Vegetable IPM in the Sacramento Valley

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Overview of IPM

- Integrated Pest Management (IPM): ecosystem-based strategy focusing on long-term prevention of pests and damage through a combination of techniques
  - Biological, cultural, and chemical working together
  - Pesticides are used only after monitoring indicates they are needed
  - Treatments made with the goal of removing only the target organism
  - Materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, environment

Outline

- Processing tomatoes
  - Weed management (postharvest/pre-plant through after planting)
    - Cultivator trial
  - Disease management (including surveys and projects)
    - Soilborne fungal pathogens
    - Insect-vectored viruses
- Fresh-market muskmelons
  - Insect management
    - Cucumber beetle projects

- Resources: UC IPM, Pest Management Guidelines for Tomatoes and Cucurbits

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Postharvest and preplant weed management

- Crop rotation
  - Corn allows for the use of herbicides to control nightshades, yellow nutsedge and field bindweed
  - Other useful rotational crops include wheat, cotton, rice, dry beans, onions, carrots, and safflower
  - Not recommended: solanaceous crops such as potatoes, peppers, and eggplant

- Field preparation
  - Avoid fields with severe weed infestations
  - Avoid moving weed seed into fields on equipment/clean before entering fields
  - Deep tilling can reduce nightshade and nutsedge populations
  - Pre-irrigation/rainfall can germinate nightshade species before planting for control with cultivation or postemergence herbicides

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Postharvest and preplant cont.

- **Soil fumigation**
  - Metam sodium, metam potassium can provide control of many weeds and other soilborne pests
  - Leave enough time between fumigant application and transplanting to prevent phytotoxicity

- **Herbicides**
  - Herbicide applications made to fall or winter beds allow early plantings
  - Rainfall is necessary to break down fall-applied herbicides so that following year's tomatoes will not be injured
  - Perennial weeds (field bindweed and little mallow) can be controlled postharvest by irrigating and applying contact herbicides
  - Some herbicides are best applied just before planting and incorporated into the soil
  - The entire bed top may be treated or band treatments applied over the seedline

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At planting

- Planting dates
  - Manipulate planting dates if possible to take advantage of weed germination under different temperatures
- Transplanting
  - Gives the crop a growth advantage over weeds
- Cultivation

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After planting

- **Cultural practices**
  - Prevent weeds from going to seed
  - Keep canal banks free of weeds
  - Avoid moving weed seeds into fields on equipment/clean equipment
  - Keep bed tops dry (drip-irrigation)
    - With furrow irrigation, maintaining alternate row irrigation prevents overly wet conditions
- **Cultivation and hand weeding**
  - Mechanical cultivation close to the seedline reduces hand weeding needs later
  - In-row cultivation (ex. finger weeders)
- **Herbicides**
  - Postemergence herbicides
    - Apply as directed on each side of the seedline and immediately incorporate
    - Variable rate layby applications can reduce herbicide cost with no loss in weed control or tomato yield

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Common weed problems

- Field bindweed
- Nightshades
- Nutsedge
- Broomrape (next slide)
- UC IPM, Integrated Weed Management
  - https://www2.ipm.ucanr.edu/agriculture/tomato/Integrated-Weed-Management/

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Broomrape, *Orobanche*

- Broomrapes are root parasites (attach to host below ground)
- At high density, can greatly reduce yield or result in crop failure

Photo credit: B. Hanson.

- In other countries, up to 70% loss in tomato
- In CA…
  - Scouting, reporting, quarantine, crop destruct…
  - Short-term goal: minimizing spread
  - Need to develop mitigation approaches

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In-row cultivator trial

- Evaluate weed control, time, and costs of using mechanical and automated in-row cultivators as part of a conventional weed management program
- Compared in-row mechanical and robotic weeders to grower standard practice and postemergence herbicides (rimsulfuron)
- Trial sites in Colusa and Merced County

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Takeaways

- Robovator provided excellent control in Colusa in 2020, but caused crop injury in Merced, and in Colusa in 2021
  - High winds/non-upright plants affect precision of Robovator and led to higher % crop injury
- Finger weeder provided excellent weed control in both fields in 2020, except for one plot in Colusa field with heavy bindweed
- Rimsulfuron and finger weeder treatments reduced costs and time for hand weeding in Merced, and rimsulfuron and both cultivators reduced costs in Colusa compared to the control

