California Melon Research Board Final Report
Vinchesi-Vahl and Grettenberger

Project Title: Management of spotted and striped cucumber beetle in melon production

Research Priority Areas: #'s (5) and (6): 'Insect pest management studies with new insecticides' and 'Control strategies for western striped and spotted cucumber beetles in the melon production'.

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Locations where work was performed:

For the insecticide evaluation: UC Davis Plant Pathology Farm. We conducted a study on cucumber beetles at the UC Davis farm on melons about 5 years ago and got a good population of spotted cucumber beetles and a fair number of striped cucumber beetles, making it a good site for a trial. Populations of both western striped (WStrCB) and spotted (WSpCB) cucumber beetles were high, especially at the end of the season.

For the trapping studies: Three organic melon fields in Yolo County and two conventional melon fields in Sutter County. The field locations were determined based on history of cucumber beetle pressure.

Objectives:

1. Evaluate insecticide and insecticide seed treatments for management of cucumber beetles in fresh-market melons.
2. Test different trap designs with floral lures to refine and improve monitoring of WStrCB and WSpCB.

Objective 1: *Evaluate insecticides and insecticide seed treatments for management of cucumber beetles in fresh-market melons.*

We based treatments on what is commonly used commercially plus newer insecticides untested in melons on cucumber beetles, including a seed treatment. The treatment list changed slightly from what was originally proposed due to availability and successful trials of certain insecticides on the east coast. We also added a second organic treatment. We direct-seeded single lines of honeydews on 60-inch beds and at a high density on June 19, 2019 and then thinned to 12 in. spacing around the four-five leaf stage. The field was previously in wheat and was mowed and disked 3 times in spring 2019. Beds were pulled, rototilled, shaped, and flat-rolled. The trial was sub-surface drip-irrigated at 4-6 inches. Our plot sizes were 20-ft by 25-ft with 4 replicates per treatment.

Once cucumber beetles were observed in the field, treatments were applied on July 22 using a backpack CO_2 sprayed at 20 GPA. Plots were treated again on August 15 and September 5. On weeks where applications in all plots were not made, weekly applications of Surround were made to the two treatments that included Surround, without the other materials included in those treatments. Beetles were counted on plants in center rows 3, 7, 10, 14, and 21 days after the first application (DAT). They were counted 4, 14, and 19 DAT2 and 4, 7, 11, and 14 DAT3. Beetles were counted on plants for a total of 4 minutes in the center 15 ft. the two middle rows of each plot (to avoid the ends of the plots). The 4 minutes was split equally between the two rows.

Trt#	**Insecticide**	**Active ingredient(s)**	**MOA**
1	Untreated check	--	--
2	Sevin	carbaryl	1A
3	Cruiser	thiamethoxam (seed trt only)	4A
4	Cruiser, Capture + Assail	thiamethoxam (seed) & bifenthrin + acetamiprid	4A/3A/ 4A
5	Voliam Flexi	thiamethoxam + chlorantraniliprole	4A/28
6	Harvanta	cyclaniliprole	28
7	Assail 70WP	acetamiprid	4A
8	Exirel	cyantraniliprole	28
9	Brigadier	bifenthrin+ imidacloprid	3A/4A
10	Capture	bifenthrin	3A
11	Entrust SC, Surround, CideTrak	Spinosad + kaolin clay + gustatory stimulant (Organic)	5
12	Celite, Surround	diatomaceous earth + kaolin clay (Organic)	--

Populations of cucumber beetles were initially low when plants were emerging, so early damage was extremely low. We therefore were not able to assess "early-season" management. Spotted cucumber beetle were the only species present at first, but striped cucumber beetle populations built up later in the season.

We assessed damage by sorting 12-20 melons (ideally 20, but limited in some plots) into cull or no cull categories based on size of scarring injury. Assessed melons had been marked several weeks earlier to enable us to focus on melons that had been susceptible to damage during applications 2 and 3. We also rated these melons on a scale of 0-3 based on severity of damage, with anything over 0 as a cull. Melons with cucumber beetle feeding scars larger than the size of quarter coin were considered a cull (rating: 1, 2, or 3). This was based on conversations with pest control advisers working with conventionally grown melons. The rating scale is defined below.

0-Little to no damage, feeding scars equal to or smaller in size than a quarter (top left) and damage minimal.
1-Minimal damage, one feeding scar larger than the size of a quarter or many smaller feeding scars in multiple areas of melon in a speckled pattern (top right).
2-Moderate damage, two feeding scars each equal to the size of a quarter, or one measuring 3-inches wide (bottom left).
3-Severe damage, three separate quarter-sized scars, two or more 3-inch feeding scars, or extensive scarring damage that blends together (bottom right).

Results

Table 1. Average WSpCB counts on plants after 1st application of treatments, applied July 22, 2019.

