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Evaluation of darkling beetle overwintering locations and movement into tomato fields

For the first several weeks after transplanting, darkling beetles are included in the list of critical pests to monitor (PMSP 2021). Typically, fields are monitored weekly for the first several weeks by checking for darkling beetle damage. Darkling beetles girdle seedlings at or below soil line by chewing which can cause significant damage and plant death when beetles are in high numbers. Darkling beetles are generally not a problem once plants are big enough to withstand the chewing damage. They move in from field edges, including weedy areas or adjacent crops like grains or alfalfa. Conventional control includes insecticides, but organic growers have more limited options. In years like 2021, when field edges dried down earlier due to lack of moisture and high heat, darkling beetles became a bigger problem for transplanted tomatoes. Understanding overwintering sites and predicting beetle movement into fields during the susceptible tomato stage could be combined with cultural and chemical control for more effective darkling beetle management.


Left: Adult darkling beetle. (Photo credit: J. K. Clark, UC IPM). Right: Darkling beetle feeding on tomato at soil line. (Photo credit: E. Miyao).

Early planting is a cultural control method that is effective in managing the darkling beetle migrations into tomato fields during the susceptible crop stage. One of the key management tools for preventing infestations is allowing complete decomposition of crop residue and other organic matter before transplanting. Fallowing and/or cultivation can help with decreasing organic matter and crop debris.

Keeping fields weed free can help eliminate potential shelter and overwintering sites (UC IPM). For conventional management, carbaryl bait (Sevin), diazinon, and esfenvalerate (Asana) are the primary insecticides used for managing heavy infestations (PMSP 2021).

This project proposed trapping and scouting overwintering sites for darkling beetles and also evaluating their movement early in the tomato season. The goal of this project was to provide more information on darkling beetle habitat and timing of movement into tomato fields to better control this pest during the early tomato growth stages. Thirty pitfall traps were placed along field edge habitat in four organic tomato fields. Examples of trap locations can be seen below. Pitfall traps consisted of plastic cups buried in the soil, so that the opening is even with the soil line and was filled with soapy water. Insects walking across the ground fall into the cup as they travel and are unable to escape.

Unfortunately, darkling beetle captures in traps were low, with only 23 beetles recorded from March-May 2022. From visual scouting of likely darkling beetle locations, no beetles were found and very little to no darkling beetle damage was seen in the fields. Pitfall traps measure activity over density, so insects and arthropods actively crawling across the ground are more likely to fall into pitfall traps. This explains the high capture of spiders and predaceous ground beetles since both organisms actively search for prey. The lack of darkling beetle capture could be attributed to pitfall trapping limitations or to the lower pressure from this pest in 2022 in the monitored fields. Darkling beetle captures varied between sites with more captures in March at site 2, in late April and May at site 1 (after transplanting), and no captures at site 4 (Figure 1). Tomatoes were transplanted in all fields the week of April 10, 2022. Darkling beetles were captured at sites 2 and 3 in mid-March, with peaks again 1-3 weeks after tomatoes were transplanted. Darkling beetles were not caught at site 1 until about a week after tomatoes were transplanted (Figure 1).

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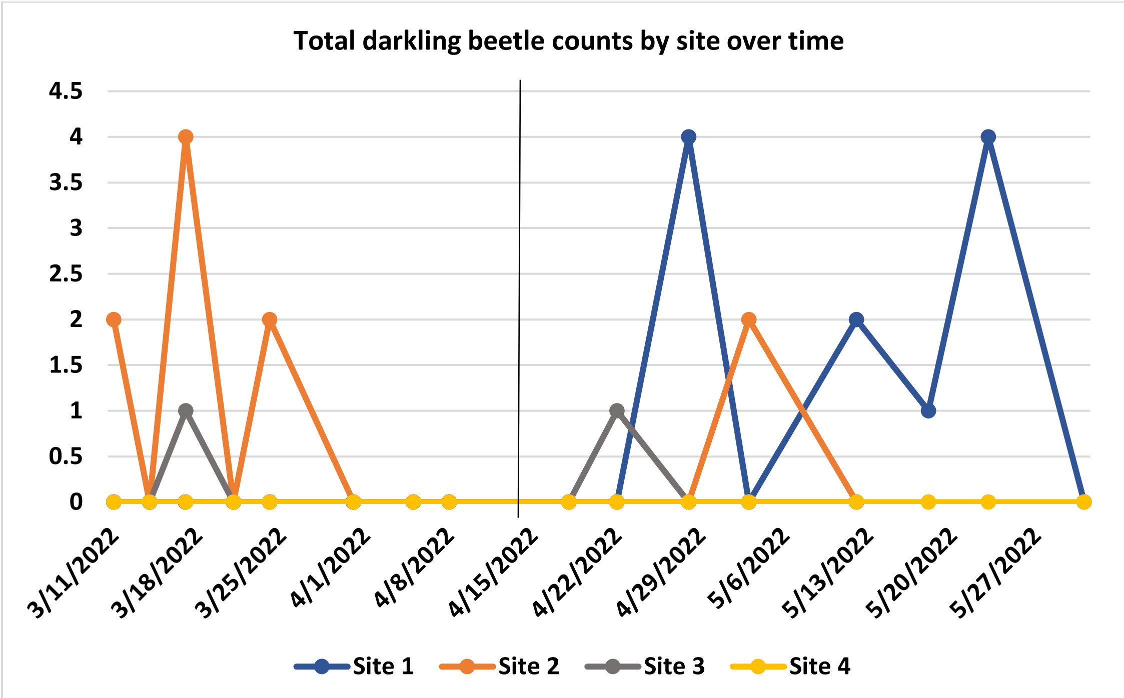

