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**California Pepper Commission**  
**Research Report 2013-2014**

**I. IDENTIFICATION**

- A. California Pepper Commission.**
- B. Insect Pest Management on Peppers**
- C. Proposal for period beginning March 2013, ending February 2014.**
- D. Principal Investigator:**
  - Dr. John T. Trumble
  - Department of Entomology
  - University of California, Riverside
- E. Cooperating Personnel:**
  - William Carson, 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
  - Ventura and Orange Counties, 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 4 June at the University of California's South Coast Research and Extension Center. 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 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 Dyne-amic as an adjuvant at 0.25% vol/vol. A single spray application of Bravo at 2 pints/Ac was applied to all plots on 30 August to control powdery mildew, which was a result of warm temperatures and higher humidity.

**Table 1: Pepper Chemical Trial List of Treatments 2013**

Treatment #	Compound	Rate-Product	Application Dates	Company
1	Control	-	-	-
2	GF 2860 WG	3.5 oz/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Dow
3	GF 2860 WG	4.5 oz/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Dow
4	GF 2860 WG	6 oz/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Dow
5	Radiant SC	10 oz/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Dow
6	Intrepid 2F+ Warrior CS	10. oz/Ac 3 oz/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Dow
7	MBI 203 DF2	2 lb/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Marrone Biosciences
8	MBI 206	2 gal/Ac	7/10, 7/17, 7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	Marrone Biosciences
9	a) Torac 15 EC	21 oz/Ac	7/10, 7/17,	Nichino

	b) Lannate 2.4 LV+ Pounce 3.2 EC c) Vydate L d) Torac 15 EC e) Lannate 2.4 LV+ Pounce 3.2 EC f) Vydate L	48 oz/Ac 8 oz/Ac 48 oz/Ac 21 oz/Ac 48 oz/Ac 8 oz/Ac 48 oz/Ac	7/24, 7/31, 8/7, 8/15, 8/22, 8/29, 9/5	
10	Lannate 2.4 LV+ Pounce 3.2 EC	48 oz/Ac 8 oz/Ac	7/10, 7/17, 7/31, 8/15, 8/29, 9/5	-



**Pepper Weevil**



**Fruitworm**

On 10 Sep, 100 mature-green to ripe fruit were harvested from the center row of each replicate (400 per treatment) and examined for Lepidopterous internal damage TFW, external damage BAW, and hemipterous pests SB. Fruit were also inspected for damage from pepper weevils PW. Results are shown in Table 2.

Lepidopteran pressure was estimated to be moderate in the categories of External damage by BAW (Figure 4). Internal damage by PW was moderate this year with the control sustaining 14% damage (Figure 2). We did see some differences between treatments for potato psyllid PP numbers (Figure 1). Treatments 6 and 10 had higher psyllid numbers. Damage to the calyx showed no statistical differences between treatments and can be attributed to TFW, BAW, and PW feeding (Figure 3).



Mean Number of Fruit Damaged/Replicate<sup>b</sup>

Table 2.

Treatment/ Formulation	Rate Amt/acre	Internal	External	All Leps	Pepper Weevil Internal	Calyx Damage	Psyllids
1 Control	-	3.25 bc	6.5	9.75 bcd	14.0	16.0	3.5 a
2 GF 2860 WG	3.5 oz/Ac	1.25 ab	5.0	6.25 ab	13.25	9.25	0.75 a
3 GF 2860 WG	4.5 oz/Ac	1.25 ab	1.5	2.75 a	4.25	7.25	0.0 a
4 GF 2860 WG	6 oz/Ac	1.5 ab	4.0	5.5 ab	5.25	11.25	0.0 a
5 Radiant SC	10 oz/Ac	0.5 a	3.5	4.0 a	8.50	9.5	0.5 a
6 Intrepid 2F+ Warrior CS	10. oz/Ac 3 oz/Ac	1.5 ab	3.25	4.75 ab	6.5	8.5	18.75 b
7 MBI 203 DF2	2 lb/Ac	5.75 d	7.75	13.5 d	14.0	14.0	2.50 a
8 MBI 206	2 gal/Ac	3.0 bc	4.75	7.75 abc	16.75	9.75	2.25 a
9 a) Torac 15 EC b) Lannate 2.4 LV+ Pounce 3.2 EC c) Vydate L d) Torac 15 EC e) Lannate 2.4 LV+ Pounce 3.2 EC f) Vydate L	21 oz/Ac 48 oz/Ac 8 oz/Ac 48 oz/Ac 21 oz/Ac 48 oz/Ac 8 oz/Ac 48 oz/Ac	4.25 cd	7.75	12.0 cd	7.0	7.25	1.50 a
10 Lannate 2.4 LV+ Pounce 3.2 EC	48 oz/Ac 8 oz/Ac	2.0 ab	3.5	7.25 abc	12.25	7.25	15.0 b
ANOVA F value (by column)		4.607	1.478	3.230	1.974	2.057	10.407
ANOVA P value (by column)		0.001	0.201	0.007	0.078	0.067	0.001

