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California Pepper Commission
Research Report 2015-2016

I. IDENTIFICATION

- A. California Pepper Commission.**
- B. Insect Pest Management on Peppers**
- C. Proposal for period beginning March 2015, ending February 2016.**
- D. Principal Investigator:**
 - Dr. John T. Trumble
 - Department of Entomology
 - University of California, Riverside
- E. Cooperating Personnel:**
 - Greg Kund, and Sean Prager
 - Department of Entomology
 - Univ. of California, Riverside
- F. Locations of Work:**
 - U.C. Riverside,
 - U.C. South Coast Res. & Ext. Center
 - Orange County, CA
- G. Insects**
 - Tomato/Potato Psyllid: *Bactericera cockerelli* (Sulc)
 - Beet armyworm (BAW): *Spodoptera exigua* (Hübner)
 - Tomato Fruitworm(TFW): *Helicoverpa zea* (Boddie)
 - Leafminer: *Liriomyza sativae* (Blanchard)
 - Leafminer: *Liriomyza trifolii* (Burgess)
 - Lygus bugs: *Miridoa* spp.
 - Stink bugs (SB): *Pentatomidae* spp.
 - Pepper weevil (PW): *Anthonomus eugenii* Cano

II. Field Screening Trials for Effective Pesticides

Seedlings were transplanted in a sandy loam type soil on 5 June at the University of California's South Coast Research and Extension Center. 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 at twilight. A tractor-mounted boom sprayer with 6 nozzles per row incorporated D-3 orifice disks, #25 cores, and 50 mesh screens. Operating pressure was 125 psi delivering 100 gpa. All treatments included MSO as an adjuvant at 0.25% vol/vol except treatment number five, which consisted of Pyrellin, Trilogy, Mycotrol, and Entrust.

Table 1: Pepper Chemical Trial List of Treatments 2015

Treatment #	Compound	Rate-Product	Application Dates	Company
1	Control	-	-	-
2	Radiant 1.0 SC	6.0 oz/Ac	7/14, 7/21, 7/30, 8/6, 8/13, 8/27	Dow
3	Sivanto 200 SL	10.0, 10.0, 8.0 oz/Ac	7/14, 8/6, 8/27	Bayer
4	IPM a-Verimark SC ^a b-Radiant SC c-Closer SC	13.5 oz 6.0 oz 5.0 oz	7/14 7/21, 8/6, 8/13, 8/27 8/6, 8/13, 8/27	Dupont Dow Dow
5	Soft IPM a-Pyrellin EC b-Trilogy c-Mycotrol EC d-Entrust	32.0 oz 64.0 oz 32.0 oz 8.0 oz	7/14, 7/21, 8/27 8/27 7/30, 8/6, 8/13 7/30, 8/6, 8/13	Web Wright Certis Laverlam Dow
6	Lannate 2.4 LV+ Pounce 3.2 EC	48 oz/Ac 8 oz/Ac	7/14, 7/21, 7/30, 8/6, 8/13, 8/27	Dupont FMC

^a Verimark was applied once on 7/14 as a soil drench



Pepper Weevil



Fruitworm

A mid season field count of psyllids was taken by counting eggs, nymphs and, adults on a single branch of five plants per replicated plot to determine what impact the treatments had on potato psyllid populations. On 3 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, and potato psyllid PP, and aphids GPA. Results are shown in Table 2..

Lepidopteran pressure was estimated to be moderate to high in the categories of External damage by BAW (Figure 4). Internal damage by PW was high this year with the control sustaining 36% damage (Figure 2). We did see some differences between treatments for potato psyllid PP numbers (Figure 1). Treatment 6 had the highest psyllid numbers on the fruit. Damage to the calyx showed differences between treatments and can be attributed to TFW, BAW, and PW feeding (Figure 3). Harvest assessment of aphid infestation showed no differences (Figure 5). The field counts of psyllids revealed significant differences between the treatments, and treatment six had the highest number of total psyllids (Figure 6).



Mean Number of Fruit Damaged/Replicate^b

Table 2.