Figure 1. Total darkling beetles captured by site over time. The vertical line depicts when tomatoes were transplanted in the fields (transplanting occurred the week of 4/10/22).

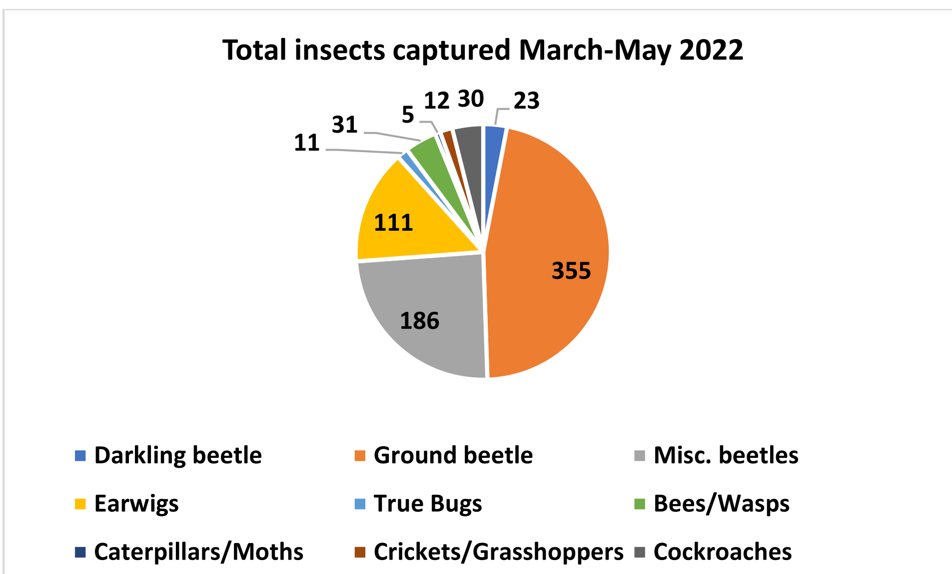

Figure 2. General overview of total insects captured in traps between March and May 2022.

Ground beetles were the most abundant insects captured (Figure 2), followed by miscellaneous beetles (not including darkling beetles) which included carrion beetles, click beetles, lady beetles, rove beetles and others in smaller numbers. Earwigs were also commonly captured along with isopods, spiders and ants (data not included). Ground beetle catches increased significantly in May 2022 with over 90 beetles captured at site 2 in late May (Figure 3).

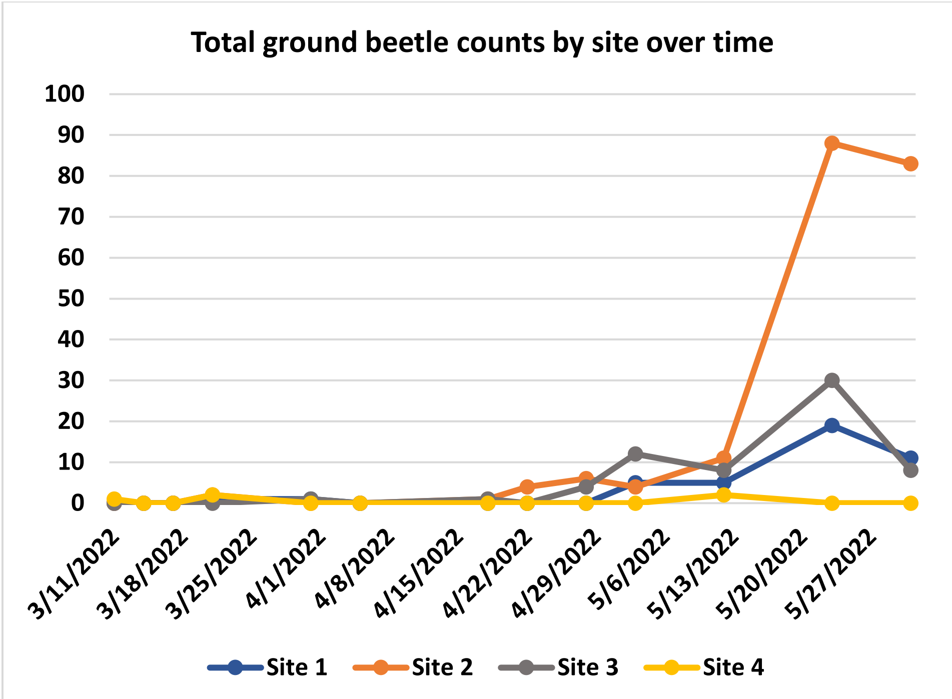

Figure 3. Total ground beetles caught per site over time.