<sup>b</sup>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

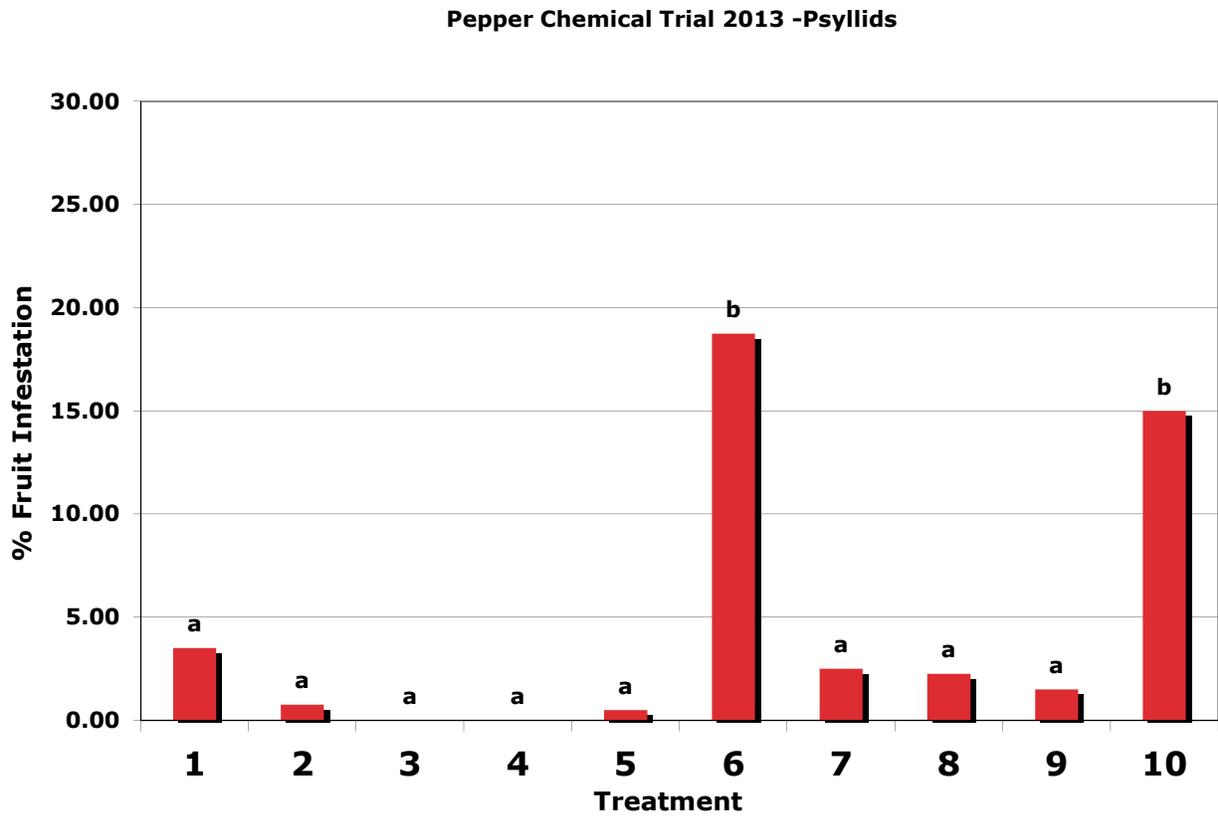


Figure 2. Pepper weevil damage

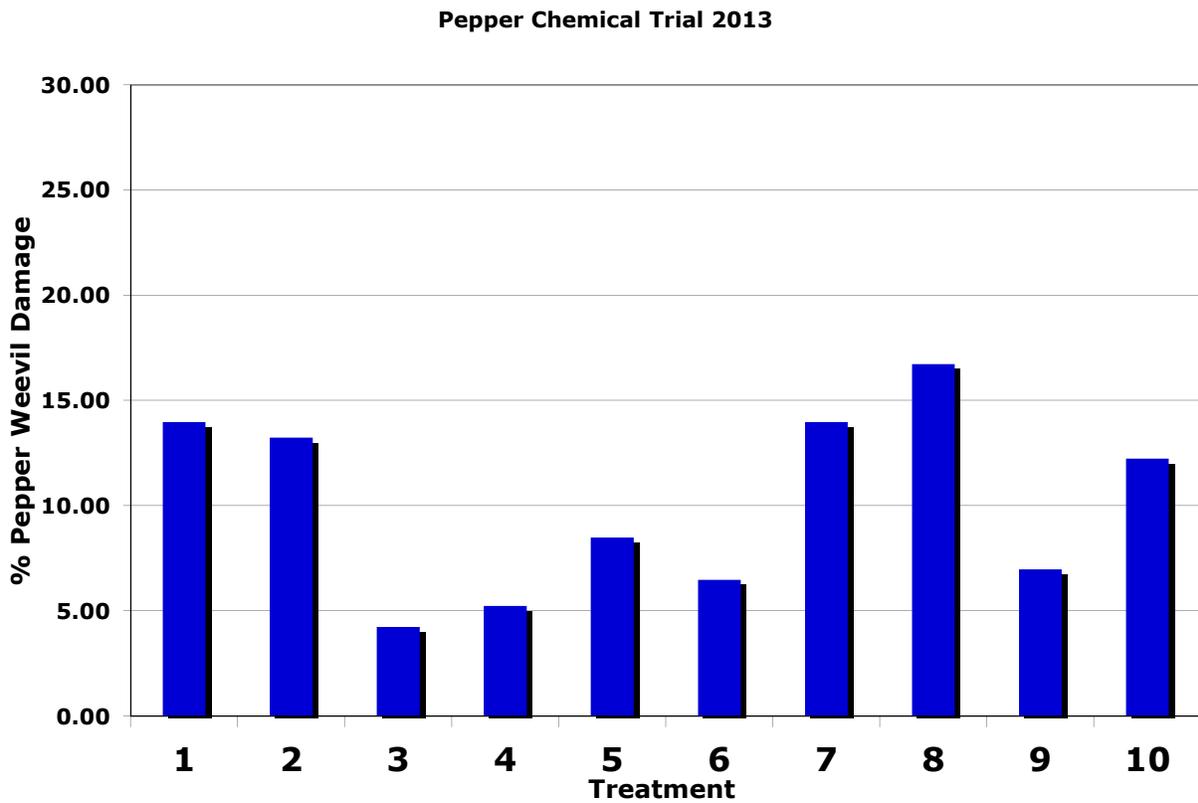


Figure 3. Calyx feeding damage

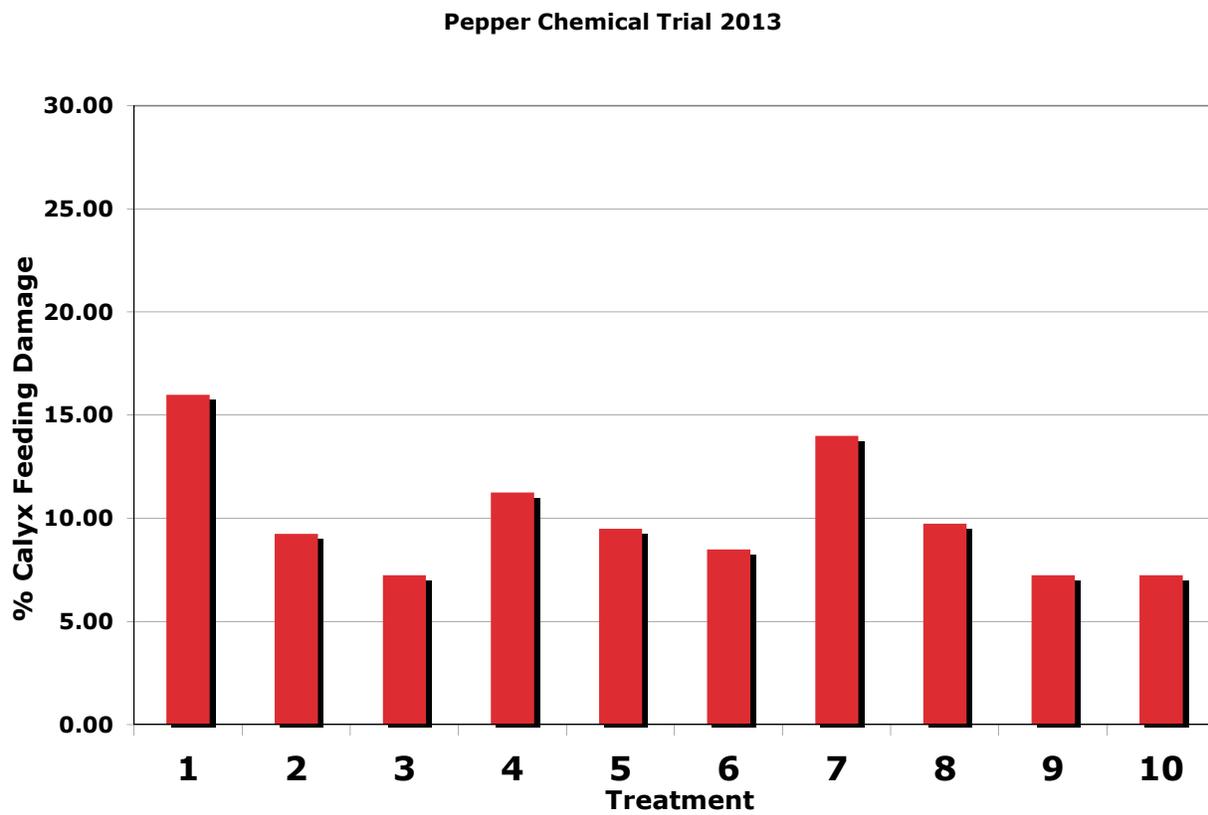
