



# Insect pest management in strawberries; a closer look at the IPM toolbox

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Dr. Sarah Zukoff

Research Entomologist, Entomology  
Program Leader

Cal Poly Strawberry Center







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## Strawberry Center

Increasing the sustainability of California's strawberry industry through research and education

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### STRAWBERRY CENTER STUDENT SUCCESS

The Strawberry Academy is a student workforce readiness program designed to provide our students with the ability to gain valuable industry skills while attending school. We have worked with the CAFES, current

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#### Recent News

Strawberry Center entomology team members present at 2022 ESA in Vancouver, BC

My Ag Life Daily News interviews Strawberry Center entomologist Sarah Zukoff

Successful 2022 Field Day highlighted in Fruit Growers News

#### Field Day 2022

#### Students

#### Strawberry Disease Info Form

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### Welcome to the 2022 lygus bug round table

Santa Maria, CA 93301  
 CALIFORNIA STRAWBERRY COMMISSION & CAL POLY STRAWBERRY CENTER

### Grower/PCA Round Table: Santa Maria Lygus Bug discussion summary

A small round table meeting was hosted by the California Strawberry Commission (CSC) in Santa Maria to help mediate a discussion on concerns of high lygus bug populations (Fig. 1). Both Cal Poly Strawberry Center (CPSC) and the California Strawberry Commission spoke on issues related to ... [Continue reading](#)

BY SARAH ZUKOFF NOVEMBER 15, 2022

### Cal Poly Strawberry Center Disease Diagnostic Service

About the plant disease diagnostic service

Soil-borne pathogens such as *Macrophomina phaseolina* are challenging strawberry production as they become increasingly prevalent

### Blog Categories

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## The perfect strawberry



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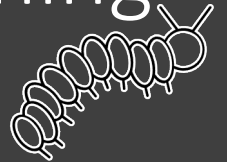






Applied research -  
integrated pest  
management (IPM)

focus: everything  
in a grower's  
“toolbox”



-prevent wasting  
(food) (\$) (time)