In summary, the 2022 trapping was unsuccessful at providing the information on darkling beetle overwintering habitat and movement into crop fields. The challenge was likely due to trap design and darkling beetle behavior, but also the lower pest pressure from darkling beetles in 2022. Due to the low beetle pressure at the field sites used, additional years of trapping could be beneficial if pressure is higher in 2023, or in future years. Multiple years of trapping efforts could provide growers with more information on darkling beetle locations to better monitor and control this early-season pest. To improve on trapping, modifications made to pitfall traps could enhance beetle capture by adding barriers to direct ground-dwelling insects into the traps. Pitfall traps with guidance barriers were up to five times more effective at capturing arthropods than traps without barriers in a study conducted in Germany (Boetzl et al, 2018). Field site locations could also be expanded to include a larger geographic range and include conventional field sites in addition to organic sites.

Acknowledgements: I would like to thank Park Farming Organics for collaborating on this project and the California Tomato Research Institute for funding this work. I would also like to thank UCCE Farm Advisor, Rachael Long, for her conversations with me about her experience with darkling beetle issues in Yolo County and UCCE Specialist, Ian Grettenberger, for his input on trap modifications.

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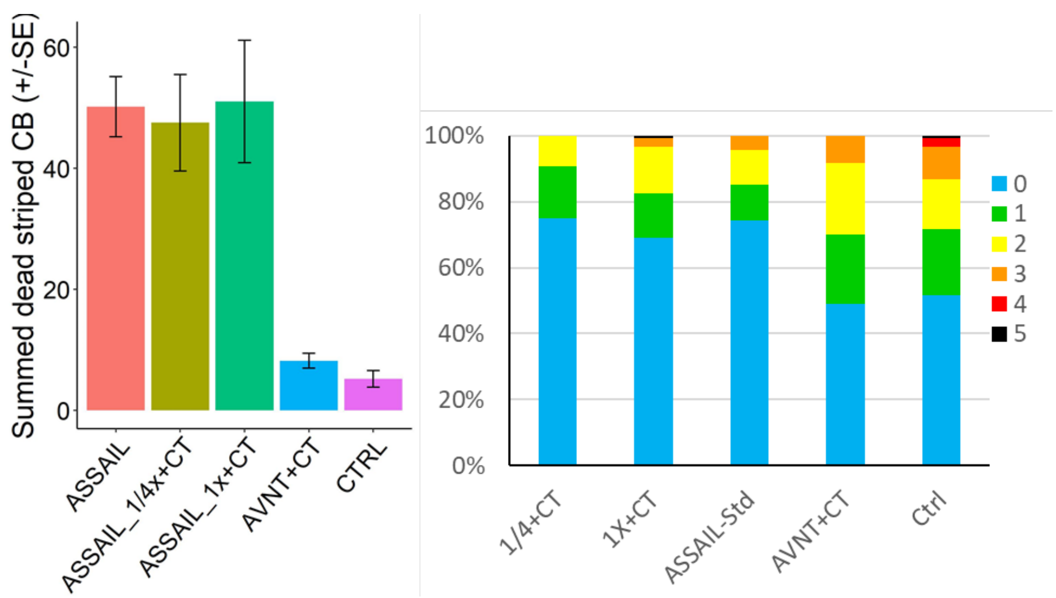
- Personal communication with UCCE Farm Advisor, Rachael Long, Yolo County.
- UC IPM Pest Management Guidelines for Cucurbits, Cole Crops, Cotton and Dry Beans.

Improved management strategies for the western striped cucumber beetle in melon production

Co-PIs: Ian Grettenberger, UC Davis Extension Entomology Specialist; Amber Vinchesi-Vahl, UCCE Colusa/Sutter/Yuba
Collaborators: Seth Jean, MS student in Grettenberger lab; Margaret Lloyd, UCCE Yolo; Don Weber, USDA-ARS Beltsville, MD
Funded by California Melon Research Board

The western striped cucumber beetle (*Acalymma trivittatum*) is a serious pest of fresh-market melons in the Central Valley. Adult western striped cucumber beetles feed on the bottom surface of fruit. This scars the rind, which produces cosmetic damage and unmarketable fruit. Melon is their preferred host with multiple generations per year in melon fields. They can also be very damaging to seedling stands.