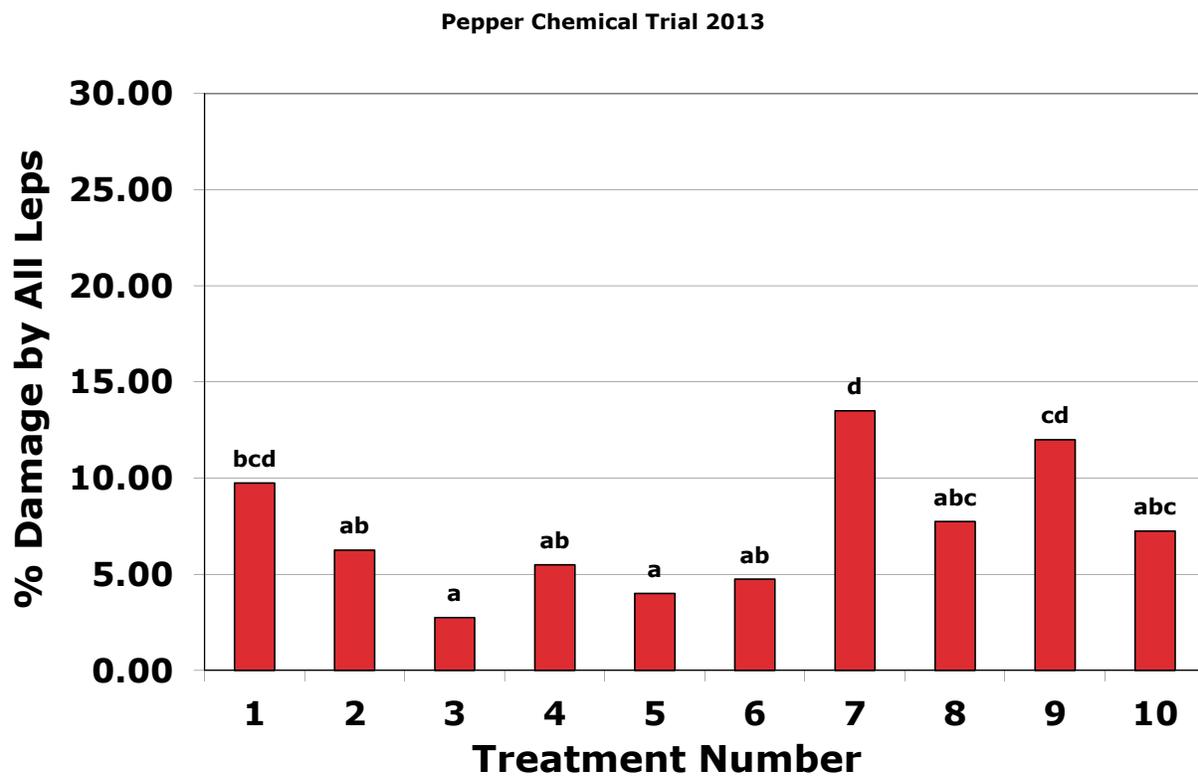


Figure 4. Lepidopteran damage



### III. IPM Strategies in Peppers

Seedlings were transplanted in a sandy loam type soil on 4 June at the University of California's South Coast Research and Extension Center. 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 RCB block design. This year the IPM program was incorporated into the chemical screening trial. Treatment 1 was the control and treatment 9 was an IPM rotation. Treatment 10 was a chemical standard.