Spotted	3DAT1			7DAT1			10DAT1			14DAT1			21DAT1		
Treatment	Avg	SE		Avg	SE		Avg	SE		Avg	SE		Avg	SE	
Assail	1.75	0.48	a	2.25	0.85	ab	2.00	0.91	a	4.50	1.66	a	5.75	1.44	a
Brigadier	3.25	0.63	bcd	5.50	2.60	ab	4.00	0.58	a	10.25	2.69	a	9.25	1.70	a
Capture	0.75	0.25	ab	4.00	1.35	ab	0.75	0.75	a	4.75	1.25	a	12.50	3.38	a
Cruiser	11.75	2.10	d	7.25	2.32	b	6.25	2.93	a	9.75	2.93	a	11.00	2.48	a
Cruiser,Assail,Capture	1.25	0.48	a	0.00	0.00	a	3.25	1.25	a	4.50	1.32	a	4.25	1.70	a
Entrust,Cidetrak,Surround	8.00	3.14	cd	7.50	3.66	ab	8.75	2.93	a	7.00	1.22	a	9.00	2.35	a
Exirel	3.00	0.71	bcd	3.50	0.65	ab	2.50	0.96	a	10.50	2.87	a	10.25	1.93	a
Harvanta	5.50	1.55	bcd	5.25	1.11	ab	5.25	1.44	a	8.00	2.12	a	8.75	2.14	a
Sevin	3.50	0.65	abc	4.75	1.89	ab	3.75	1.55	a	7.00	2.48	a	10.25	1.44	a
Surround,Celite	6.00	1.87	cd	5.75	2.29	ab	6.00	2.52	a	7.25	1.70	a	12.00	1.08	a
Untreated	5.75	3.45	cd	13.50	3.80	b	6.25	2.17	a	10.75	1.44	a	9.00	2.16	a
VoliamFlexi	1.75	0.75	abc	1.25	0.25	ab	3.25	1.44	a	8.75	1.38	a	7.75	3.22	a

Table 2. Average WStrCB counts on plants after 1st application of treatments, applied July 22, 2019.

Striped	3DAT1			7DAT1			10DAT1			14DAT1			21DAT1		
Treatment	Avg	SE		Avg	SE		Avg	SE		Avg	SE		Avg	SE	
Assail	0.00	0		0.00	0		0.00	0		0.00	0		2.00	0.91287	a
Brigadier	0.00	0		0.00	0		0.00	0		0.00	0		2.25	1.31498	a
Capture	0.00	0		0.00	0		0.00	0		0.00	0		3.25	1.10868	a
Cruiser	0.00	0		0.00	0		0.00	0		0.25	0.25		0.50	0.28868	a
Cruiser,Assail,Capture	0.25	0.25		0.25	0.25		0.00	0		0.25	0.25		1.00	0.70711	a
Entrust,Cidetrak,Surround	0.00	0		0.00	0		0.00	0		0.25	0.25		1.75	0.75	a
Exirel	0.00	0		0.00	0		0.00	0		0.25	0.25		3.25	0.47871	a
Harvanta	0.50	0.5		0.00	0		0.00	0		0.00	0		1.25	0.47871	a
Sevin	0.00	0		0.00	0		0.00	0		0.00	0		1.00	0.40825	a
Surround,Celite	0.00	0		0.00	0		0.00	0		0.00	0		1.25	0.25	a
Untreated	0.00	0		0.00	0		0.25	0.25		0.25	0.25		2.50	1.19024	a
VoliamFlexi	0.00	0		0.00	0		0.00	0		0.25	0.25		1.50	0.28868	a

Table 3. Average WSpCB counts on plants after 2nd application of treatments, applied August 15, 2019.

Spotted	4DAT2			14DAT2			21DAT2		
Treatment	Avg	SE		Avg	SE		Avg	SE	
Assail	0.50	0.29	a	4.75	1.18	a	2.00	1.41	ab
Brigadier	2.25	1.31	abc	10.25	1.49	ab	3.75	0.85	ab
Capture	1.25	0.48	ab	5.50	1.04	a	1.50	0.29	ab
Cruiser	12.00	3.70	c	11.25	3.04	ab	10.50	3.86	b
Cruiser,Assail,Capture	1.25	0.48	ab	7.00	1.73	ab	0.75	0.48	a
Entrust,Cidetrak,Surround	9.25	3.50	bc	11.25	2.21	ab	9.25	2.93	b
Exirel	6.00	2.80	abc	10.50	2.02	ab	9.25	2.53	b
Harvanta	3.00	0.41	abc	6.75	1.49	ab	6.25	1.11	ab
Sevin	2.75	1.31	abc	5.50	0.96	a	2.75	0.85	ab
Surround,Celite	8.75	3.77	bc	12.25	1.93	ab	7.75	2.25	ab
Untreated	6.25	2.59	abc	17.00	3.70	b	7.00	2.74	ab
VoliamFlexi	1.75	0.48	abc	7.25	2.14	ab	9.00	2.38	b

Table 4. Average WStrCB counts on plants after 2nd application of treatments, applied August 15, 2019.

Striped	4DAT2			14DAT2			21DAT2		
Treatment	Avg	SE		Avg	SE		Avg	SE	
Assail	0.00	0	a	0.00	0	a	0.25	0.25	a
Brigadier	1.75	1.0308	ab	1.75	1.4361	a	1.50	0.5	ab
Capture	2.00	0.5774	ab	0.25	0.25	a	0.25	0.25	a
Cruiser	5.00	1.9579	b	1.25	0.75	a	1.75	1.1087	ab
Cruiser,Assail,Capture	0.00	0	a	0.25	0.25	a	0.25	0.25	a
Entrust,Cidetrak,Surround	5.00	2.6771	ab	2.25	1.0308	a	0.25	0.25	a
Exirel	2.75	0.4787	ab	0.50	0.2887	a	4.00	1.2247	b
Harvanta	3.00	1.7795	ab	0.25	0.25	a	0.75	0.75	ab
Sevin	0.00	0	a	0.25	0.25	a	0.00	0	a
Surround,Celite	2.50	1.5546	ab	2.50	1.0408	a	2.25	1.315	ab
Untreated	3.50	1.1902	ab	3.00	1.0801	a	0.50	0.2887	ab
VoliamFlexi	0.25	0.25	ab	0.25	0.25	a	0.50	0.2887	ab

Table 5. Average WSpCB counts on plants after 3rd application of treatments, applied September 5, 2019.