Treatment/ Formulation	Rate Amt/acre	Internal	External	All Leps	Pepper Weevil Internal	Calyx Damage	Psyllids
1 Control	-	1.25	7.75 b	9.00 b	18.00 b	11.25 b	9.75 b
2 Radiant 1.0 SC	6.0 oz/Ac	0.25	5.75 ab	6.00 ab	17.25 b	11.25 b	7.75 ab
3 Sivanto 200 SL	10.0, 10.0, 8.0 oz/Ac	0.50	10.75 b	11.25 b	26.75 c	14.50 b	8.75 b
4 IPM a-Verimark SC ^a b-Radiant SC c-Closer SC	13.5 oz 6.0 oz 5.0 oz	0.25	8.75 b	9.00 b	17.50 b	16.00 b	3.75 a
5 Soft IPM a-Pyrellin EC b-Trilogy c-Mycotrol EC d-Entrust	32.0 oz 64.0 oz 32.0 oz 8.0 oz	0.50	7.00 b	7.50 b	20.50 bc	11.75 b	8.75 b
6 Lannate 2.4 LV+ Pounce 3.2 EC	48 oz/Ac 8 oz/Ac	0.25	1.50 a	6.00 ab	9.00 a	5.00 a	15.00 c
ANOVA F value (by column)		1.200	3.457	2.953	4.741	4.537	6.413
ANOVA P value (by column)		0.349	0.023	0.041	0.007	0.008	0.001

^a Verimark was applied once on 7/14 as a soil drench

^b Means in columns followed by the same letter are not significantly different (P<0.05 level, Fisher's Protected 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. Potato Psyllid infestation