Photo credits: S. Stoddard

Photo credit: S. Light

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Processing tomato diseases

Disease/Field Issue	2016	2017	2018	2019	2020	2021	2022
Bacterial canker			1	2	4	2	
Fusarium crown and root rot		1	4	2	1	**6**	**8**
Fusarium falciforme				3	1	**4**	**8**
Fusarium wilt			**18**	7	3	2	4
Root-knot nematode	3			1		1	
Southern blight	1	5	2	3		1	
Verticillium wilt			2	1	1		
Beet curly top virus	2					**10**	**11**
Tomato spotted wilt virus (resistance-breaking)						2	2

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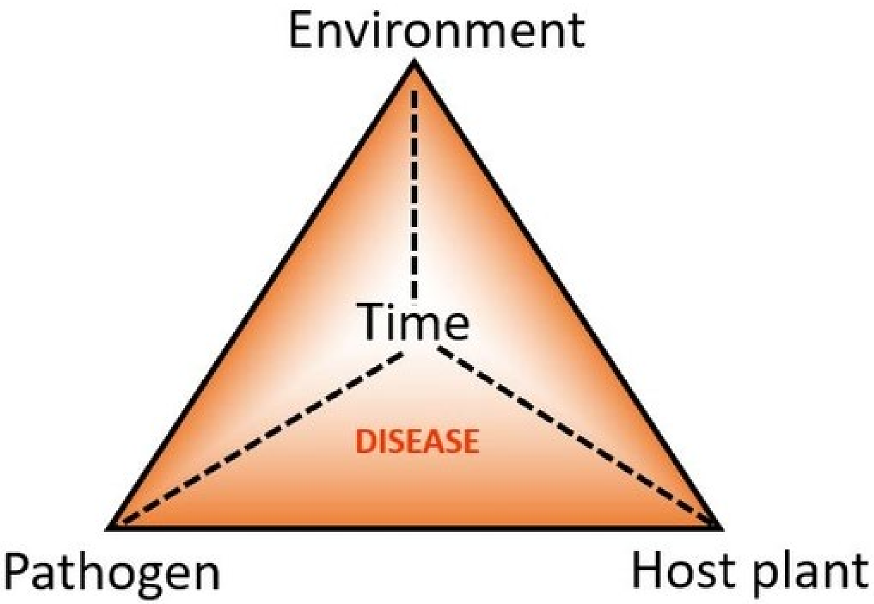
Disease Triangle



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Fusarium crown and root rot

- *Fusarium oxysporum* f. sp. *radicis-lycopersici*
- Yellowing on margin of oldest leaves, then necrosis
- Plant slowly declines over many weeks
- Crown rot is a LOCALIZED lesion
- Stem is brown on the outside and rotten on the inside
  - IF you cut at 6” and 12” the stem will be healthy looking
- Roots will also often be decaying
- Overwinters and survives for many years in the soil as spores
- Favored by cool soil temperatures
- Spread by machinery and transplants
- Management: disease-free transplants


Photo credits: C. Swett

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Fusarium wilt race 3

- *Fusarium oxysporum* f. sp. *lycopersici*
- Individual branches become yellow and wilt
- Internal dark brown discoloration extends far up the stem
- Shows up later in the season compared to Verticillium wilt (45 days)
  - Favored by warm weather, drought stress, heavy fruit load
- Overwinters and survives for many years as spores in the soil and on other plants without causing them harm
- Spread is by seed, transplants, soil on machinery
- Management:
  - Resistant varieties
  - Clean farm equipment
  - Avoid nematode infestations
  - Rotate out of tomato for several years to reduce inoculum level

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Fusarium falciforme

- Branch or whole plant chlorosis
- Deep leaf curling, deformity, little leaves
- Leaf speckling→ leaf death→ whole plant dies
- Vine decline
- Look for foot/crown/stem rot to differentiate between other Fusariums and virus/herbicide/salt damage
  - Only consistent symptoms
  - Crown rot starts below soil line