Spotted	4DAT3			7DAT3			11DAT3			14DAT3		
Treatment	Avg	SE		Avg	SE		Avg	SE		Avg	SE	
Assail	2.25	1.31	a	2.00	0.71	a	2.25	1.31	a	1.50	0.29	a
Brigadier	2.75	0.75	a	3.25	1.25	a	1.75	0.75	a	3.75	0.75	a
Capture	2.25	0.25	a	4.00	1.22	a	2.25	0.75	a	1.50	0.29	a
Cruiser	10.25	2.14	a	6.25	1.31	a	4.25	2.59	a	6.25	3.92	a
Cruiser,Assail,Capture	1.25	0.25	a	2.75	0.85	a	2.25	0.95	a	1.50	0.50	a
Entrust,Cidetrak,Surround	8.50	3.71	a	4.50	0.50	a	3.50	1.19	a	3.25	1.31	a
Exirel	7.75	2.69	a	4.25	0.48	a	2.00	0.82	a	2.25	0.48	a
Harvanta	8.50	2.90	a	3.00	1.08	a	2.25	1.03	a	2.50	0.29	a
Sevin	2.25	0.85	a	4.00	1.22	a	2.50	0.65	a	1.75	0.48	a
Surround,Celite	5.75	0.63	a	7.00	1.08	a	4.00	0.71	a	4.50	1.32	a
Untreated	5.75	2.84	a	5.50	2.18	a	1.50	0.29	a	1.75	0.25	a
VoliamFlexi	4.50	1.55	a	2.50	1.19	a	2.75	0.48	a	2.75	0.48	a

Table 6. Average WStrCB counts on plants after 3rd application of treatments, applied September 5, 2019.

Striped	4DAT3			7DAT3			11DAT3			14DAT3		
Treatment	Avg	SE		Avg	SE		Avg	SE		Avg	SE	
Assail	0.50	0.50	a	0.25	0.25	a	0.50	0.29	a	0.00	0.00	a
Brigadier	1.50	0.96	a	0.25	0.25	a	0.25	0.25	a	0.00	0.00	a
Capture	0.50	0.29	a	0.00	0.00	a	0.50	0.50	a	1.00	0.58	a
Cruiser	0.75	0.48	a	1.50	0.87	a	1.00	0.41	a	0.50	0.29	a
Cruiser,Assail,Capture	0.00	0.00	a	0.50	0.50	a	0.50	0.29	a	1.00	0.41	a
Entrust,Cidetrak,Surround	0.50	0.50	a	0.25	0.25	a	0.50	0.29	a	0.50	0.50	a
Exirel	1.50	0.87	a	1.25	0.63	a	0.00	0.00	a	0.50	0.50	a
Harvanta	1.25	0.48	a	1.75	0.75	a	0.00	0.00	a	0.75	0.25	a
Sevin	1.00	0.41	a	0.25	0.25	a	0.25	0.25	a	0.00	0.00	a
Surround,Celite	1.50	0.50	a	2.00	0.41	a	0.00	0.00	a	0.25	0.25	a
Untreated	1.25	0.48	a	0.25	0.25	a	0.00	0.00	a	0.00	0.00	a
VoliamFlexi	1.00	0.71	a	0.00	0.00	a	0.75	0.48	a	0.00	0.00	a

Table 7. Summed averages of WSpCB and WStrCB counts on plants during insecticide trial.

Spotted	Summed			Striped	Summed		
Treatment	**Avg**	**SE**		**Treatment**	**Avg**	**SE**	
Assail	2.63	0.70	a	Assail	0.29	0.07	ab
Brigadier	5.00	0.48	bcd	Brigadier	0.77	0.27	abcd
Capture	3.42	0.40	ab	Capture	0.65	0.19	abcd
Cruiser	8.90	1.80	d	Cruiser	1.04	0.13	cd
Cruiser,Assail,Capture	2.50	0.49	a	Cruiser,Assail,Capture	0.35	0.10	abc
Entrust,Cidetrak,Surround	7.48	1.06	cd	Entrust,Cidetrak,Surround	0.94	0.26	bcd
Exirel	5.98	0.48	bcd	Exirel	1.17	0.15	d
Harvanta	5.42	0.20	bcd	Harvanta	0.79	0.10	abcd
Sevin	4.23	0.38	abc	Sevin	0.23	0.02	a
Surround,Celite	7.25	0.23	cd	Surround,Celite	1.02	0.02	cd
Untreated	7.50	1.13	cd	Untreated	0.96	0.17	bcd
VoliamFlexi	4.44	0.69	abc	VoliamFlexi	0.38	0.13	abc

Tables 1-7 represent cucumber beetle counts after each treatment. Western striped cucumber beetle populations were low at the beginning of the season (Table 2). There were no significant differences between treatments after the 3rd application on September 5th for either WSpCB or WStrCB (Tables 5 and 6). The Cruiser seed treatment was not effective at reducing beetle numbers in the later season and because of low beetle pressure in the early season, we cannot comment on efficacy. We hope to test this treatment again in 2020. Assail and Cruiser + Assail + Capture resulted in the lowest WSpCB counts when all counts were averaged by treatment. For WStrCB, Sevin and Assail resulted in the lowest average beetles. The organic treatments were not significantly different from the untreated control when beetles were counted.