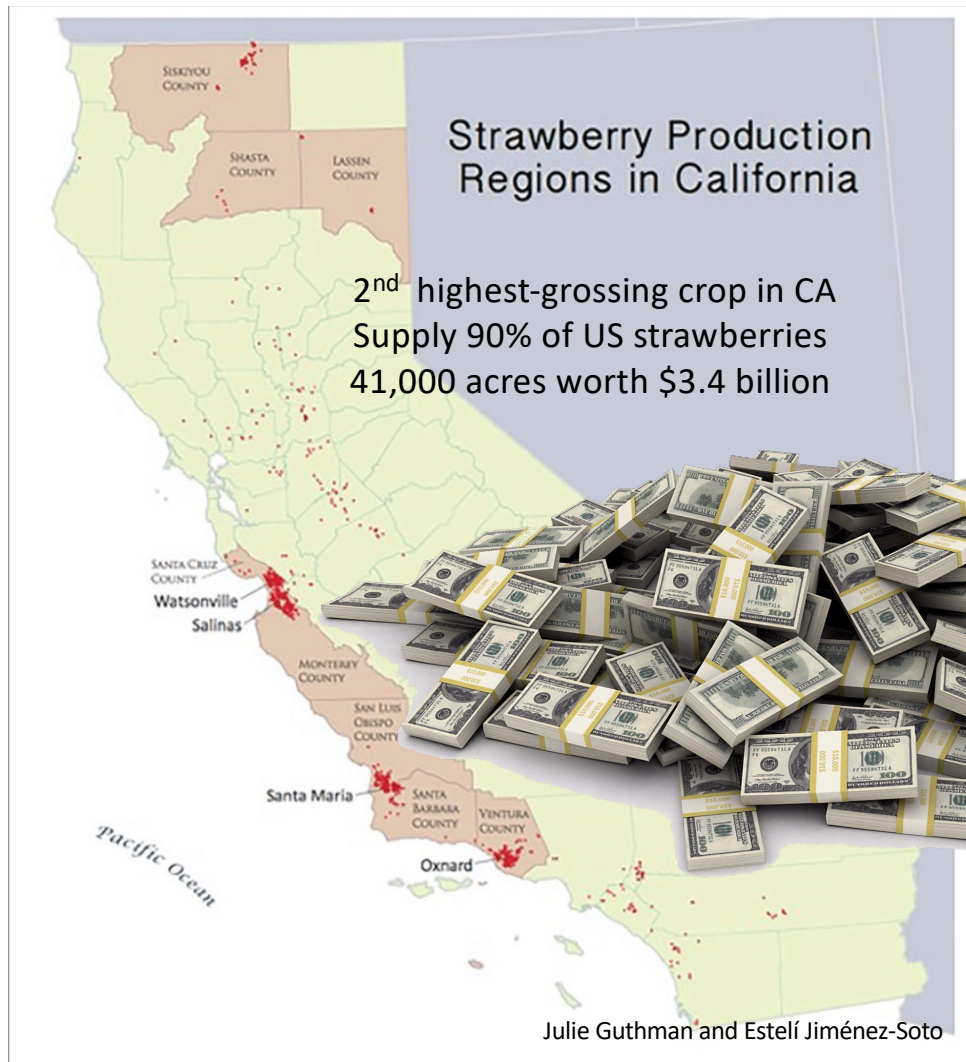


# The billion \$ crop...



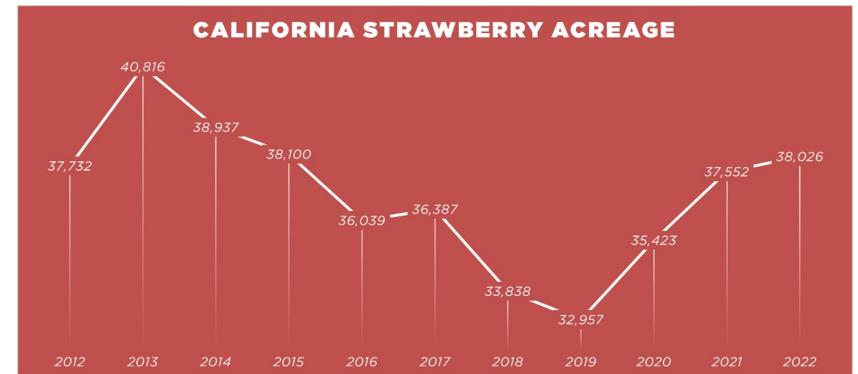
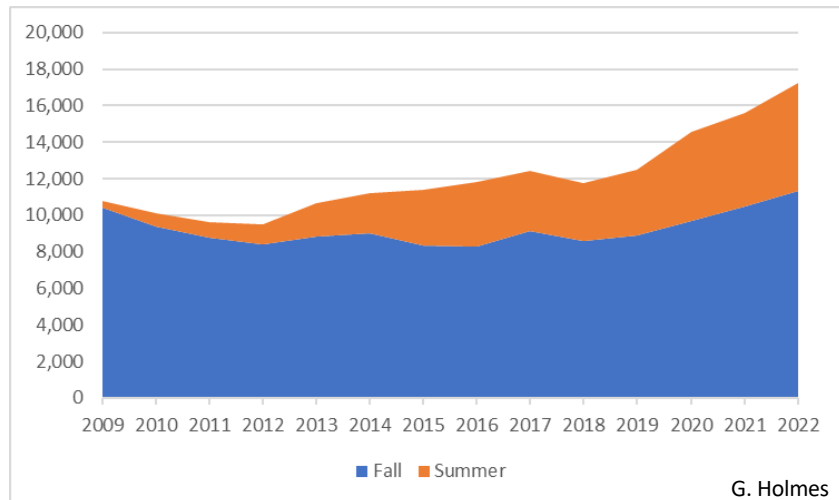
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**Cost \$95,000 to  
farm 1 acre in  
California  
=68,000 lbs**

(Kansas corn worth \$4.6 billion=6 million acres)



Investigating the pest issues

Continuous year-round planting=year  
round bug food





## Investigating the pest issues



1. 2-6 wks pest buildup
2. Green bridge
3. blame game



## Investigating the pest issues

Best: host free period

Mowed



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## Investigating the pest issues