Photo credits: C. Swett

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F. falciforme project

- Evaluating F. falciforme in variety trial to determine tolerance and/or susceptibility and scouting previously confirmed fields for infection in rotational crops (alternate hosts?)
- 2019-2 tomato fields and 1 pumpkin field
- 2020-1 tomato field
- 2021-4 tomato fields and 1 cucumber field
- 2022-8 tomato fields

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Verticillium wilt, *Verticillium dahliae*

- Yellow, V-shaped areas that narrow from margin on older leaves, then turns brown and leaf dies
- Light tan discoloration appears in the vascular tissue near the base of the plant
- Fungus survives as microsclerotia in the soil and persists indefinitely
- Favored by cool soil and temperatures—early season issue usually
- Seldom kills plants but reduces vigor and yield
- Management:
  - Sanitation and washing equipment
  - Rotate to nonhost crops like corn and small grains to reduce inoculum

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Southern blight, *Sclerotium rolfsii*

- Destructive crown rot disease
- Rapidly kills tomato plants
- Over 500 plant hosts
- Persists year to year in crop debris
- Favored by high temperatures, high soil moisture, dense canopies, and frequent irrigation
- Management:
  - Rotate with non-host crops if possible (corn, sorghum, rice, small grains) for at least 2 years to reduce inoculum
  - Deep plowing to bury plant debris may help destroy sclerotia
  - Keep bed tops dry to help reduce the disease (favored by humidity)

Photo credits: C. Swett

Photo credit: J. Nunez

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Root knot nematode, *Meloidogyne*

- Cause galling of roots
  - Galls interfere with flow of water and nutrients to the plant
- Plants yellow, wilt, and respond poorly to fertilizer—patchy distribution
- Check roots of plants midseason or later, check earlier if aboveground symptoms are present
- Damage more likely in sandier soils
- Management:
  - Manage weeds
  - Use resistant varieties
  - Rotate with non-host crops
- Relationship between root knot nematode and Fusarium wilt (possibly other Fusariums) and breaking resistance
  - Poorly understood

Photo credit: E. Miyao

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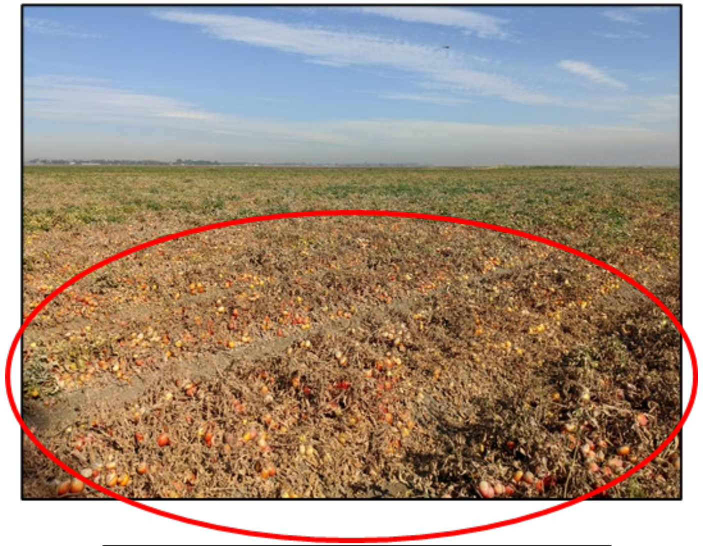
Root-knot nematode and Fusarium complex

- RKN feed on tomato roots, affecting nutrient uptake and reducing yield
- RKN breaking resistance
  - Heat events, diseases, cultivar resistance traits
- RKN-Fusarium complex→ predisposing plants to disease, overcoming resistance and increasing damage severity
- Field trials to determine efficacy of nematicides and fungicides to co-manage RKN and Fusarium wilt and how Fusarium wilt resistant cultivars interact with nematode infection



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Beet curly top virus (BCTV)

- Transmitted by beet leafhopper
- Purpling, leaf curling and premature small red fruit, stunted growth in tomatoes
- Looks different for cucurbits: yellowing, wilting, leaves turn necrotic and crispy, swollen veins, proliferation of shoots