Figure 1. Percent of melons in each rating category (0-3) for severity of cucumber beetle feeding scar damage.

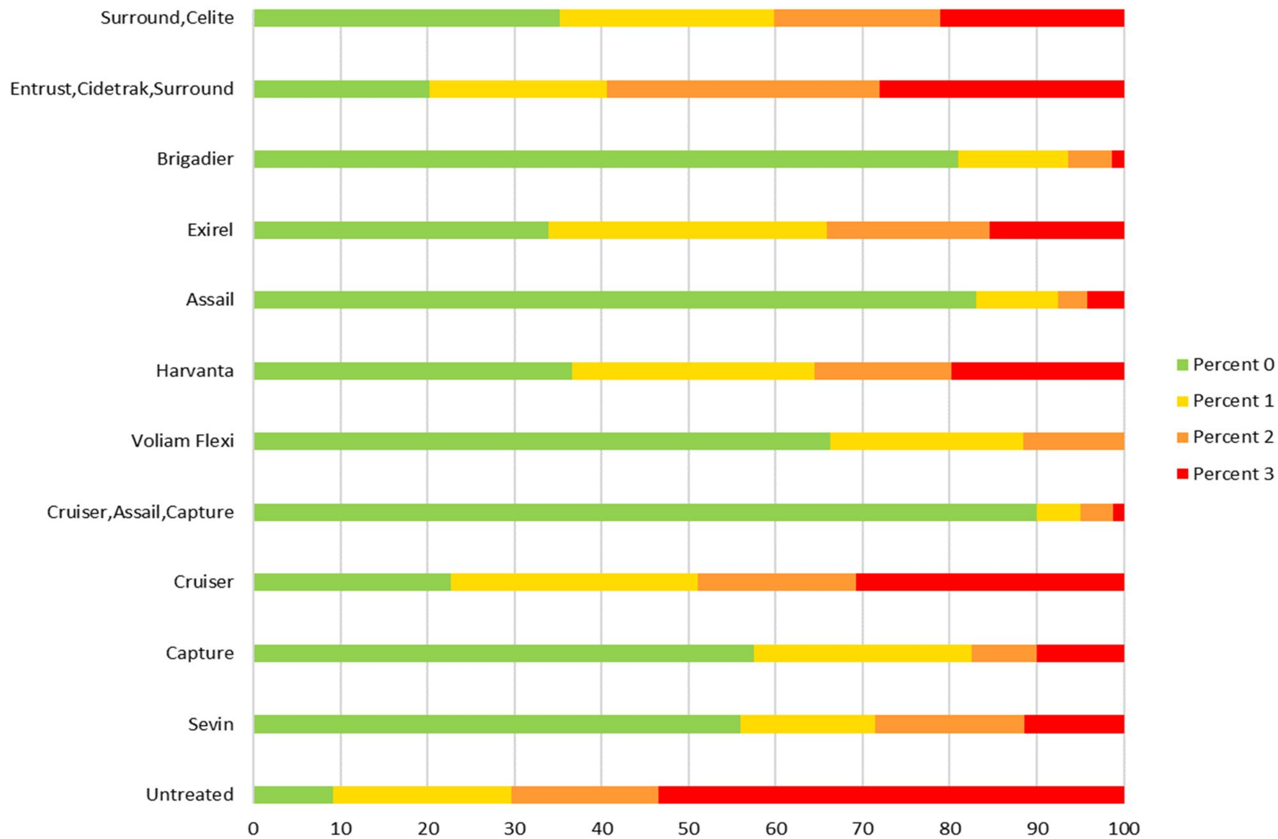
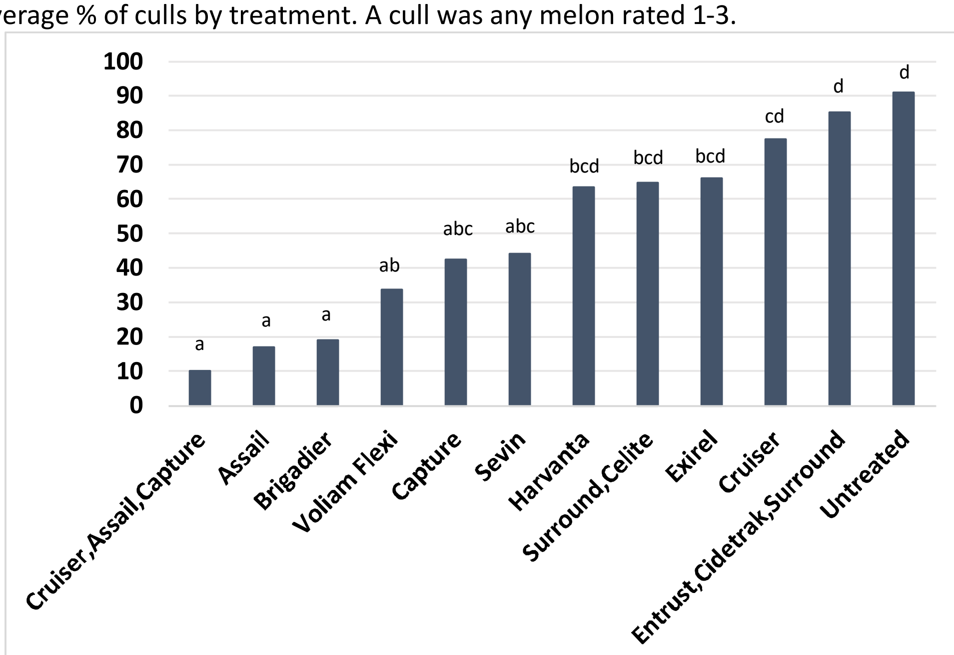