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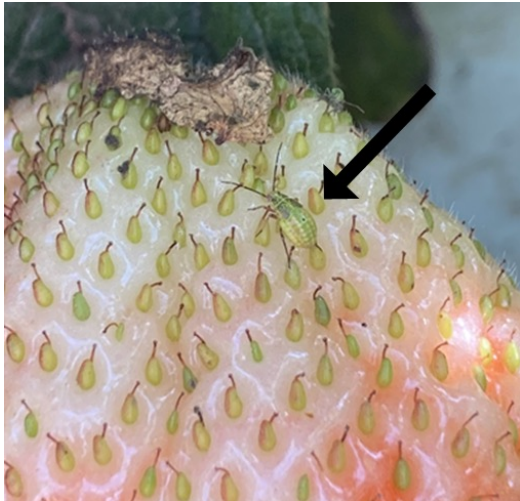




## Investigating the pest issues

### Lygus bugs #1/2 pest

- Western Tarnished Plant Bug *Lygus hesperus*
- Pale Legume Bug *Lygus elisus*



Often run out of options mid-season in areas of heavy pressure.



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## Investigating the pest issues

Two spotted spider mites



Lewis mite



#1/2  
pest

- Weekly miticide sprays
- Infest all year long
  - early summer



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Investigating the pest issues

Spotted Wing  
*Drosophila*  
#3-ish



# Intro and overview Zukoff lab IPM projects

- Nonchemical options for lygus bugs
- Best use of chemical options for lygus bugs
- UVC ?
- How to make predators work!
  - Pred mites BMP
  - SWD parasitoids?
- Honey bees in strawberries?





Investigating the pest issues

# Non-chemical IPM for lygus bugs?



Julia Campos



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95% CA strawberry growers use lygus bug vacuums

5-20% efficacy  
(kills 98%)

Strict use and maintenance standards to reach 20% efficacy.

2022 Survey

50% rigs operating too slow

Most operating with clogged or caked baffles

Drivers using them to clean out old plant material

Operating too close or too far from the canopy

CSC research Team



Chemical Name	Trade Name	Resistance Detected?	Knock Down?	Classification	Moa	Omri-Listed	Bee Precaution
Bifenthrin	Brigade	Yes	Yes	Pyrethroid	3a	No	Toxic To Bees
Plant Essential Oils (Clove, Peppermint, Rosemary) Or Oil Based	Pest Out Ultra, PureCrop1 Gargoil	No	No			Some	
Bifenthrin+ Abamectin	Athena	?	yes	Pyrethroid+GluCl	3A+6	No	Toxic To Bees
Acetamiprid	Assail	Yes		Neonicotinoid	4a	No	Hazardous To Bees
Thiamethoxam	Actara	Yes	Yes	Neonicotinoid	4a		Do Not Apply During Bloom Or When Bees Are Foraging The Area
Pyrethrins	Pyganic	Yes	Yes	Pyrethroid	3a	Some	Hazardous To Bees
Azadirachtin	Neemix, Trilogy, Azaguard, Debug, Turbo	?	No	Repellent		Some	

Flupyradifurone	Sivanto	Yes	No	Butenolides	4d		
Fenpropathrin	Danitol	Yes	Yes	Pyrethroid	3a	No	Toxic To Bees
Flonicamid	Beleaf	Yes	No	Flonicamid	29	No	
Malathion	Malathion	Yes	Yes	Organophosphate	1b	No	Hazardous To Bees
Naled	Dibrom	Yes	Yes	Organophosphate	1b	No	Use In Evening After Bee Activity Has Ended.
Novaluron	Rimon	Yes	No	Chitin Inhibitor	15	No	
<i>Beauveria Bassiana</i>	Botegha	No	No	Entomopathogenic Fungi		Some	
<i>Chromobacterium Subtsugae</i>	Grandevo	No	No	Bacteria		Yes	Temporarily Repels Bees; Adjust Use According
<i>Metarhizium Brunneum</i>	Met 52 Ec	No	No	Entomopathogenic Fungi		Yes	
<i>Isaria Fumosorosea</i>	Pfr-97	No	No			Yes	
Alcohol Ethoxylate	Oroboost	No	No				