While insecticides can be effective for managing cucumber beetles, there still remain opportunities for continuing to improve efficacy. In addition, current rotations rely on pyrethroids and neonicotinoids. Both modes of action have received attention from regulatory agencies due to concerns about water contamination and effects on pollinators. There is the possibility that a new material (CidetrakL, Trécé) containing cucurbitacins, feeding stimulants for cucumber beetles, could lead to greater efficacy of current insecticides or comparable efficacy with reduced rates. Also, it could possibly be combined with different insecticides than those currently relied upon for cucumber beetle management. Results from 2022 demonstrated acetamiprid (Assail) + CidetrakL is a promising pairing, at both the full rate and even at ¼ rate when paired with CidetrakL. These treatments caused the highest striped cucumber beetle deaths and limited scarring severity on fruit compared to the untreated control. We will be exploring this relationship further in 2023. We also tested indoxacarb (Avaunt) because it worked very well in the eastern US on the closely related corn rootworm, but it was not as successful as the acetamiprid (Assail) treatments.



Left: Average dead striped cucumber beetles, summed across the entire study. Values are averages. Right: Damage ratings for the different treatments. Portions of the stacked bar represent the average proportion of melons that fit within that category. Damage ratings go from 0 (undamaged) to 5 (completely scarred).

Both conventional and organic growers could benefit from testing novel attractants for use in an attract-and-kill strategy for cucumber beetles. Since 2019, and working with Don Weber of USDA-ARS in Beltsville, Maryland, we have tested the cucumber beetle aggregation pheromone for its attractiveness to the western striped cucumber beetle and have had some success, especially when adding a floral lure. This suggests that the pairing of these attractants with an appropriate trap could provide growers the opportunity to kill large quantities of beetles before they colonize melon fields in the spring and then again in the fall when beetles are leaving fields or moving and preparing to overwinter. We tested two types of traps utilizing the pheromone and floral lures during the 2022 season, but had low beetle catches and not enough to warrant using these traps in an attract-and-kill strategy. We plan to examine trap modifications and additional trap types to use in a potential attract-and-kill system.

2023: Jump starting BCTV awareness and pro-active management in the Sacramento Valley

PI: Bob Gilbertson, Department of Plant Pathology, UC Davis; Co-PIs: Amber Vinchesi-Vahl, UCCE Colusa/Sutter/Yuba; Neil McRoberts, Department of Plant Pathology, UC Davis
Collaborators: Tom Turini, UCCE Fresno; Diane Ullman, Department of Entomology and Nematology, UC Davis; Other UCCE Advisors, growers and PCAs
Funded by the California Tomato Research Institute

Due the outbreak of beet curly top virus (BCTV) in the northern counties in 2021 and continued prevalence of the virus in 2022, we will be monitoring beet leafhopper and BCTV in early 2023. Most of the monitored field sites will be near the western foothills. For each field, we will place yellow sticky cards both facing the foothills and facing away from the foothills. The cards will be exchanged biweekly February-May. The sticky cards will be brought to the Gilbertson lab at UC Davis where they will detect the number of beet leafhoppers on the cards and test them to determine if they are carrying BCTV. Once tomatoes are transplanted, plants will be examined for BCTV symptoms and % disease incidence will be calculated. If BCTV is observed, samples will be collected and also brought to the Gilbertson lab for confirmation of the virus and to determine the strain of the virus.

In addition to our trapping efforts, we also plan to develop an extension bulletin for BCTV and beet leafhopper, conduct field visits as needed, and host informational meetings for growers and PCAs about BCTV, beet leafhoppers, and managing this pest and virus in the northern counties.

An experimental aggregation pheromone shows promise for cucumber beetle monitoring and further management strategies

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-Ian Grettenberger, Field and Vegetable Crops Extension Entomology Specialist, UC Davis
-Amber Vinchesi-Vahl, UCCE Vegetable Crops Advisor, Colusa and Sutter-Yuba counties

The fresh-market melon industry in California is affected by a pest complex known as cucumber beetles (CB). Two closely related species of beetles form this complex: the western striped CB (*Acalymma trivittatum*) and the western spotted cucumber beetle CB (*Diabrotica undecimpunctata undecimpunctata*). Both species will damage melons but have notable differences in biology and feeding behavior. One key difference is western striped CB is a cucurbit specialist, reproducing only on cucurbits and relying on cucurbits as hosts for most of their life cycle. Western spotted CB will feed on many different plant types. In addition, another primary difference is that the adult western striped CB prefers to feed on fruit rinds, rendering the fruit unmarketable. In contrast, the western spotted CB damage is generally limited to the crop's foliage, although they will also scar fruit (Fig 1). This feeding behavior makes the western striped CB the most problematic species. Both species are also early season pests of cucurbits and readily feed on seedlings, reducing plant stands.

Figure 1. Left: Adult western spotted CB on foliage; Middle and right: adult western striped CB on honeydew rind and on summer squash foliage.

Most specialty varieties of fresh-market melons are grown in California. Muskmelons (cantaloupe and honeydew) are preferred cultivars by the western striped CB, especially smooth rind varieties like Crenshaw and Casaba. Unfortunately, these varieties are the most susceptible to CB damage; anything larger than a quarter-coin in size can put melons into the "cull" pile (Fig 2). Unfortunately, western striped CB in particular are quite tough to manage, especially in the later season when beetles hide under the fruit and cannot be reached by contact insecticides.