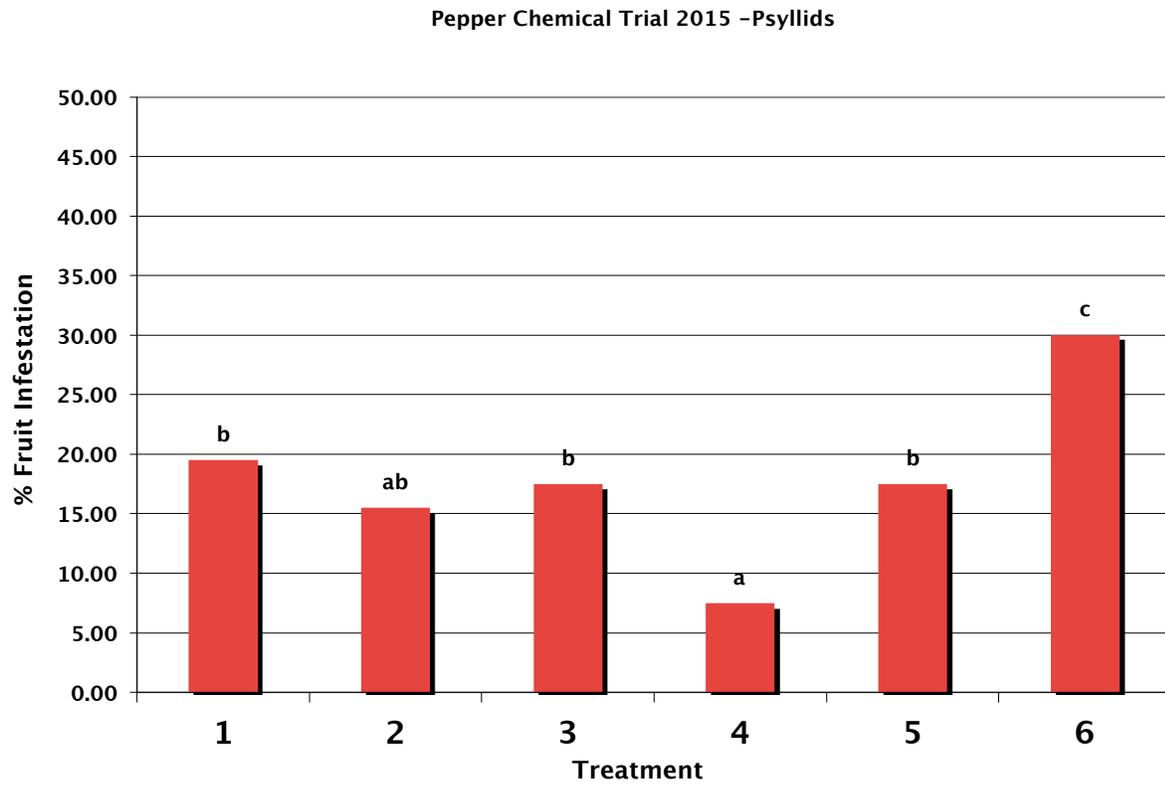


Figure 2. Pepper weevil damage