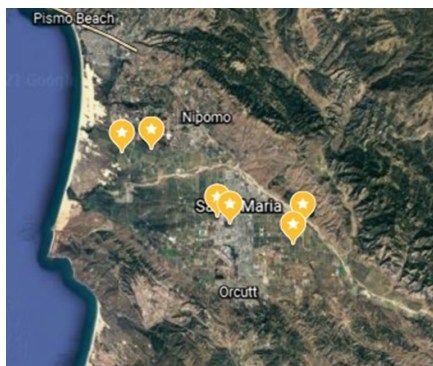
All chemicals listed for lygus management in California strawberries: what is working and what isn't?

Not many...





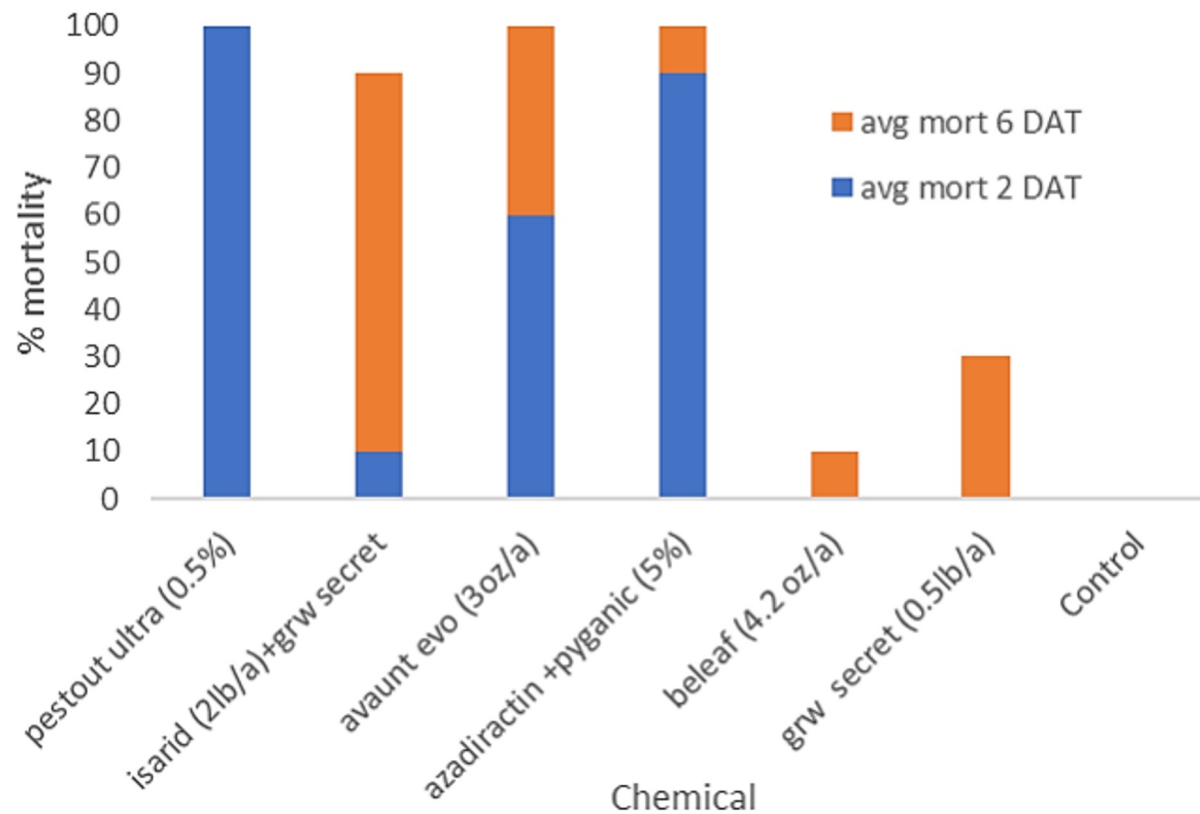
# Lygus hesperus Insecticide Resistance Status in California Strawberries



Kiley Jensen  
M.S. student



# Lygus bug insecticide screening



Noelia Ayuso  
Undergraduate  
Student intern  
Senior project



Dip assay simulating 100%  
coverage

Non-chemical alternatives?