Figure 2. Honeydew melon cosmetically damaged by CB chewing (left); Adult western striped CB on mature honeydew melon (right).

What are the current management practices, and what are the gaps?

In conventional systems, the most effective management strategy has been broad-spectrum insecticides. Chemistries such as pyrethroids and neonicotinoids help minimize damage on young melons. However, the overuse of pesticides can lead to problems with insecticide resistance. Moreover, broad-spectrum chemistries can pose unwanted issues on pollinators and natural enemies. In organic operations, the damage risk by these insects is higher because there are few options available. Integrated Pest Management (IPM) practices for organic systems include cultural practices such as row covers or plastic mulches, which carry material and labor costs.

An effective IPM program begins with preventive measures, such as monitoring the insect of interest. However, the current monitoring practices for CB, such as scouting fields, are time-consuming and difficult to link to pest populations across the field. The thresholds in conventional operations to spray insecticides can be one western striped CB and a handful of western spotted CB per field. This approach can lead to unnecessary sprays, since cucumber beetles tend to have a patchy distribution in the field. However, the male cucumber beetle releases an aggregation pheromone that attracts other cucumber beetles, which accounts for the low threshold before chemical control is used.

Vittatalactone, an experimental aggregation pheromone for monitoring

One way to improve current management practices for both organic and conventional is to implement an effective monitoring tool. Fortunately, USDA scientists on the east coast have identified a new aggregation pheromone that shows promise as a monitoring or management tool. Aggregation pheromones are chemical volatiles that animals produce to communicate. The male striped CB (*Acalymma vittatum*) emits an aggregation pheromone identified as vittatalactone. The striped CB is the sister species to the western striped CB, and both species belong to the same genus. The aggregation pheromone, vittatalactone, is the same for both the eastern and western species.

Vittatalactone field trials 2020 and 2021

In 2020 and 2021, we tested vittatalactone in field settings in northern California. The design of the experiment consisted of deploying clear sticky monitoring cards (Fig 3) attached to wooden stakes at two organic farms in the Sacramento Valley. In 2020, we initially tested vittatalactone in a randomized trial with two treatments. Later in the season, we added a commercial floral lure (AgBio, Inc) to the vittatalactone treatment to test whether the floral lure would enhance beetle capture. In 2021, we ran the same experiment but altered the treatment list to a factorial design: control, pheromone, floral lure, and pheromone + floral lure.

Figure 3. Clear sticky card (Trece, Inc) attached to wooden stakes. Left panel pheromone, right panel pheromone and floral lure.

Western striped cucumber beetle results

In 2020, western striped CB attraction to the aggregation pheromone (vittatalactone) followed a similar pattern across both sites. When we tested the pheromone alone at the beginning of the season, we observed that vittatalactone attracted more beetles than the control, although the effect depended on the date (Fig 4). Overall, fewer beetles were captured at site one than site two because of the planting schedule. This showed that the pheromone becomes less attractive to beetles once the cucurbits are in the field (Fig 4).

For the second half of the 2020 season, including the harvest/post-harvest months of August to October, we added the pheromone + floral lure combination. The efficacy of our treatments at attracting beetles did depend on date, although the pheromone was again attractive to the beetles (Fig 4). In addition, the added pheromone + floral lure combination treatment was also attractive to the beetles, generally more so than the pheromone alone. We saw dramatic peaks with this treatment late season, averaging ~275 beetles per trap at the first site compared to ~50 in the pheromone alone and ~10 in the untreated control (Fig 4).