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 Dyne-amic as an adjuvant at 0.25% v/v. On (10 September), all of the mature-green to ripe fruit were harvested from the center row of each replicate. From each replicate 100 fruit were sampled (400 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, and from pepper weevils (Figure 3), hemipterous pests and presence of psyllids (Figure 1). The results for insect damage are summarized in (Table 2).

Lepidopteran pressure was low to moderate in the categories of external damage by beet armyworm and no differences were seen. Internal damage from tomato fruitworm was low this year. Internal damage by pepper weevil was moderate to high this year. There were moderate levels of damage to the calyx but there were no 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 10 which is a chemical standard treatment. This treatment used carbamates and pyrethrins 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.

### IV. Insecticide Resistance Work

Laboratory studies to determine resistance levels of thiamethoxam and imidacloprid to psyllids have been completed. The results were published, and we found that psyllids from Texas collected in 2012 are showing some levels of resistance to imidacloprid, compared to psyllids collected from Texas in 2006. California collected psyllids did not show any level of resistance to imidacloprid. All Psyllids collected from Texas did not show any levels of resistance to thiamethoxam.

**Prager, S. M., B. Vindiola, G. S. Kund, F. J. Byrne, and J. T. Trumble. 2013.** Considerations for the use of neonicotinoid pesticides in management of *Bactericera cockerelli* (Šulk) (Hemiptera: Triozidae). Crop Prot. 54: 84–91.

### V. Patterns of Host Plant Use in *Bactericera cockerelli*

Studies were performed to determine if psyllids prefer different host plants based on geographic location, insect haplotype, and the rearing host plant species. These research findings are in press.

The potato psyllid *Bactericera cockerelli* has been reported on many different plant species. The pathogen it vectors, *Candidatus Liberibacter solanacearum* (CLso), can infect multiple solanaceous plant species. However, it is unknown whether potato psyllids are equally likely or capable of using the different plants they have been reported on. We conducted a series of three-

choice, no choice, and behavioral bioassays to determine the patterns of host use in potato psyllids. The bioassays revealed that host use decisions are complicated and influenced by multiple factors that can include the plant species a psyllid developed on, the plant species psyllids are exposed to, and in some instances the psyllid's haplotype. Additionally, the results suggest that potato psyllids from California prefer and perform better on bell peppers than on potatoes, while psyllids from Texas generally preferred tomato and potato (Figure 5). We found no association between a potato psyllid nymph's ability to develop on a plant and host plant preference.

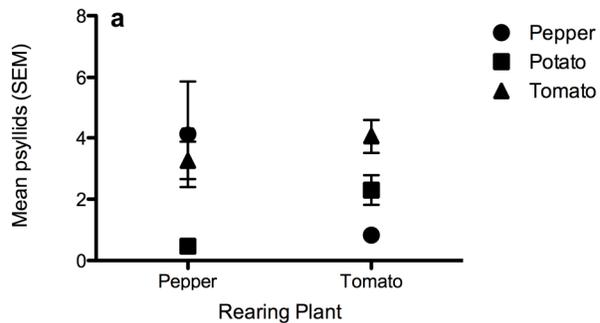
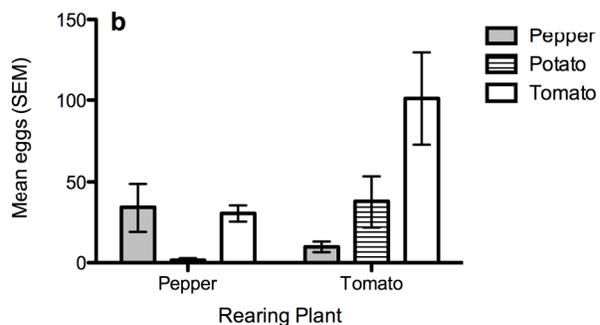


Figure 5: (a) the mean number of psyllids settling on pepper, potato and tomato when reared on either pepper or tomato. (b) the mean number of eggs laid on pepper, potato and tomato when psyllids are reared on pepper or tomato.



## VI. Virus Interaction Studies

We are beginning to investigate 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. Future work will investigate how infection with viruses such as TSWV influences transmission of CLso. Additionally, we are collaborating with researchers at the USDA to determine biochemical responses correlated with

these behaviors and infection rates. We are currently preparing a USDA-NIFA grant for this research.

### **VII. 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 have also submitted an IR-4 grant to study pepper weevil control.

### **VIII. 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.