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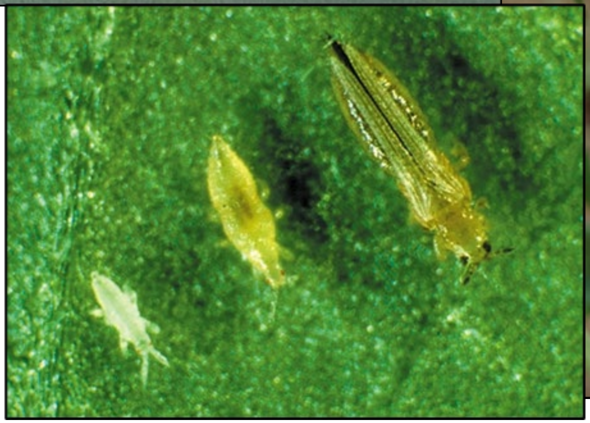
Tomato spotted wilt virus (TSWV) and RB-TSWV

- Transmitted by thrips
- Early infection leads to stunted growth
- Leaves curl, wilt, yellow/bronze and develop necrotic spots or rings
- Initial symptoms are leaf bronzing and wilting, then necrotic leaf spotting and some vein, stem or petiole necrosis
- Plants may look crumpled
- Fruit may be distorted and have ringspots



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Pest Management Strategic Plan (PMSP)

- Planning document detailing pest-management issues and management practices in a particular crop directly from stakeholders
  - Needs Assessment
- First PMSP for processing tomatoes
- Priority research, regulatory, and education needs for California processing tomato
- Published Summer 2021
- https://ipmdata.ipmcenters.org/documents/pmsps/2021_07_22_Processing_Tomato_PMSP_final.pdf

UC CE

Western IPM Center

UC IPM

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Insect issues in fresh-market melons

- #1 Cucumber beetle
- Loopers
- Melon aphid
- UC IPM Pest Management Guidelines for Cucurbits

Photo credit: I. Grettenberger

Loopers

- Caterpillars with a narrow, white stripe along each side and several narrow lines down the back
- Arch to their back as they crawl
- Adult moths have brown, mottled forewings marked in the center with a small, silver figure eight
- Feed on the underside of leaves, skeletonizing them
- High populations may feed on the fruit surface
- Natural enemies can keep loopers under damaging levels as long as they are not sprayed out
- Pressure varies year to year

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Melon aphid (cotton aphid)

- Prefers underside of leaves
- Not deterred by high temperatures like some other aphids
- Usually more a late season problem
- Extensive host range (cucurbits, citrus, cotton)
- Host weeds include milkweed, jimsonweed, pigweed, and field bindweed
- Distort and curl leaves, produce large amounts of honeydew → sooty mold
- Vector cucumber mosaic, zucchini yellow, and watermelon mosaic viruses
- Loss of vigor, stunting, or even death of the plants
- Preserve habitat for beneficials around the field and keep dust down to encourage parasitism and predation
- Natural enemies will help keep melon aphid under control until late in the season
- Very difficult to control with insecticides

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Western striped cucumber beetle

- *Acalymma trivittatum*
- Difficult to control with insecticides
- Damaging to seedlings
- Fruit feeding causes scarring→ unmarketable fruit
- #1 pest of fresh-market muskmelons
- Appear to overwinter in leaf litter adjacent to melon fields

Photo credits: I. Grettenberger

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Western spotted cucumber beetle

- *Diabrotica undecimpunctata undecimpunctata*
- Feed on the foliage, flowers, and fruit, but remain in the plant canopy
- Easier to control with insecticides
- Overwinter in other crops (alfalfa and corn) and migrate into melon fields in the spring

Photo credits: I. Grettenberger

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Current management

- Fields regularly scouted for beetles
- Conventional control relies almost exclusively on insecticides when beetles are detected
- Applications are repeated as needed throughout the season to avoid crop injury

Photo credit: M. Koivunen

Cucumber beetle research

- Developing tools to better monitor and manage cucumber beetles in melons
  - Pheromone trial
  - Non-crop habitat