Figure 2. Average % of culls by treatment. A cull was any melon rated 1-3.



From Figure 1, there were differences in severity of damage between treatments. Due to the lack of beetle pressure early season, we did not expect to see much effect from the Cruiser seed treatment. Standard conventional treatments containing Assail or a bifenthrin formulation (Capture and Brigadier) appeared to be most successful at protecting melons from cucumber beetle feeding and preventing culls. Though the thiamethoxam seed treatment (Cruiser) is a neonicotinoid and has shown promise in the past, the low beetle pressure in the early season made it challenging to assess efficacy of a seed treatment. The seed treatment loses efficacy as the plants grow. The foliar pyrethroids and neonicotinoids were the most effective conventional treatments.

The standard conventional treatments, acetamiprid (Assail) and bifenthrin (Capture) are still the best options for protecting melon fruit from cucumber beetle feeding, with <20% of the melons we rated sorted as culls. Brigadier, which includes imidacloprid also performed well. Out of the new treatments we tested, Voliam Flexi showed promise and was not significantly difference from the top performers when looking at % of culls (Figure 2). Voliam Flexi also appeared to prevent the most extreme categories of damage. Harvanta and Exirel did not protect melons as well as the standard treatments, especially in terms of % culls. Looking at severity of damage in Figure 1, both organic treatments provided better control compared to the untreated plots, however % culls was high. It is worth noting that the market for organic melons has different standards when it comes to cucumber beetle feeding damage. From Figure 1, we see that most of ratings were 1-2 for the organic treatments, whereas with the untreated control, many melons were rated 3. This suggests that the organic treatments could help reduce the most severe categories of damage.

Pitfalls

Beetle pressure was low early season for the insecticide trial, especially for WStrCB. This made it difficult to assess efficacy of a seed treatment. Our timing of insecticide applications could also be increased, with more frequent applications. This may lead to more efficacy with some materials in our trial that didn't provide protection similar to the current industry standards. The same is also true for the organic materials.

Benefits to melon industry

By rating the melons for severity of feeding damage, in addition to culls and beetle counts, we can see which treatments protect melons from feeding damage in addition to decreasing beetle numbers in the field. In our trial, the anthranilic diamides (Harvanta and Exirel) were not very effective compared to the standard pyrethroid and neonicotinoid treatments used in conventional systems. However, Voliam Flexi, a diamide combined with a neonicotinoid, appears promising, providing a potential option for producers. For the organic treatments, though beetle numbers were not reduced compared to the untreated control, damage to the melon was less severe than in the control plots.

Objective 2: *Test different trap designs with floral lures to refine and improve monitoring of WStrCB and WSpCB.*

Based on trap availability, our three traps consisted of Japanese beetle traps (with sticky card inside), yellow sticky card traps, and yellow sticky card traps on top of large yellow corrugated plastic board to increase visual stimulus. Floral lures were attached to each trap. Three of each type of trap were placed in two conventional fresh-market melon fields in Sutter County and three organic melon fields in Yolo

County. The traps were placed 20 m apart (at one site where the field was small, 10 m) and on different edges of the fields (blocks), to avoid disrupting in-field farming activities. The trap types were randomly assigned within each block. Traps were collected and replaced weekly from early July until late September and assessed for both WStrCB and WSpCB.

We also counted beetles on 2 plants at least 5m in front of the traps, resulting in two-plant counts per block. We visually assessed the melon foliage and searched under melon fruit. This counting was done to verify that the traps are working to attract cucumber beetles. Multiple counts on pairs of plants appears to be more precise than sticky traps baited with floral lures for the western species of cucumber beetles, but are also much more time consuming (Pedersen 2009).



Results

Across sites, there were no significant differences between the traps that included yellow sticky cards. The Japanese beetle traps were unsuccessful at all sites. We unfortunately caught very few beetles with this trap and were concerned about possible issues catching excess honey bees when this trap is used with a floral lure.

Figure 3. Mean WSpCB per trap at two conventional field sites over the season. Japanese beetle traps were excluded.