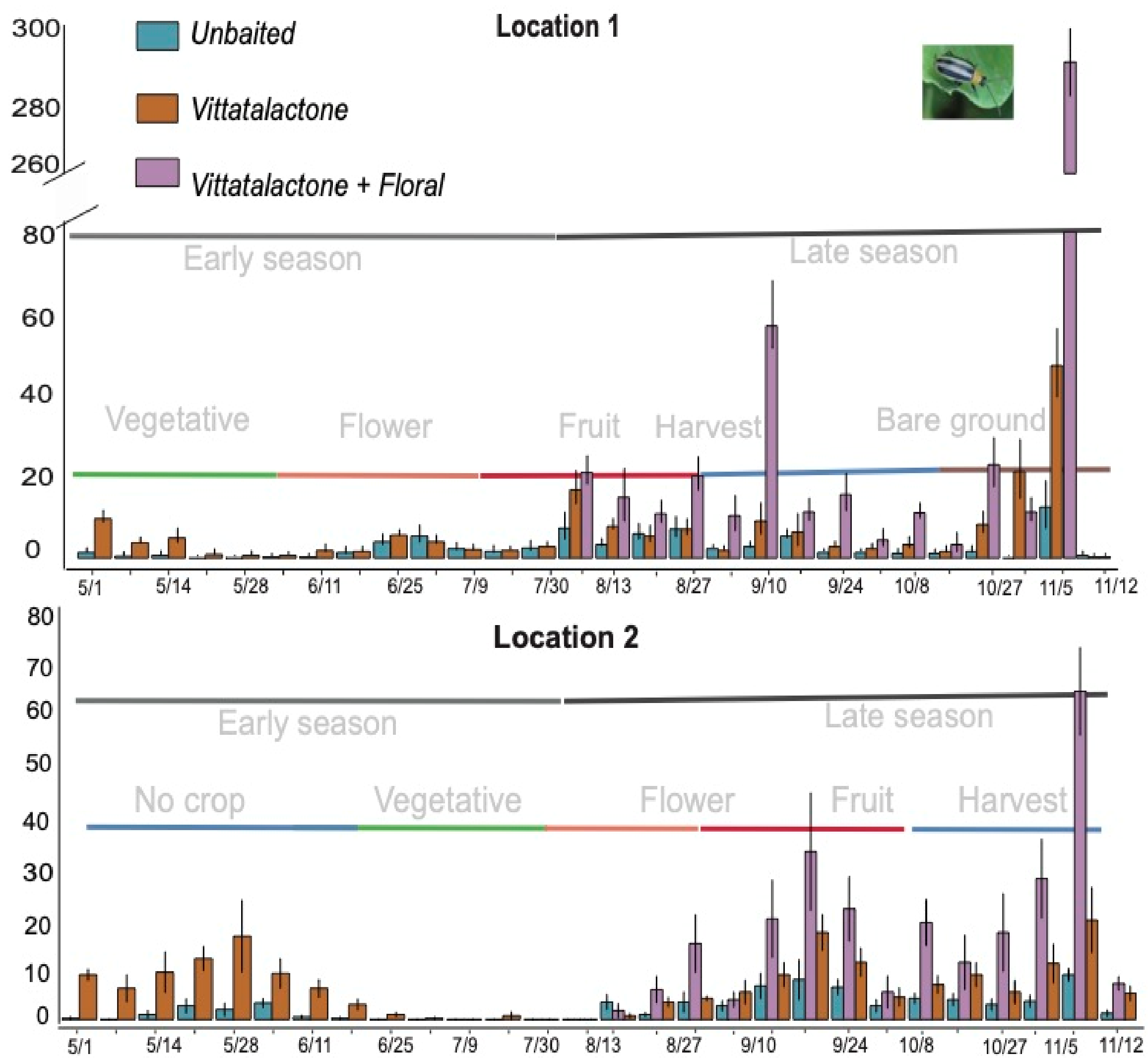

Figure 4. Average western striped CB captured per trap from May-November 2020. Growth stage of cucurbits Is also shown. Site 1 had much higher captures than site 2.

In 2021, from early March to late November, we used a factorial design where we tested the floral lure and pheromone individually (as well as combined) to separate their independent effects. The pheromone + floral lure combination had the most captures at site one, followed by the pheromone alone (Fig 5). The floral lure alone captured more beetles compared to the control (no lures and no pheromone). Again, we observed that the treatment effect of the pheromone depended on date. For example, between May and June, trap captures decreased (Fig 5). This decrease in captures was also observed in 2020, where beetles seemed to be less attracted to the pheromone and floral lure once crops were in the field. At site two, we had mixed results, and the data is not presented here. We observed the most beetles captured with the combination of pheromone + floral lure throughout the entire season with the exception of some dates.