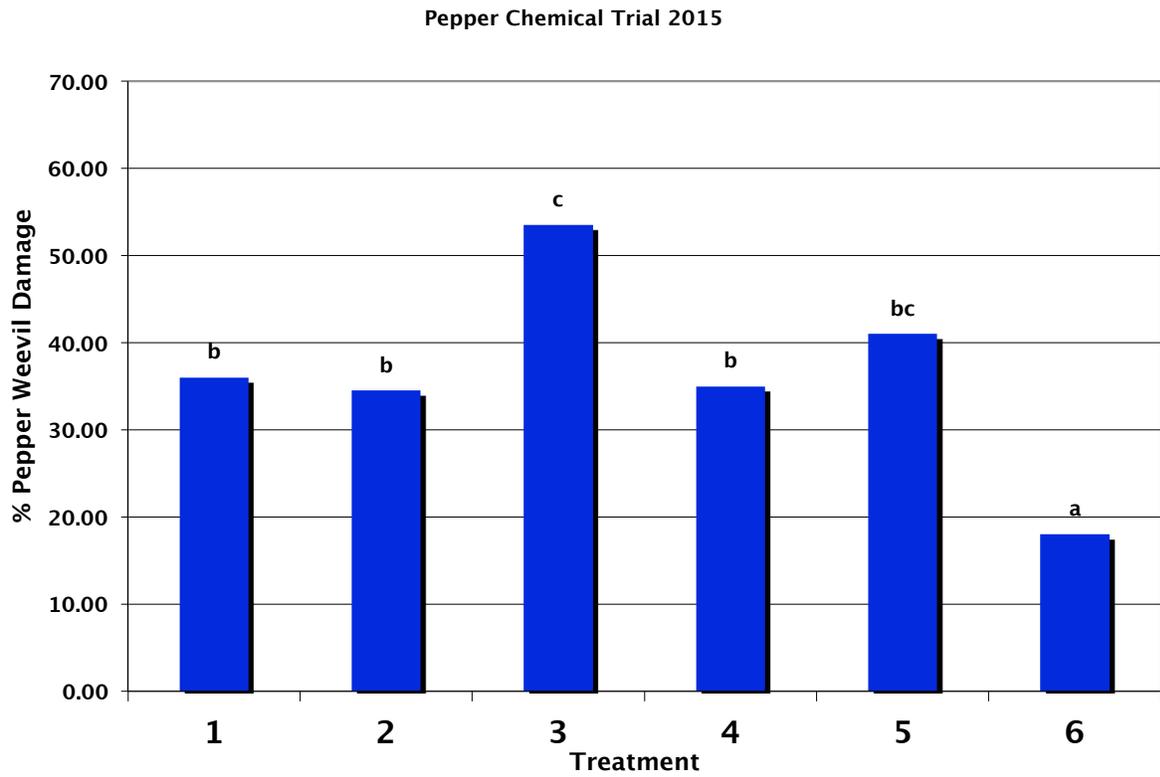


Figure 3. Calyx feeding damage

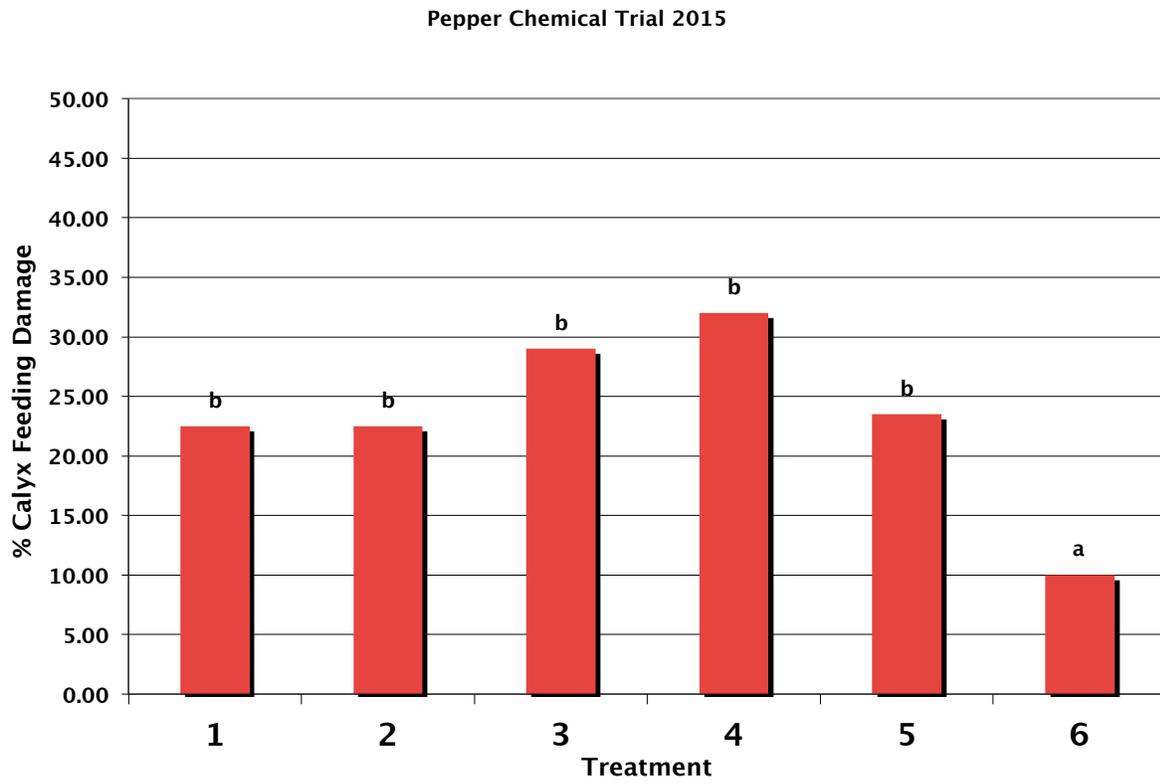