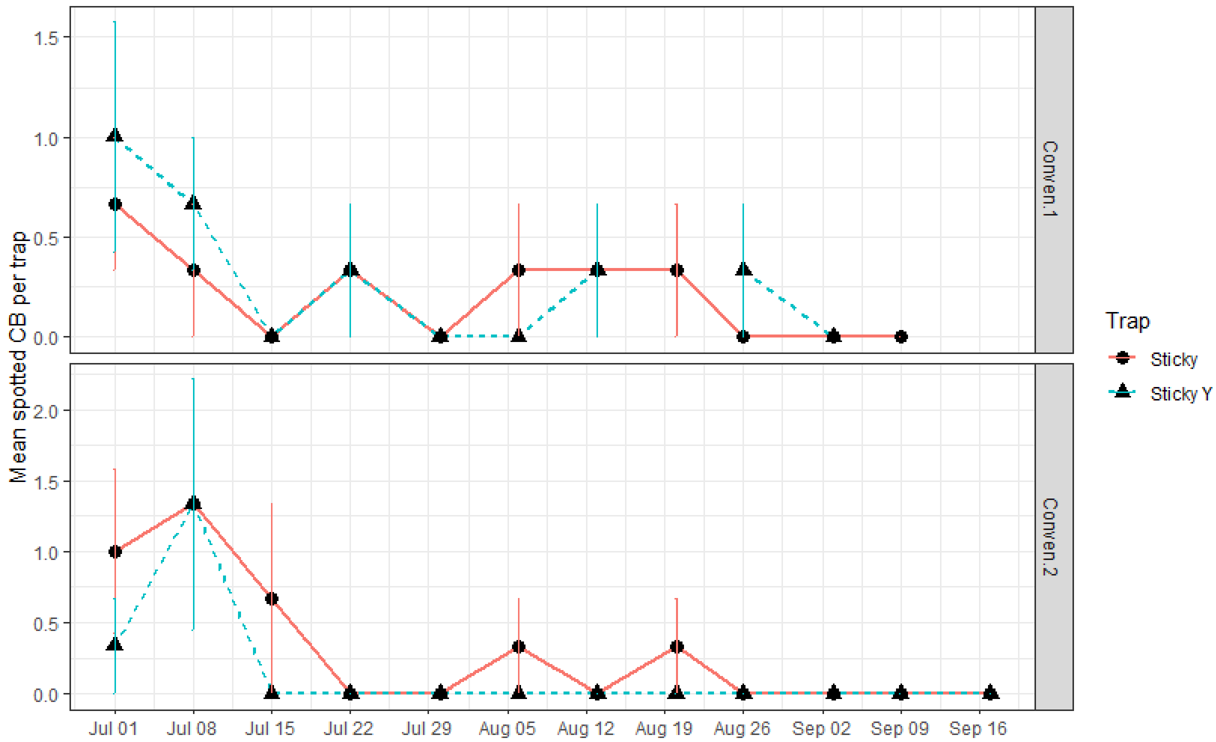
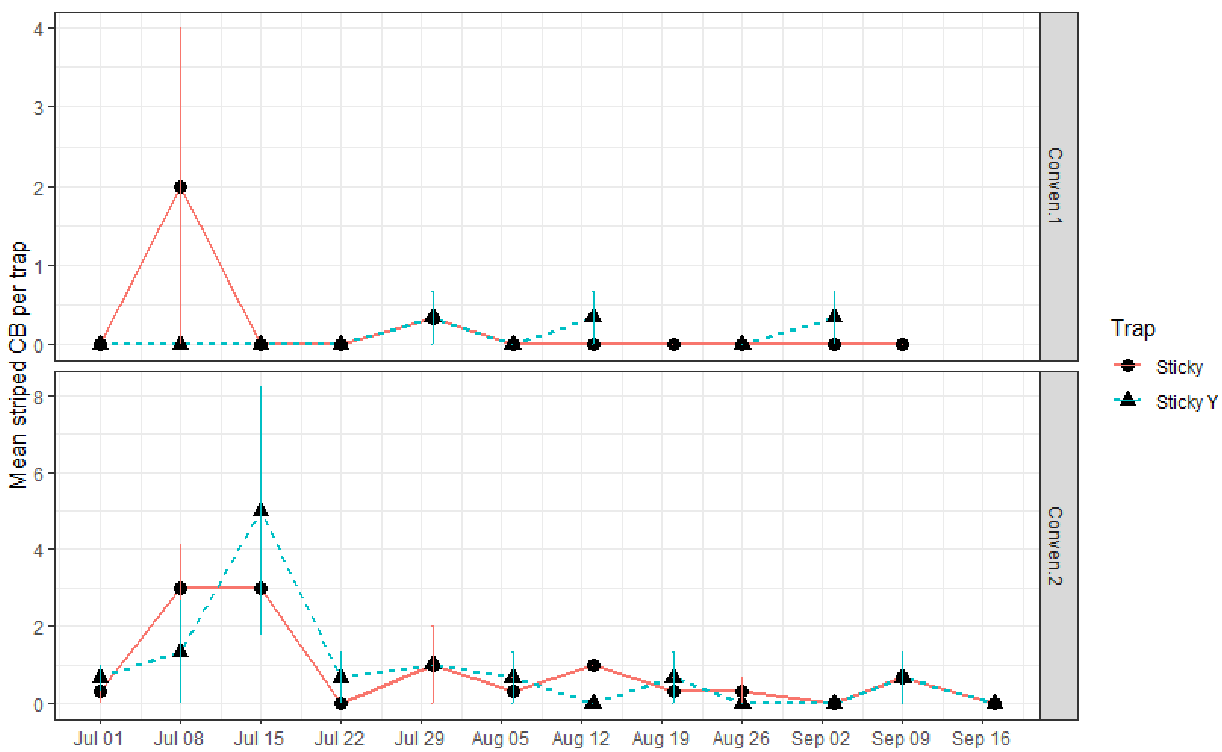


Figure 4. Mean WStrCB per trap at two conventional field sites over the season. Japanese beetle traps were excluded.



