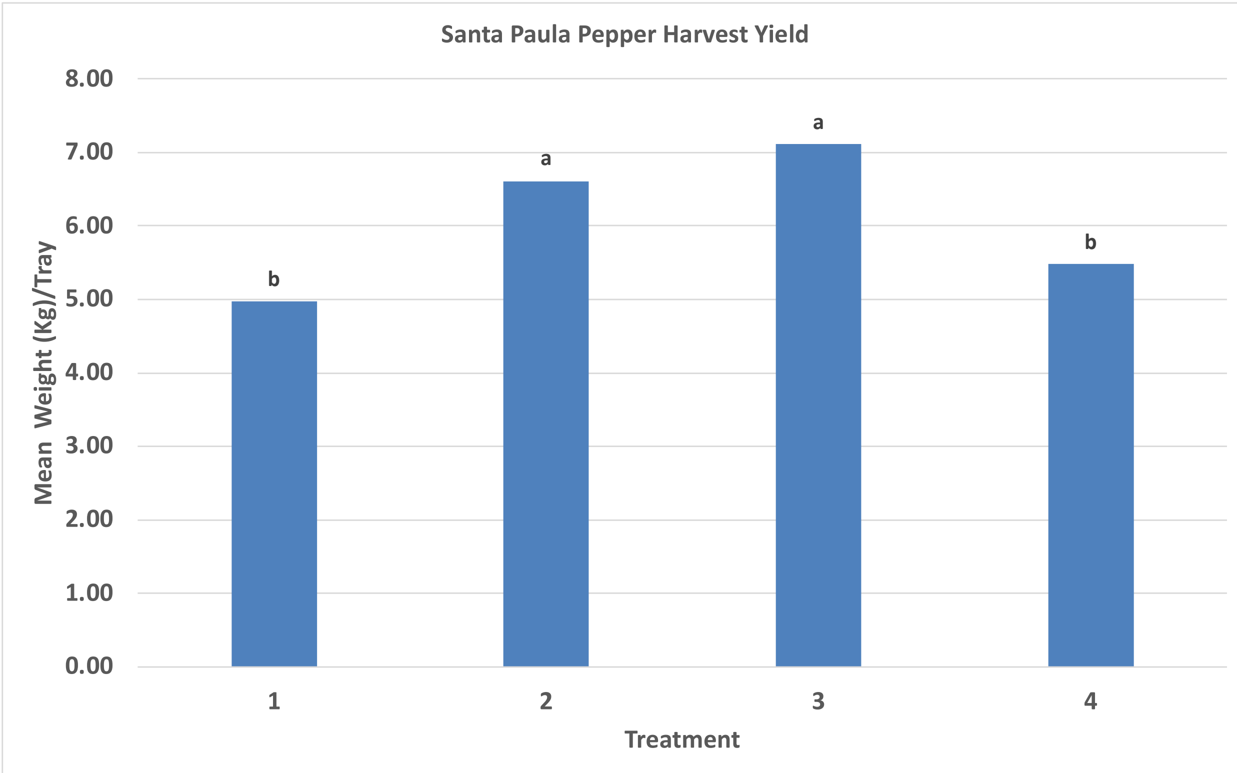


Figure 11. Calyx feeding damage

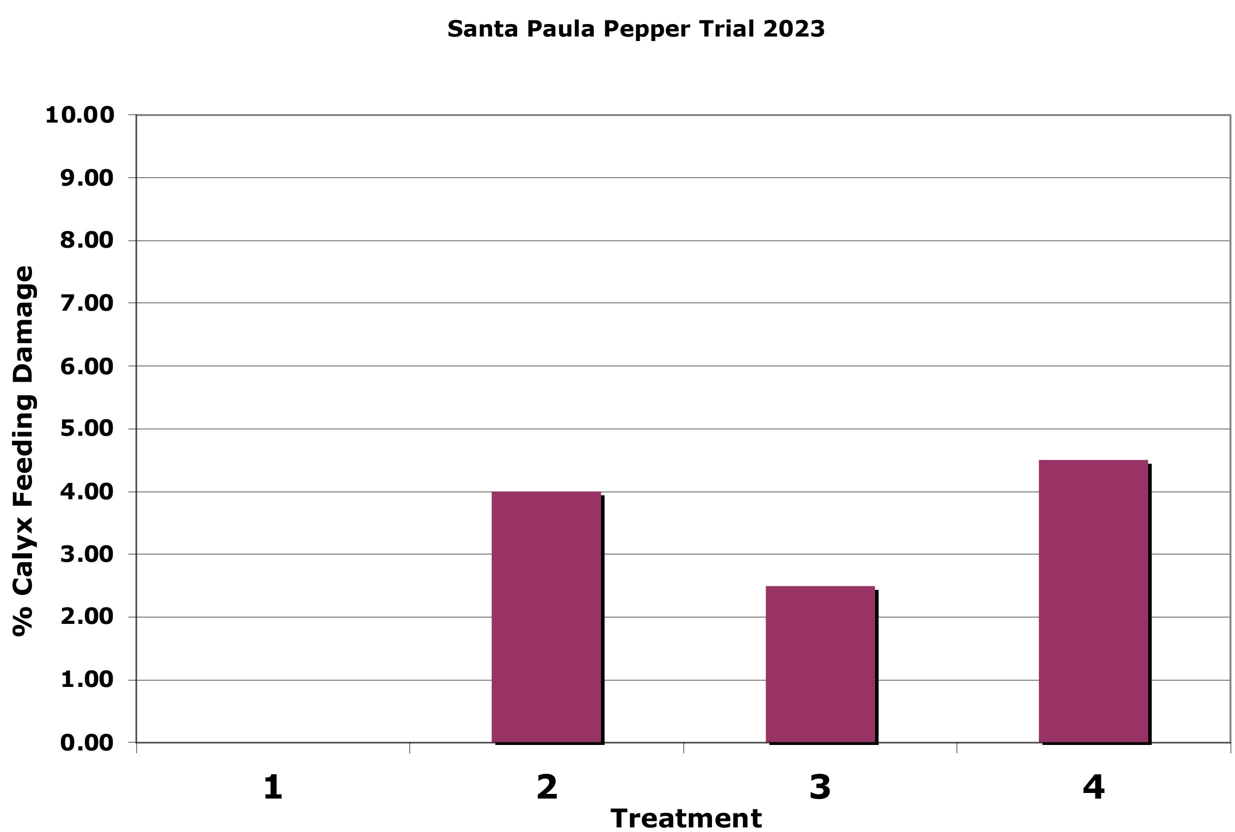


Figure 12. Lepidopteran damage

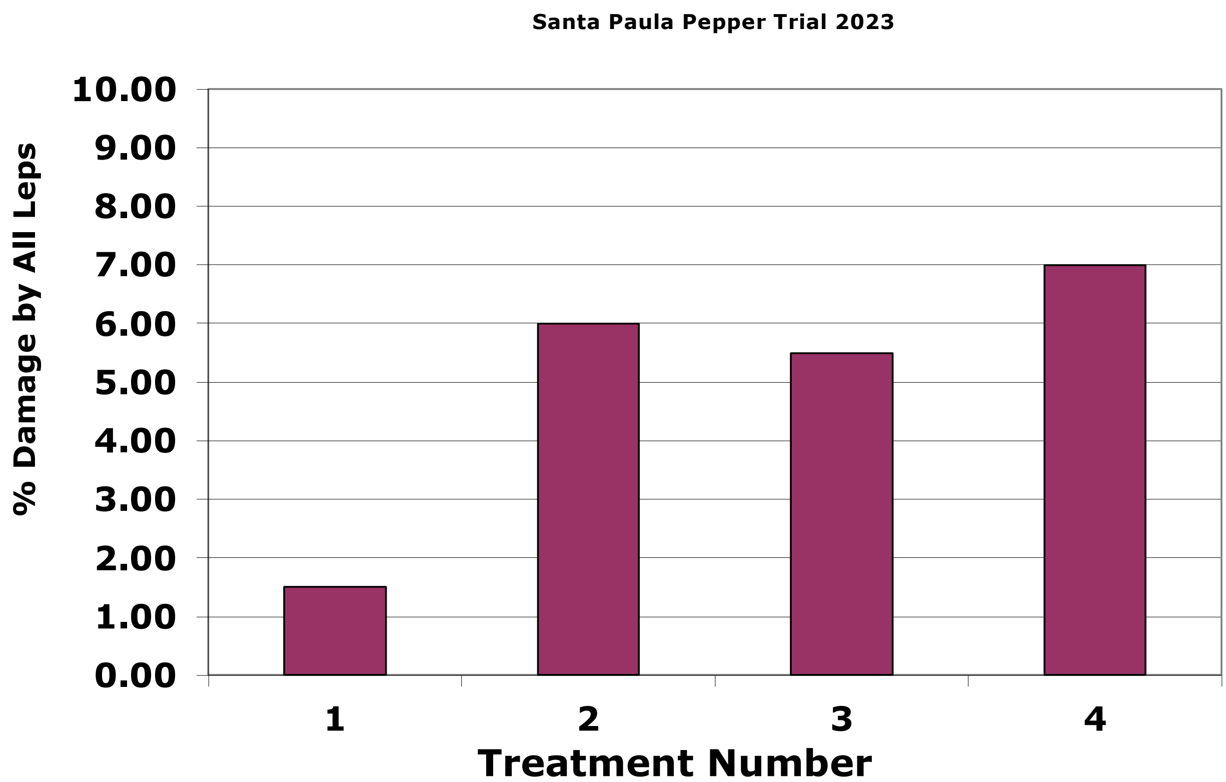