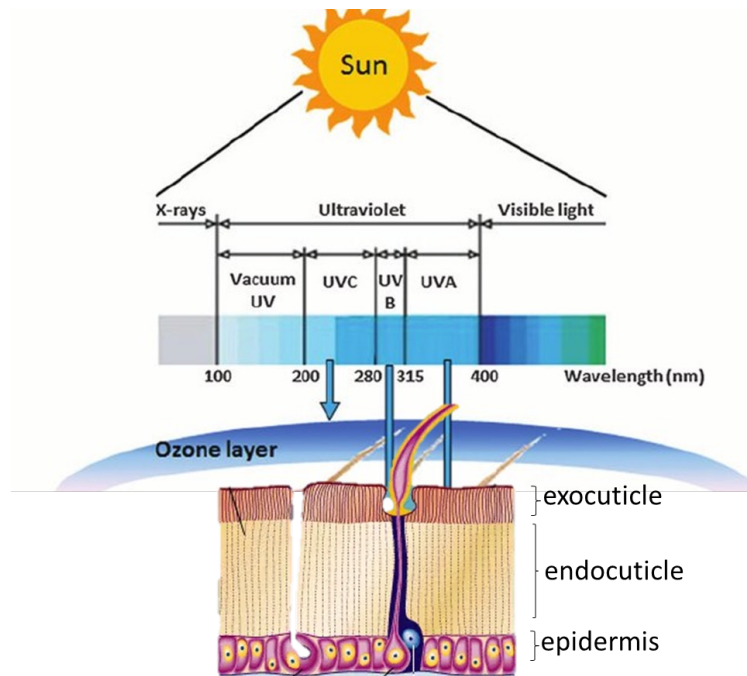
## Can UV-C be used to manage insect pests?



Jose L. Alvarado Rojas  
Research/lab assistant  
M.S. student



Savana Becerra  
Student intern



We are studying how UVC can be used in strawberries for insect management in both the lab and field.

- All organisms including insects have a natural repair mechanism that activates *during daylight* to repair damage done by UV.
- A repair enzyme absorbs natural light from the sun to obtain energy for the repair processes.
- For UVC to be effective in doing damage to pest insects it must be applied *only at night*.
- Different stages of insects may react differently to different dosages of UVC.
- Understanding the dose of UVC required to damage different species while not disrupting the plants' ability to thrive is critical.