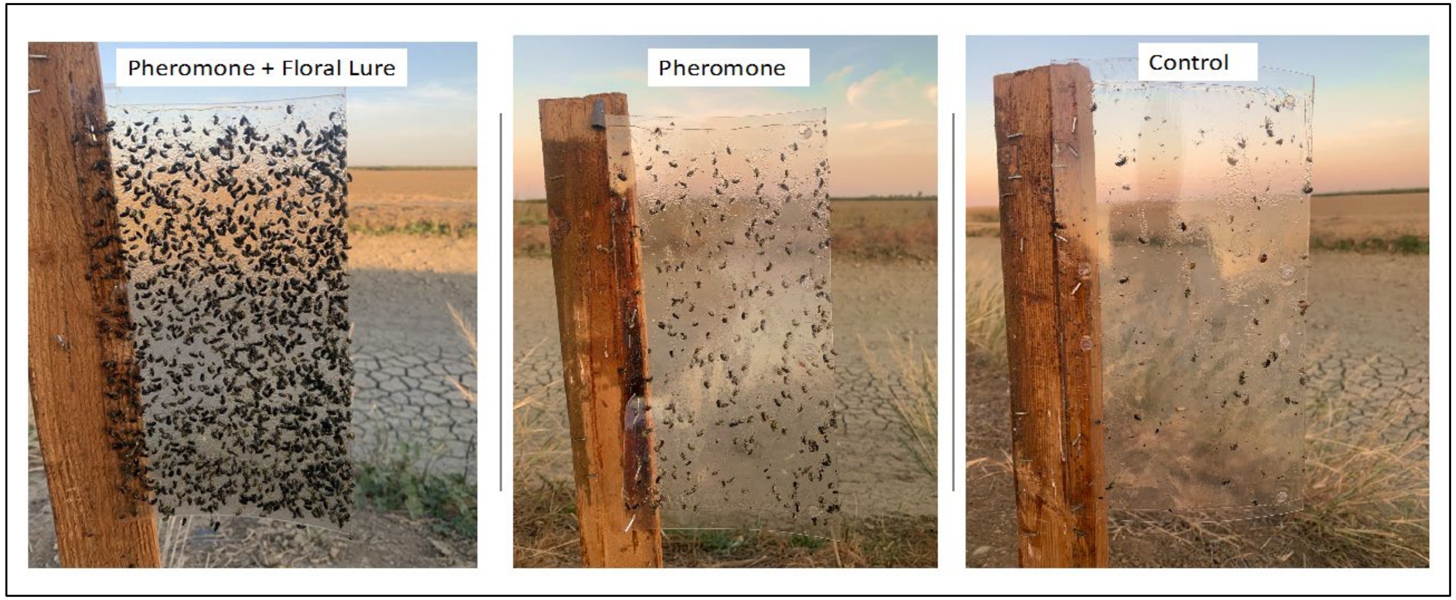

Photo credit: J. Ramirez Bonilla

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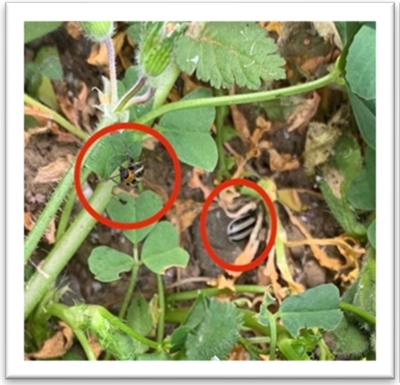
Non-crop habitat studies