Figure 4. Lepidopteran damage

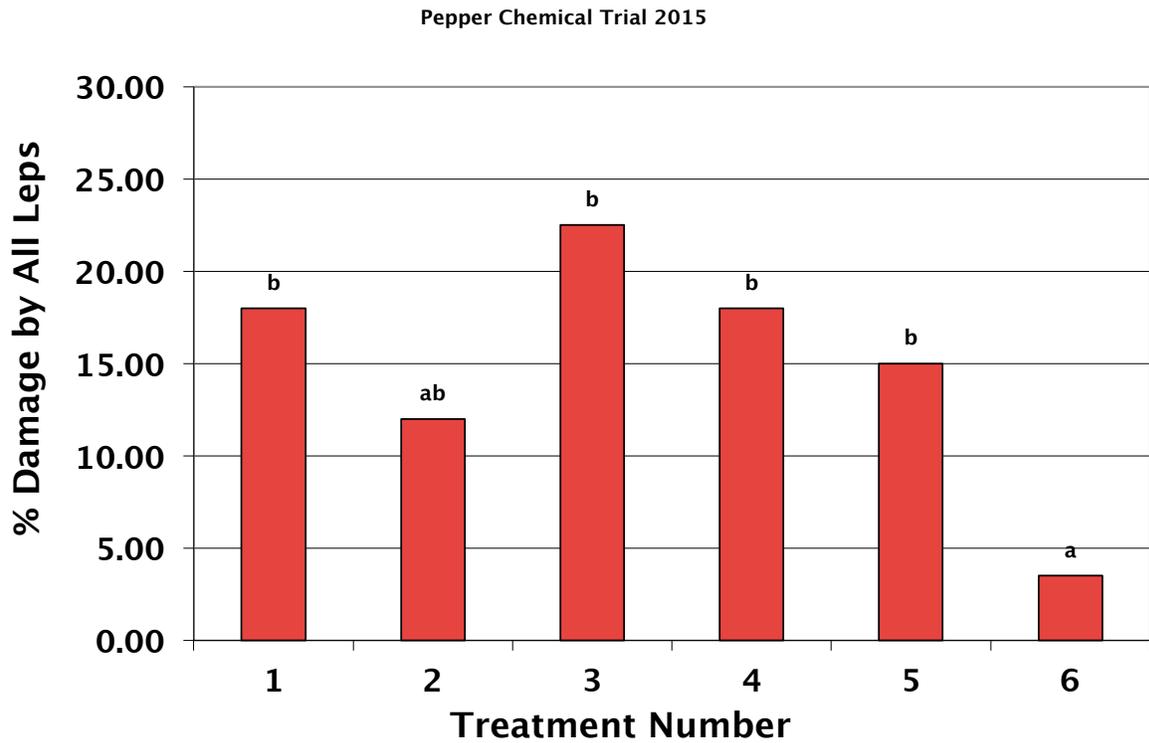


Figure 5. Aphid infestation