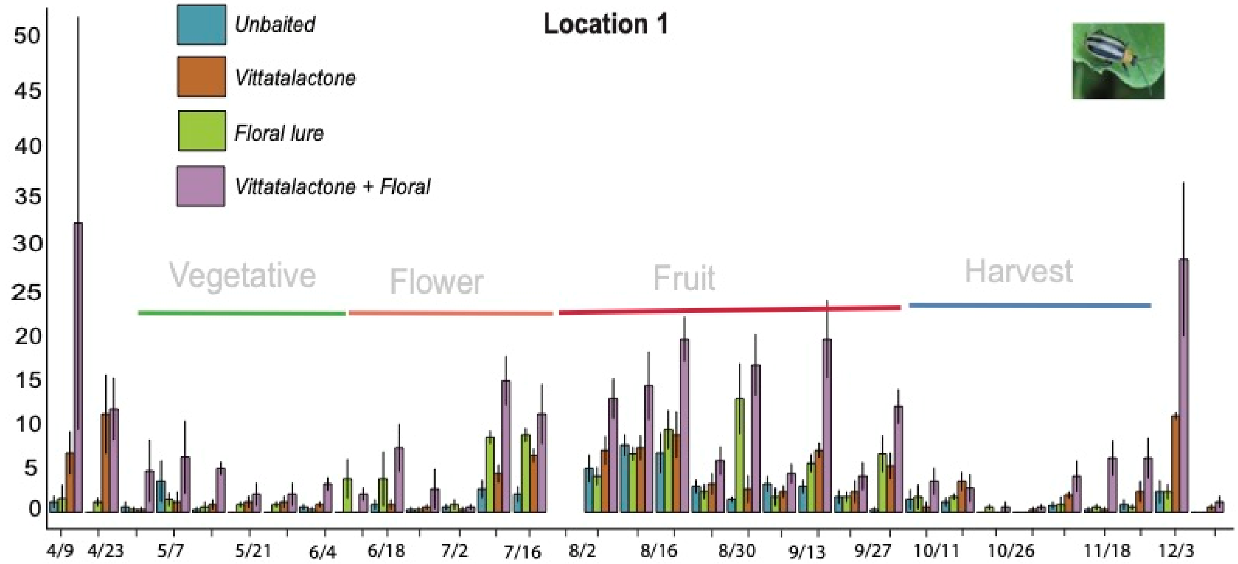

Figure 5. Average western striped CB captured per trap from April-December 2021 at site 1. Growth stage of cucurbits is also shown. Data from site 2 is not included.

Western spotted cucumber beetle results

Beetle captures for the western spotted CB were analogous to the capture patterns observed for the western striped CB in 2020. The pheromone alone captured more beetles than the control between May and June (Fig 6). However, patterns varied across both sites in the middle of the season, June-August. At site one, we see that the pheromone had more captures than the control, but we also saw an uptick of beetle captures in the control, which can be explained by the fact that traps were moved closer to the field and the control traps likely captured beetles by proximity (Fig 6). At site two, we observed a decrease in captures (Fig 6). This decrease in beetles is likely due to western spotted CB phenology. This species is a generalist and will feed and reproduce on other crops. In addition, this species might also be less attracted to the pheromone once cucurbits are in the field.

For the second part of the season, when we added the pheromone + floral lure treatment, we saw a gradual increase of beetle captures for both sites. This treatment had the most substantial number of beetles captured compared to the pheromone alone. This was especially apparent at site one where we see a dramatic peak averaging 800 beetles per trap (Fig 6). At site two, there was also a significant peak at the end of the season, indicating that the combination of floral lure + pheromone was the most attractive treatment to the western spotted CB, particularly at the end of the season (Fig 6).