Figure 13. Lygus and stink bug damage

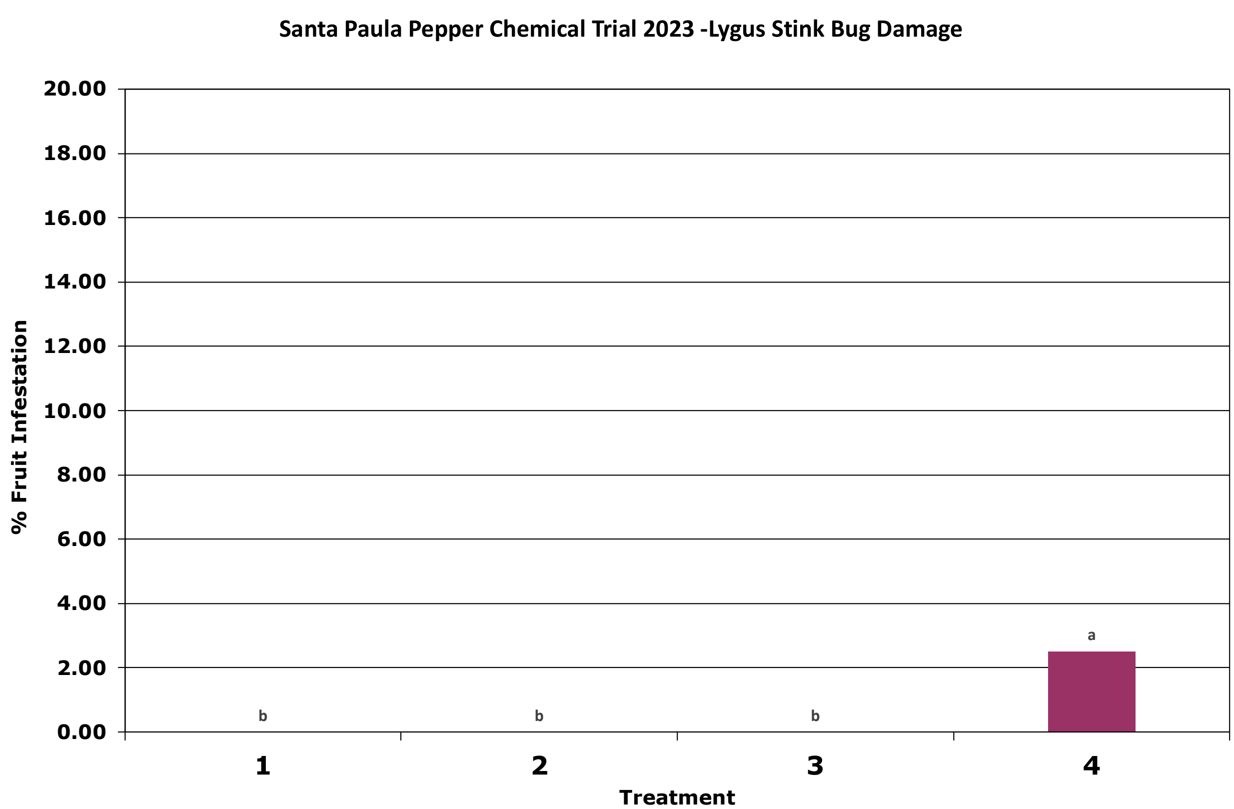


Figure 14. Pepper weevil damage

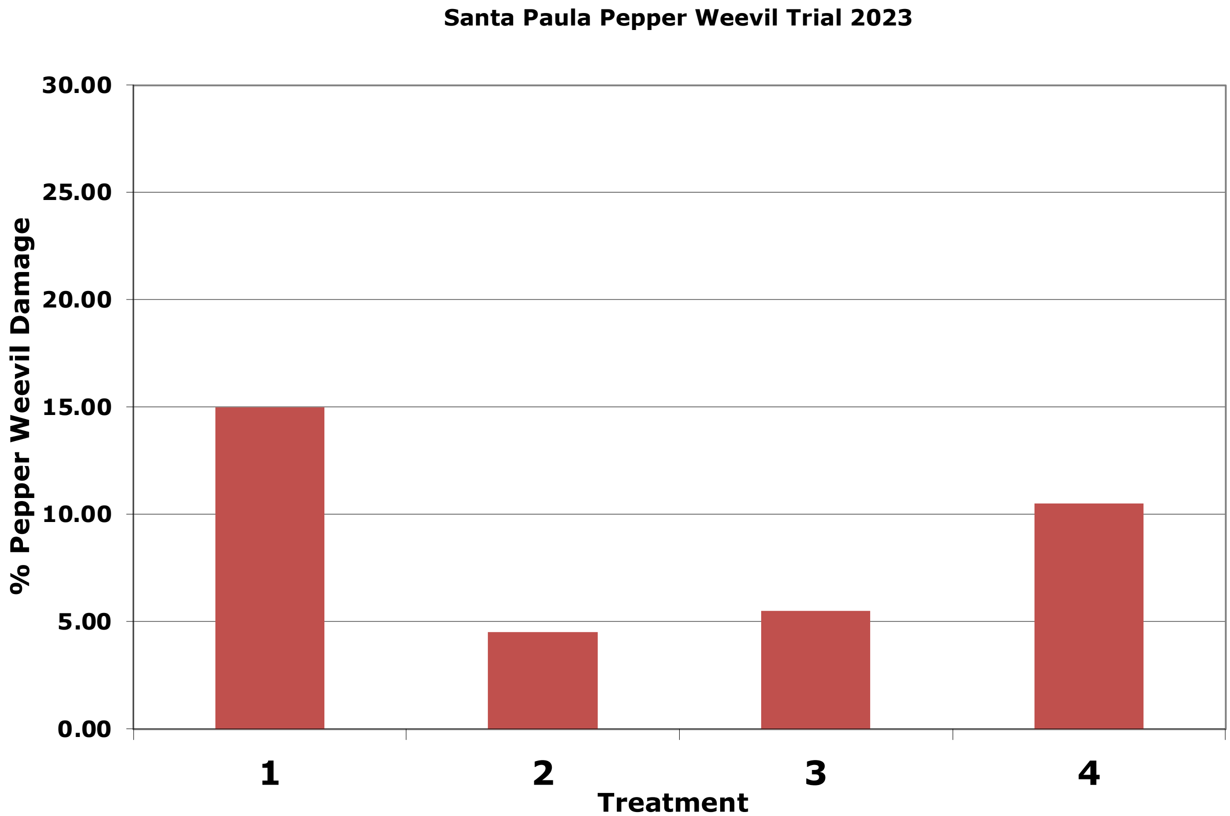
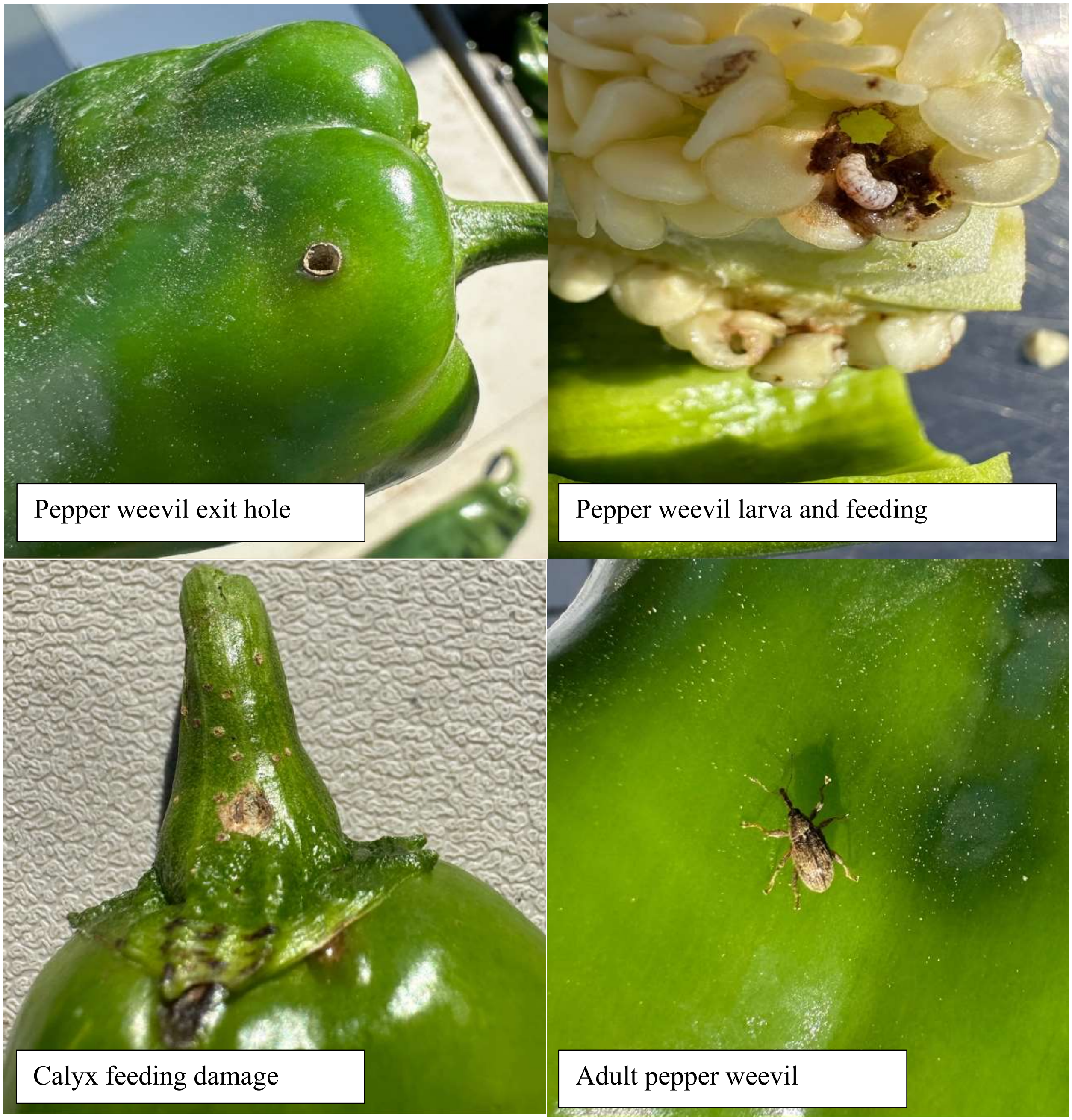


Figure 15. Pepper weevil feeding damage.



IV. Additional Research

We continue to test strategies and chemicals for psyllid and leafhopper control that disrupt insect behavior and cause mortality. Successful repellents and insecticides will be incorporated into an IPM program. We have been testing several novel compounds that have shown promising results for insect control, and we are hopeful that some of these products will eventually be available to pepper growers. We are continuing to study pepper weevil control and are testing some alternative products that would comply with the Food Quality Protection Act.