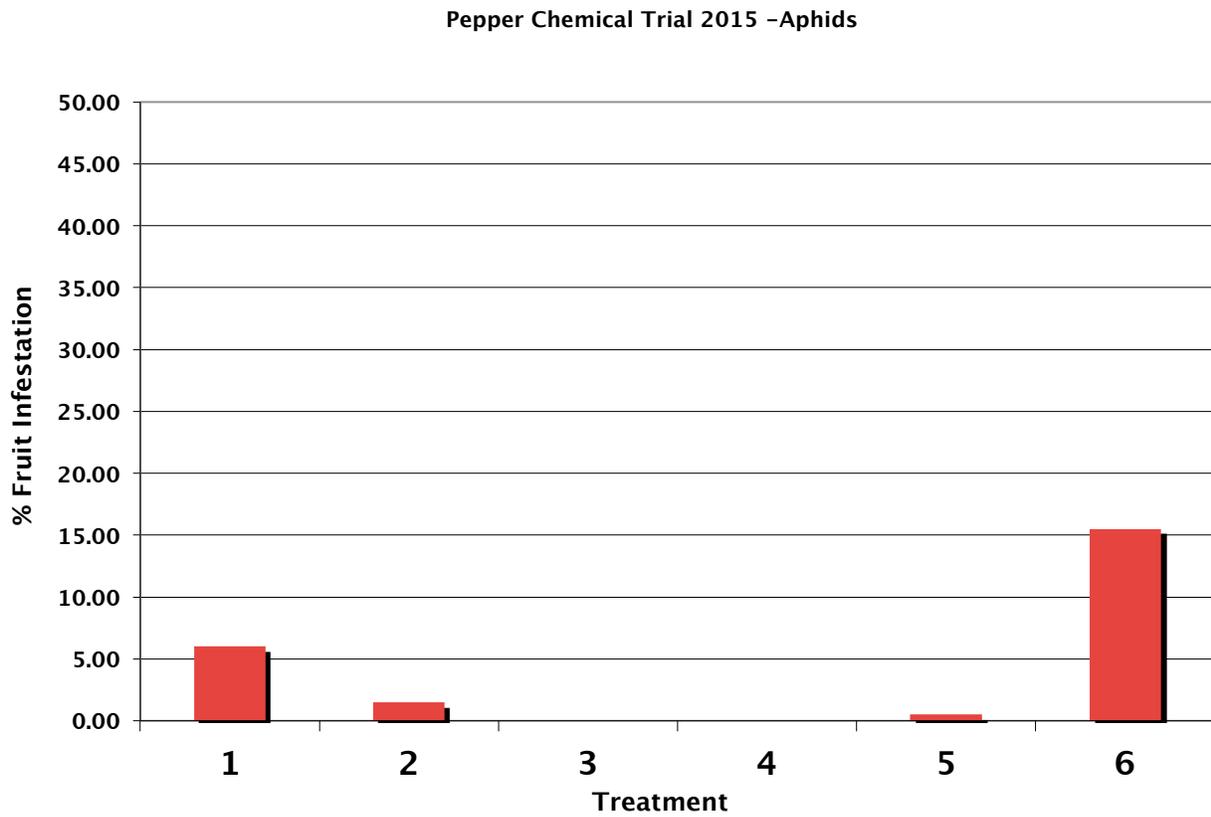
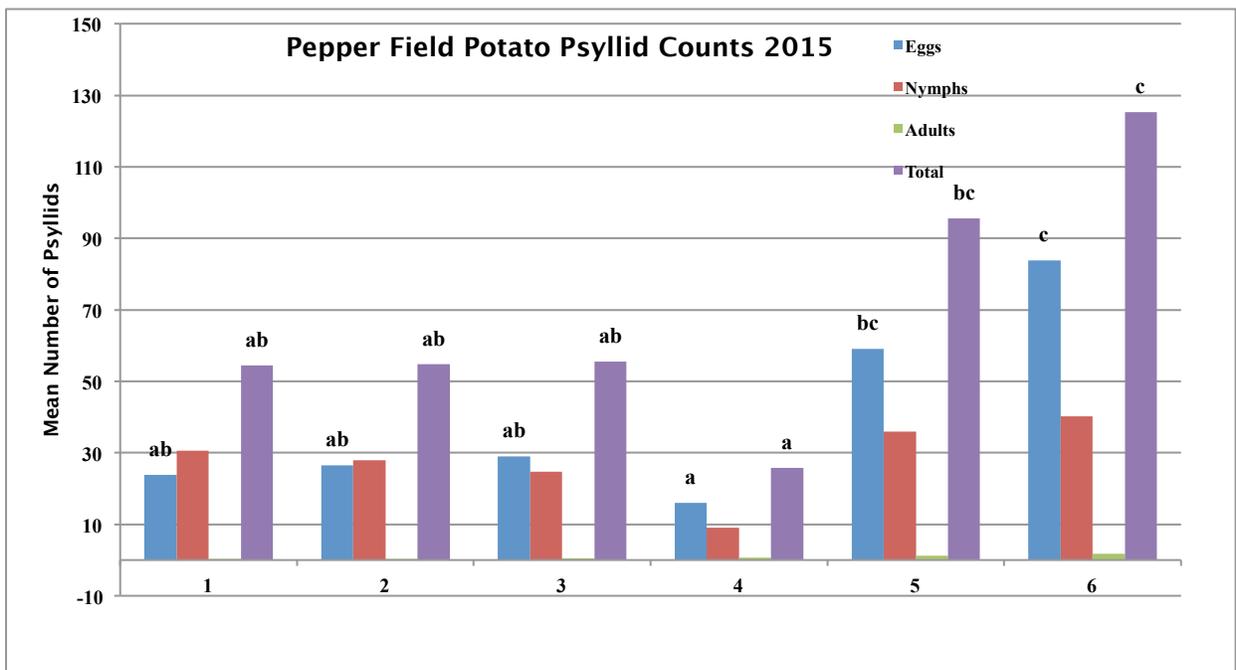