TRIC Robotics

Saga Robotics



TRIC Robotics





TRIC Robotics

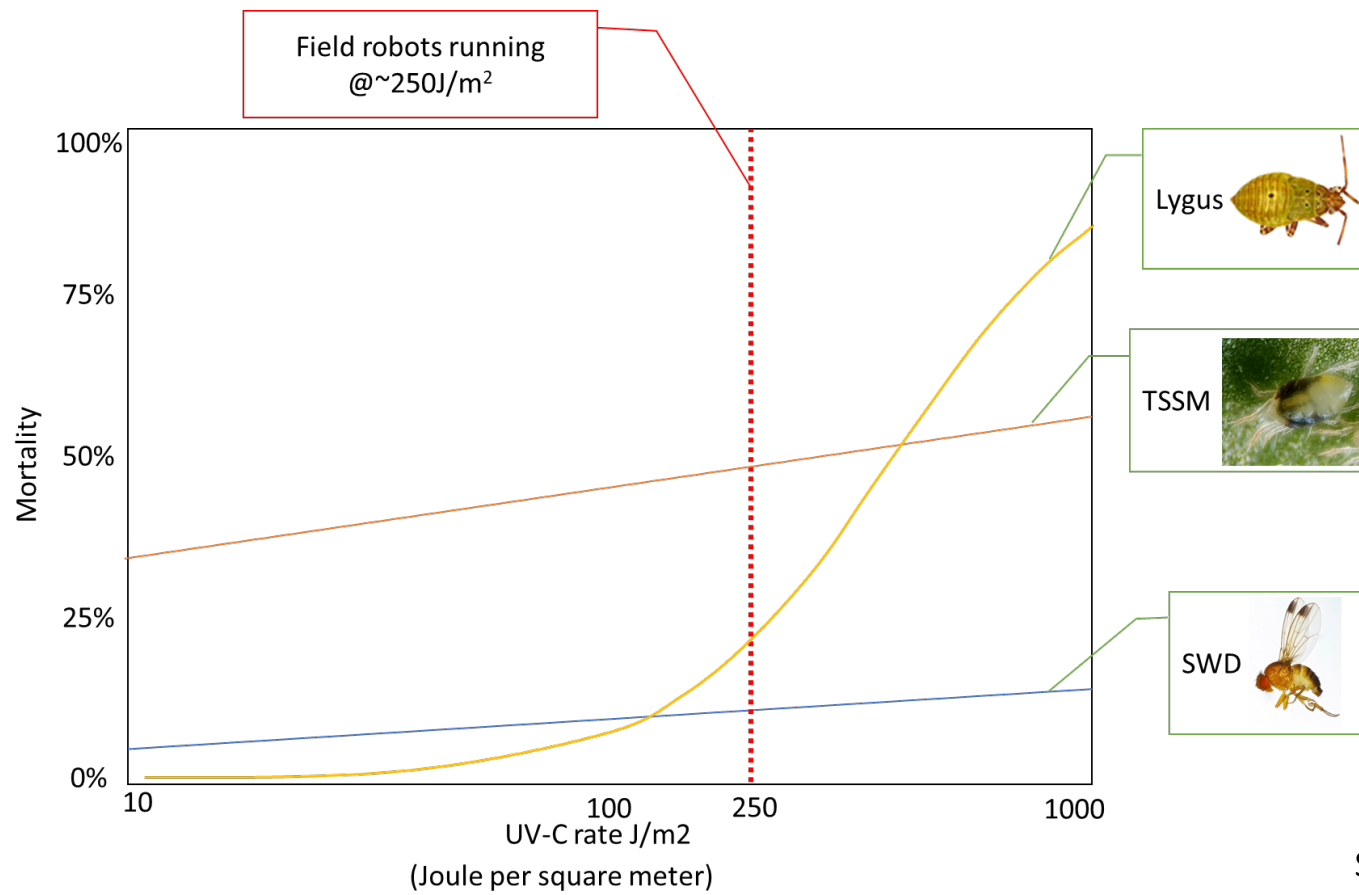




Saga Robotics







Several field studies in Salinas  
and Santa Maria...

# Improving predatory mite use in strawberries



Sam Bregman  
Student intern



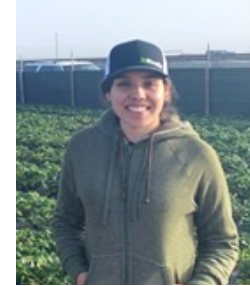
Jesus Alberto  
Martinez-Rodriguez  
Graduate student