- Characterize the non-crop habitat and observe the feeding behavior



- Mainly on milk thistle and mallow, will feed on milk thistle and brassicas but not mallow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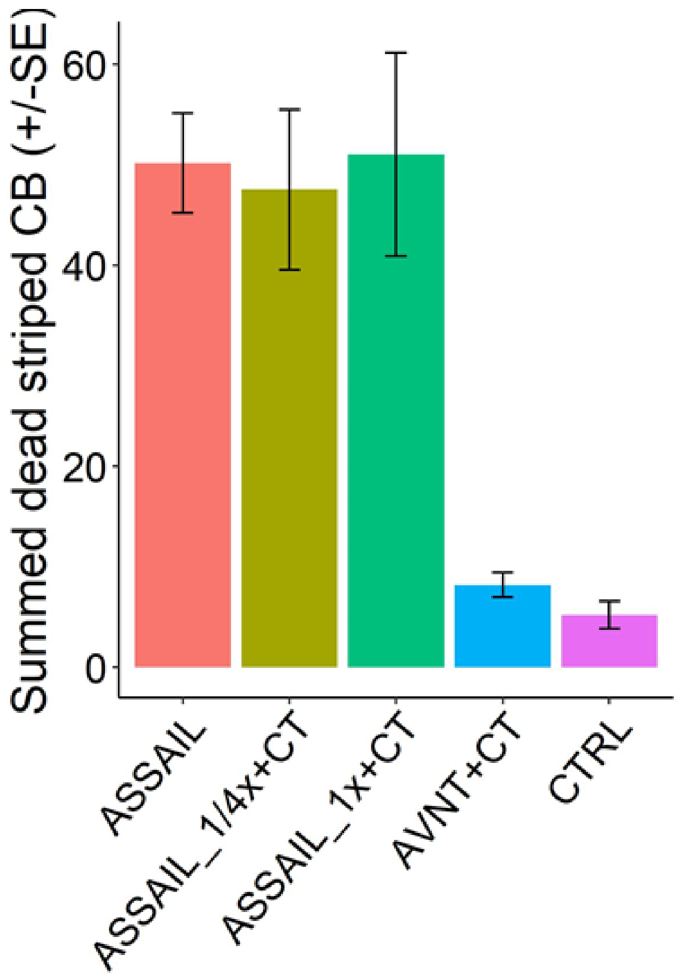
CidetrakL trials 2022

- Acetamiprid combined with CideTrakL (gustatory stimulant) at full rate and ¼ rate
- Indoxacarb with CidetrakL—showed success against corn rootworm in Midwest
- Testing again 2023



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Scarring severity ratings 2022

Rating	Damage for rating
0	None or small scars below damage rating 1
1	One 24mm diameter scars (quarter coin size) OR four 18 mm size scars
2	Two 24mm diameter size scars OR one 6 cm scar/patch of scars
3	Two 6cm patches OR one 6 cm patch + three 24mm scars OR four 24mm scars
4	Three 6cm patches OR five 24mm scars OR two 6cm patch + three 24mm scars OR extensive light spots
5	Extensive damage, blends together