Figure 6. Pepper field Potato Psyllid counts



III. IPM Strategies in Peppers

Seedlings were transplanted in a sandy loam type soil on 5 June at the University of California's South Coast Research and Extension Center. 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). This year the IPM program consisted of four treatments see Table 2).

Additionally, we compared the effects of a standard commercial fertilizer rate and a lower (50% less) rate, on the insect populations within the fields. The purpose was first to see if using half the rate would reduce insect pressure. Several studies have shown that insects grow faster on plants with high N. We asked the question, if N is reduced, would insect populations become less of a problem. The second purpose was to reduce potential for N runoff, which is a major concern for growers. As part of this study we also examined yield effects.

To accomplish these tasks we setup two separate fields which contained the four treatments that were replicated 4 times in a RCB block design. Field A received fertilizer at the low rate on 8 June (20 lb/Ac), 6 July (30 lb/Ac), and 22 July (25 lb/Ac). Field B received the full rate of fertilizer on 8 June (20 lb/Ac), 6 July (30 lb/Ac), 22 July (25 lb/Ac), 5 August (20lb/Ac), 17 August (30 lb/Ac), and 27 August (25 lb/Ac). Peters soluble 20-20-20 was used for all fertilizer drip irrigation applications. Treatment 1 was the control and treatment 4 was an IPM rotation consisting of Verimark SC (applied once as a soil drench), Radiant SC, and Closer SC. Treatment 5 was a softer IPM rotation program using Pyrellin, Trilogy, Mycotrol, and Entrust. Treatment 6 was a chemical standard using Lannate and Pounce. Applications were made as specified in (Table 1). All applications were made at twilight. A tractor-mounted boom sprayer with 6 nozzles per row incorporated D-3 orifice disks, #25 cores, and 50 mesh screens. Operating pressure was 125 psi delivering 100 gpa. All treatments included MSO as an adjuvant at 0.25% vol/vol except treatment number five. On (3 September), the standard fertilizer field rate "Field B" had 50 of the mature-green to ripe fruit harvested from the center row of each replicate (200 per treatment) and examined for Lepidopterous internal damage (tomato fruitworm) and external damage (beet armyworm) (Figure 4). Fruit were also inspected for damage to the calyx (Figure 3), and from pepper weevils (Figure 2), hemipterous pests and presence of psyllids (Figure 1). The results for insect damage are summarized in (Table 2). "Field A" with the low fertilizer rate was inspected for insect damage in the same manner. The results from "Field A" are not shown because there were no differences with "Field B."

Lepidopteran pressure was moderate to high in the categories of external damage by beet armyworm. Internal damage from tomato fruitworm was low this year and no differences were seen among the treatments. Internal damage by pepper weevil was high this year and differences were shown. Calyx damage was high and there were differences between the treatments. No phytotoxicity was observed in any of the treatments. We did see a significant difference between the chemical standard and IPM rotations for the infestation levels of psyllids. There was a significant increase in psyllid numbers with treatment 6, which is a chemical standard treatment. This treatment used carbamates and pyrethroids, which can kill beneficial insects and actually cause an increase in the numbers of psyllids. We have seen this occur in our previous chemical standard trials.

Comparing the standard and low fertilizer rates did not reveal any significant differences in any of the treatments when we analyzed the insect field counts and insect damage at harvest. There were no differences in yield when we compared "Field A" and "Field B". Potential advantages of reducing fertilizer rates are to reduce fertilizer runoff in the environment and reduce the amount the nitrogen in the plants, which could make the plants less preferable to insects. Careful

management of fertilizer applications could assist with these issues while not affecting the overall yield of the crop.

A closer look at treatments 4 and 6 reveals that treatment 4 does a better job of controlling psyllids and worms but does not do well controlling pepper weevils. Treatment 6 controls pepper weevils and worms but actually increases psyllid numbers. In future trials we would like to try an IPM rotation consisting of a blend of treatments 4 and 6 to potentially control all of the pest complexes. If Lannate and Pounce treatments are used sparingly within an IPM rotation, we may get the benefits of controlling pepper weevils while still maintaining worm and psyllid control. In addition, the beneficial insects would have a chance to survive and provide some biological control.

IV. Virus Interaction Studies

We investigated the ecological and epidemiological relationships among solanaceous plants, plant pathogenic viruses, vectoring, and non-vectoring insects. It is typically assumed that within fields, there is one pathogen, one host plant, and one insect vector. However, many settings such as crop fields are mosaics of plants, diseases, and insects, and viral infection leads to plant immune defense that can alter insect behaviors. Of particular concern is the pathogen Tomato Spotted Wilt Virus (TSWV). In our preliminary studies, a model system using solanaceous plants are infected with Tobacco Mosaic Virus (TMV) by a mechanical transmission technique. This model system allows us to obtain results much quicker than working with other viruses, which are difficult to maintain in culture. Our early findings have been interesting.

We have determined that plants infected with viruses will alter the responses of potato psyllids. In particular, potato psyllids seem to avoid plants that are infected with pathogenic viruses. This leads to less landing on plants and also to less oviposition. We investigated how infection with viruses such as TSWV influences transmission of CLso. Additionally, we collaborated with researchers at the USDA to determine biochemical responses correlated with these behaviors and infection rates. We have submitted a manuscript for publication.

V. Additional Research

We are testing alternative strategies and chemicals for psyllid control such as repellents to disrupt insect behaviors. Successful repellents 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.

VI. 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 from USDA and the Specialty Crop Research Initiative (SCRI) to study and develop pepper IPM program strategies, as well as chemical industry support. We submitted a phase II grant proposal to DPR focusing on development of IPM programs in commercial pepper growing operations.