Bella Donati  
STUDENT INTERN



Jimi Valov  
Senior  
Project



Paola Guido  
Student Intern  
SENIOR PROJECT



Noelia Ayuso  
Student intern



Alvin Xu  
STUDENT INTERN



Ben Grossman-Thompson  
STUDENT INTERN





# Non-chemical IPM for spider mites





Spider mite destroyer





# Biological Control: Our Primary Defense

Predatory mite



Pirate bug



Six-spotted  
thrips



Spider mite  
destroyer

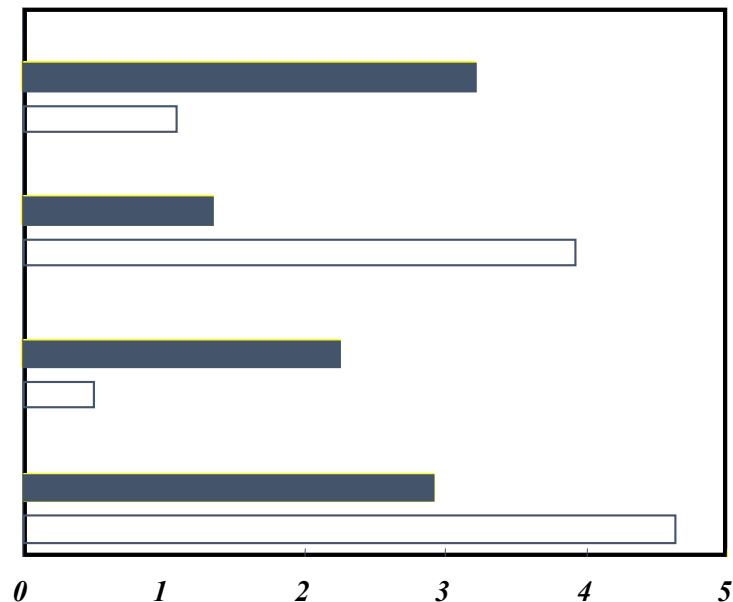


adults  
nymphs

adults  
nymphs

adults  
nymphs

adults  
larvae



*Field Estimates for Mean Number of  
Spider Mites Consumed/Predator/Hour*



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L. T. Wilson, T. Archer et al.





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Video by Jose Alvarado Rojas




# Classical biocontrol of mites

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https://www.amazon.com/000-Live-Adult-Predatory-Mites/dp/B079YWLWXY/ref=asc\_df\_B079YWLWXY/?t...

MyCenturaHealth - A... Biological control book Biological Control of ... 9th International IPM ... Functional and Numer... NIFA Reporting Portal Volume 2: Evolution a... bluecross price compa...



Roll over image to zoom in

### 4,000 Live Adult Predatory Mites - P. persimilis a Predatory Mite Species for Spider Mite Control - Ships Next Business Day!

by Nature's Good Guys

★★★★☆ 1 customer review


Price: ~~\$69.99~~ ✓prime

Pay ~~\$69.99~~ \$67.89 after using available Amazon Rewards Visa Card Points.

- Package includes approx 4,000 P. persimilis predatory mites for Spider Mite Control
- Harmless to vegetation and great at controlling Two Spotted Spider Mites.
- Easy to release. P. persimilis survive on pollen in the absence of prey.
- For use in most growing climates. Release rates 5 -10 mites per sq. ft.
- Can tolerate temperatures up to 90 degrees.

New (1) from ~~\$69.99~~ ✓prime

Report incorrect product information.



Bazos 1500 Live Ladybugs - Good Bugs - Ladybugs - Ladybugs for Garden - Guaranteed Live...

★★★★☆ 62

\$6.26

Ad feedback

**\$69.99** ✓prime

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In stock.

Usually ships within 2 to 3 days.

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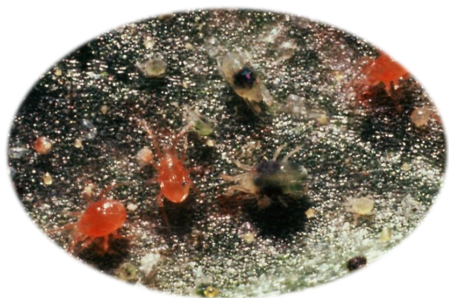


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## How to submit a sample



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Zukoff Entomology Lab  
Office: 805-540-4876  
zukoff@calpoly.edu

**Predatory mite quality assessment submission form**

---Lab copy

Please limit submission to 3-4 bottles per species per pickup  
\*\*Storage temp 50F during delivery\*\*

Contact person for submission results: Name \_\_\_\_\_ Email \_\_\_\_\_  
Farm/grower name: \_\_\_\_\_ PCA name: \_\_\_\_\_  
Date/time picked up: \_\_\_\_\_ Date of planned release: \_\_\_\_\_

Delivery company name (circle) UPS FEDEX USPS DHL Picked up Other: \_\_\_\_\_  
Mite Supplier (circle) Koppert Smites Biotactics Bioline Biobest Biobee CCI Other: \_\_\_\_\_  
Predatory mite species: \_\_\_\_\_  
Please indicate requested diagnoses A) Quantity of live mites B) Eggs laid per female

--- Customer copy

**Predatory mite quality assessment submission form**

Mite Supplier (circle) Koppert Smites Biotactics Bioline Biobest Biobee CCI Other: \_\_\_\_\_  
Date/time picked up: \_\_\_\_\_ Farm/grower name: \_\_\_\_\_  
Results emailed within 8 days.  
Questions? Contact Sarah Zukoff at zukoff@calpoly.edu, cell (805) 540-4876

Note: a copy of the results will be shared with the mite supplier.