In conventional fields, the yellow sticky card traps with the added visual stimulus and yellow sticky card traps were the most successful, and there was no significant difference between these two. Beetle pressure was low at site 1, and very high at site 2. Both fields were cantaloupe fields. Site 1 was planted in late May and located in the Sutter Basin and site 2, located in the Meridian area of Sutter County was planted the first week of July. Site 2 was planted to cantaloupe in 2018 and the field next to it was also in cantaloupe in 2018 (sunflower in 2019). Beetle pressure was so high at site 2, many insecticide applications were applied and the sunflowers were aerial sprayed due to beetle pressure from the volunteer cantaloupes in that field. This explained why beetle numbers decreased on the traps in August and September at this particular site.

Figure 5. Mean WSpCB per trap at three organic field sites over the season. Japanese beetle traps were excluded.

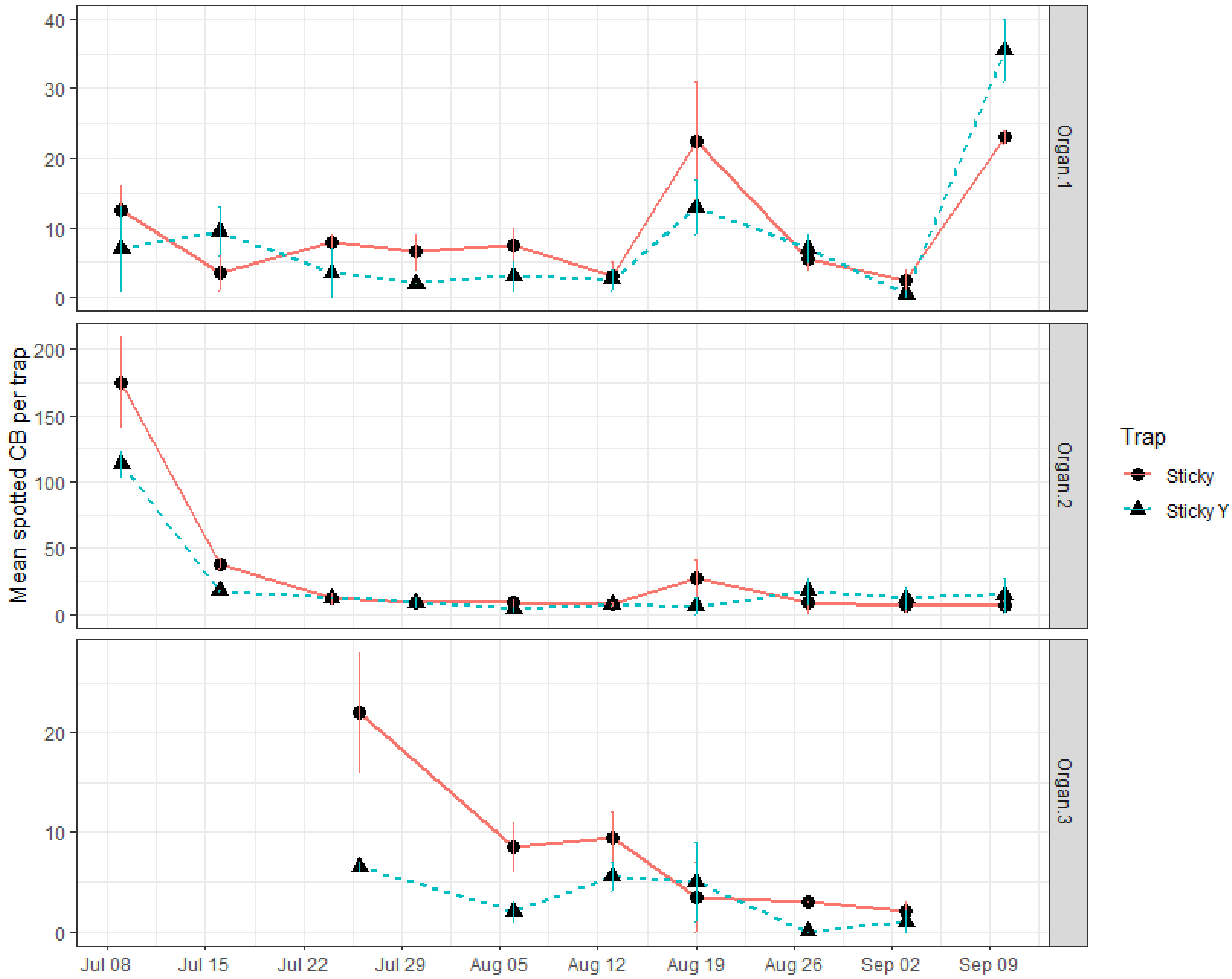
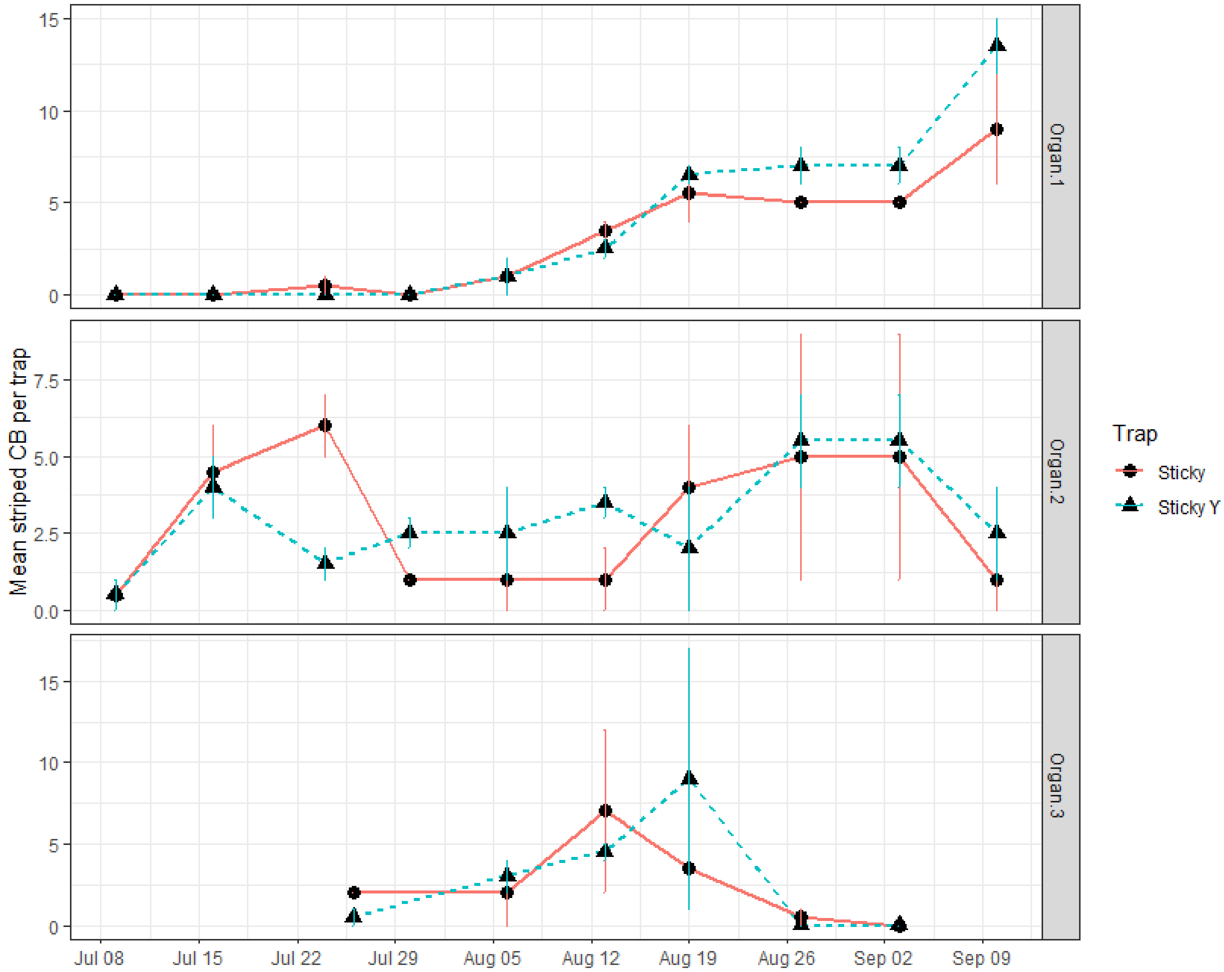