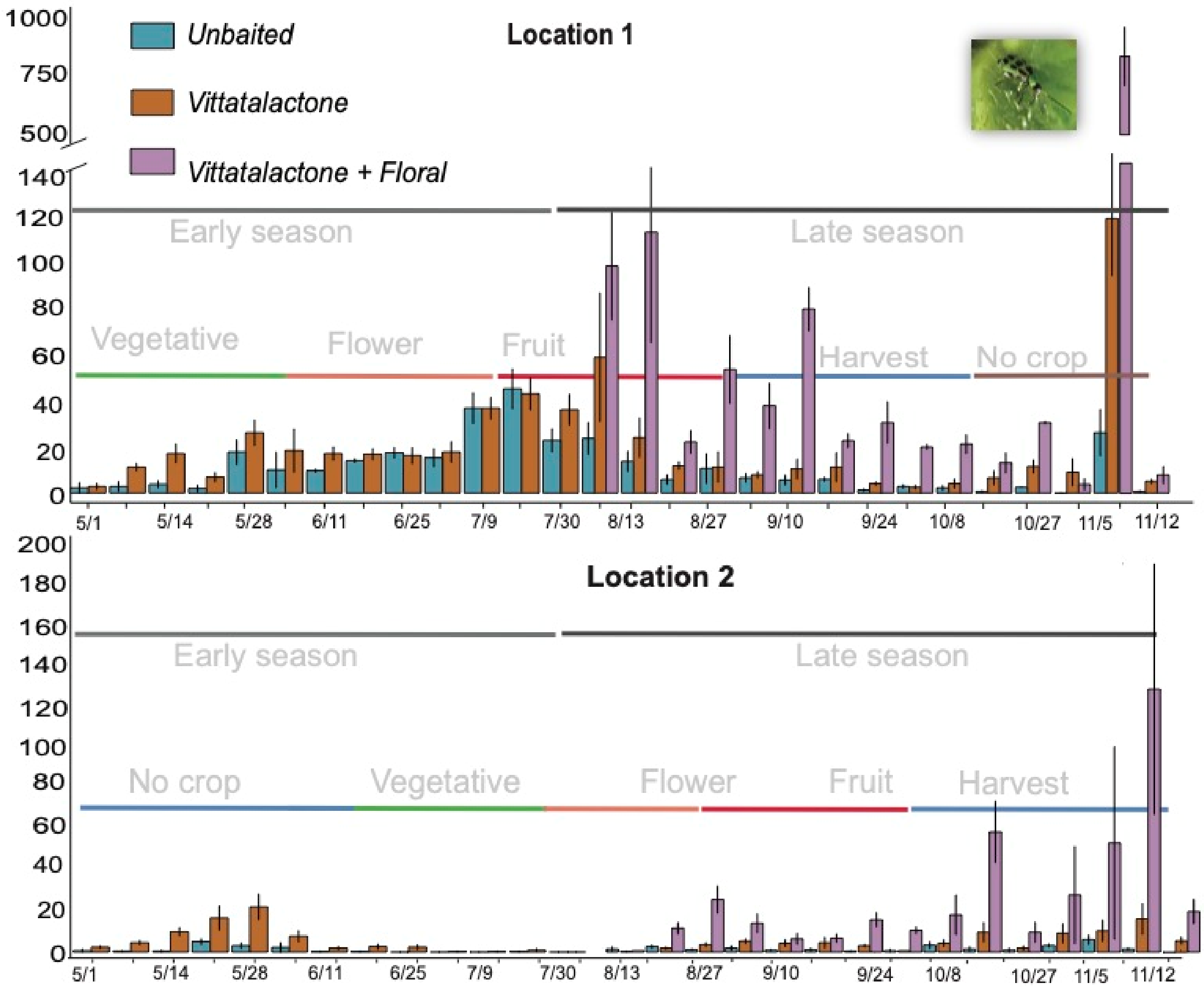

Figure 6. Average western spotted CB captured per trap from May-November 2020 at each site. Growth stage of cucurbits is also shown. Site 1 had significantly more captures than site 2.

In 2021, beetle captures differed across both sites throughout the sampling season. The pheromone alone had higher captures than the control at site one (Fig 7). At site two we observed that there were no substantial differences in beetle captures until the end of May. This is most likely due to phenology, since the western spotted CB populations build up in other crops such as corn or alfalfa and then move into cucurbit fields once the plants are more established in the ground. The pheromone + floral lure continued to have the highest number of captures when compared to the other treatments with the treatment effect depending on date (Fig 7).

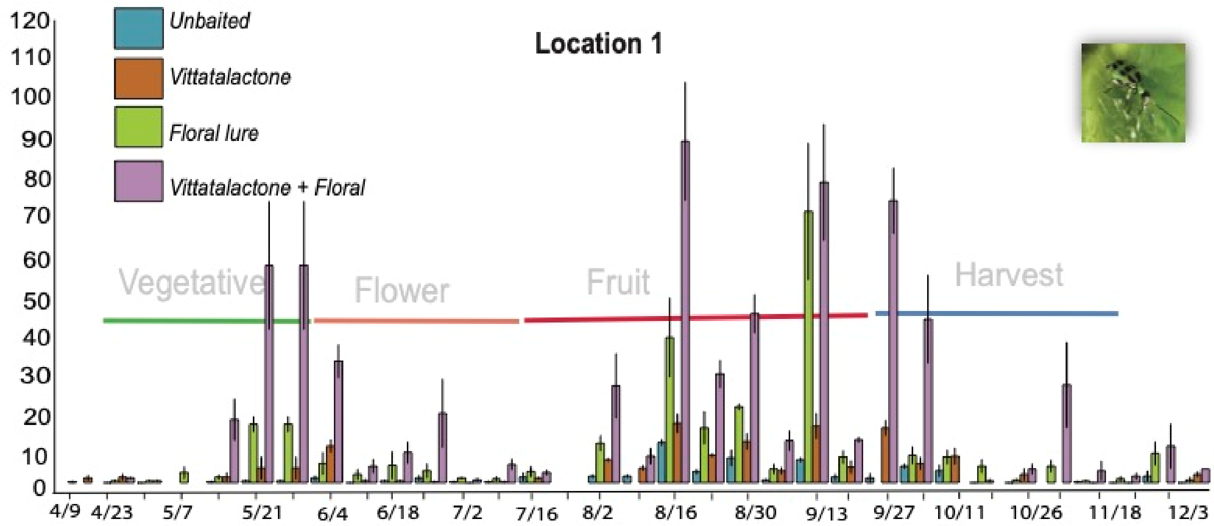

Figure 7. Average western spotted CB captured per trap from April-December 2021 at site 1. Growth stage of the cucurbit is also shown. Data for site 2 is not included.

A new monitoring tool for cucumber beetles on the horizon

Through our trials, we found that vittatalactone attracted the western striped CB and western spotted CB. When combined with the commercial floral lure we observed a synergy that resulted in higher captures (Fig 4-7), though this was most apparent late in the season, when cucurbits were no longer available in the field.

We believe that vittatalactone could be useful for cucumber beetle management in fresh-market melons, although this pheromone appears to be most attractive when there are no cucurbits in the field. Vittatalactone attracts cucumber beetles of both western species when tested alone or in combination with the floral lure, but has difficulty competing with a field full of cucurbits. This suggests that while lures with these chemicals could be useful for monitoring, they may not be useful over the entire season. The addition of the floral lure did appear to create a synergy for attracting beetles of both species. Therefore, this treatment combination could also be a key component in management approaches, such as an attract-and-kill design to control field infestations before melons are planted or after they are harvested. This approach could potentially minimize pest populations moving into the field in the spring, throughout the growing season, and beetles moving out of the fields to overwinter.