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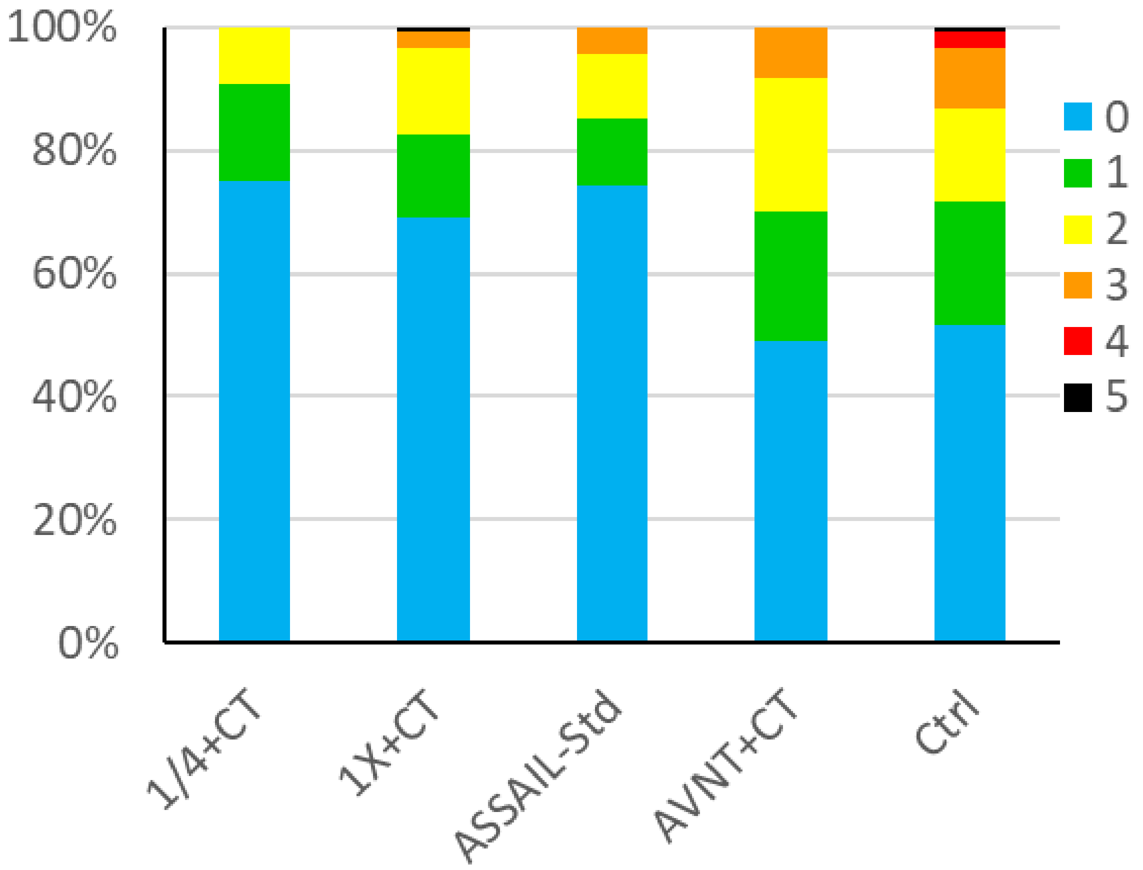
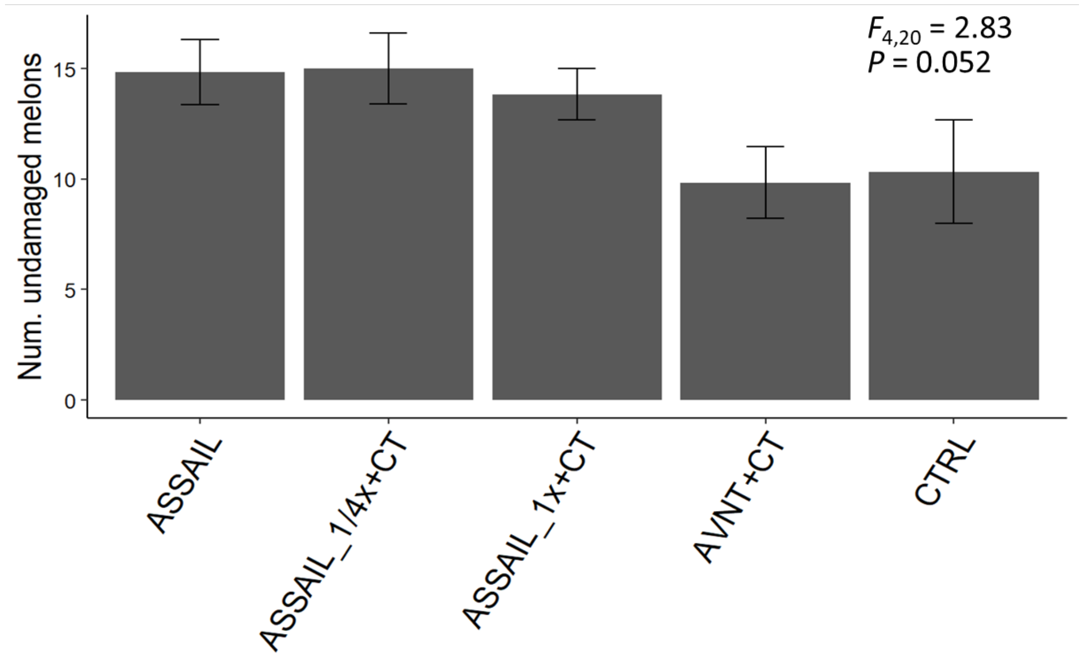
Damage assessment 2022





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Conclusions

- CidetrakL paired with acetamiprid (Assail) looks very promising, even with reduced rated of the insecticide, continuing this work in 2023
- In the long-term, we hope that improved IPM practices, including monitoring and targeted management, will help prevent and suppress damage by these pests

Photo credits: I. Grettenberger

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Thank you!

- **Subscribe to my newsletter for research updates and local pest information on vegetable crops!**
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- **acvinchesi@ucanr.edu**

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