Figure 6. Mean WStrCB at three organic field sites over the season. Japanese beetle traps were excluded.



In the organic fields, beetle catches were much higher than in conventional fields, especially for WSpCB (Figure 5). Beetle populations on these farms were overall much higher because the fields were not sprayed with broad-spectrum insecticides like the conventional fields, and are smaller acreage. There was no significant difference between the yellow sticky card trap and the sticky card trap with the additional yellow board.

For the plant counts, the numbers were consistently low for both species, especially in the conventional fields, where they were nearly all zero. The counts were higher in the organic fields, but lower than was what was caught on the traps. Based on conversations with pest control advisors for the conventional fields, beetles were present in the conventional fields, but either the timing of our counts were not timed with the new influx of beetles, or the number of plants checked was not sufficiently large ("walk and scout" vs intensive plant counts).

Pitfalls

One challenge we encountered was the attractiveness of the floral lures to bees. Due to significant bee kill in the first week, Japanese beetle traps were removed. To solve this problem, wire mesh was placed at the top of the Japanese beetle traps so that bees would not be able to get into the trap, but cucumber beetles could fit through. The floral lure was also placed further above the sticky traps and the traps were deployed into the field again.

Benefits to melon industry

We have established an effective way to capture cucumber beetles for research purposes, especially in organic fields using sticky cards with a floral lure. This trapping does not seem to affect beetle pressure in the field and could not serve as an attract and kill strategy. It does provide us information on the effectiveness of the floral lure and we will continue to use sticky card traps in our future studies to monitor for beetles. Our data also suggest that the sticky traps might be a useful monitoring tool, although they may not be substantially better than scouting for beetles on plants. It is also likely that they need to be more attractive to beetles (visual or chemical stimuli) or need to be deployed in greater numbers to increase their sensitivity.

References:

Pedersen, A. B. (2009). Improved integrated pest management of two cucumber beetle species (Coleoptera: Chrysomelidae) in California melon agroecosystems. University of California, Davis. Retrieved from ProQuest Dissertations Publishing.