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Zukoff Entomology Lab  
Office: 805-540-4876  
zukoff@calpoly.edu

**Predatory mite quality assessment Report**

Sample# XXX-XX

Contact person for submission results: Name: \_\_\_\_\_ Email: \_\_\_\_\_  
Farmer name: \_\_\_\_\_ PCA name: \_\_\_\_\_  
Address (city/ state): \_\_\_\_\_ Date of planned release: \_\_\_\_\_  
Delivery company name (circle) UPS FEDEX USPS DHL Other: Picked up  
Mite Supplier (circle) Koppert Smites Biotactics Bioline Biobest Biobee Mighty Mite  
CSC pick person: \_\_\_\_\_

**Rating scale**

	% live mites /# listed on label			
	poor	fair	good	excellent
all pred mites	<60%	60- 79%	80- 100	>100 (exceeds label)
# eggs/7days	poor	fair	good	excellent
Phytoseiulus persimilis	0-3	4-6	7-9	10+
Neoseiulus californicus	0-2	3-4	5-6	7+
% survival	poor	fair	good	excellent
all pred mites	<40%	40- 59%	60- 79%	80%+

**Initial bottle assessment**

Pressure in bottle upon opening? \_\_\_\_\_  
Active mites apparent at opening? \_\_\_\_\_  
Bottles were at F \_\_\_\_\_

**Sample 101-25 Assessment**

Rating	Assessment	Average number eggs/female	Test conducted
# eggs / 7 days			32 adult females x 1 bottle
% live mites /# listed on label		Bottle avg: #1 #2	whole bottle counts
% survival		%	32 adult females x 1 bottle
Health notes			

Questions? Contact Sarah Zukoff at zukoff@calpoly.edu, 805-540-4876

Note: a copy of the results will be shared with the mite supplier.

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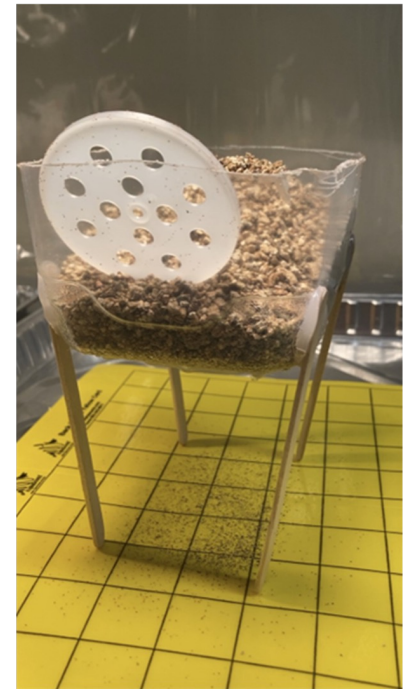


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# Predatory mite quality summary for 2021-2022

year	company	# samples received
2021	Biotactics	4
	Bioline	10
	Koppert	6
	Mighty Mite	4
2022	Biobest	2
	Bioline	2
	Mighty Mite	12
	Smites	12
	USA AG	2
	Central Coast Insectary	1



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2021      2022  
~63%    ~45%

# lives mites per bottle/# listed on bottle label=  
% live mites

Year	Predatory mite company	Average number of live mites per bottle	Species
2021	PM-A	100%	<i>Neoseiulus californicus</i>
2021	PM-A	47%	<i>Phytoseiulus persimilis</i>
2022	PM-A	41%	<i>Phytoseiulus persimilis</i>
2021	PM-B	64%	<i>Neoseiulus californicus</i>
2021	PM-C	19%	<i>Phytoseiulus persimilis</i>
2022	PM-C	40%	<i>Phytoseiulus persimilis</i>
2021	PM-D	70%	<i>Phytoseiulus persimilis</i>
2021	PM-E	75%	<i>Phytoseiulus persimilis</i>
2022	PM-E	54%	<i>Phytoseiulus persimilis</i>
2022	PM-F	75%	<i>Phytoseiulus persimilis</i>
2022	PM-G	12%	<i>Phytoseiulus persimilis</i>











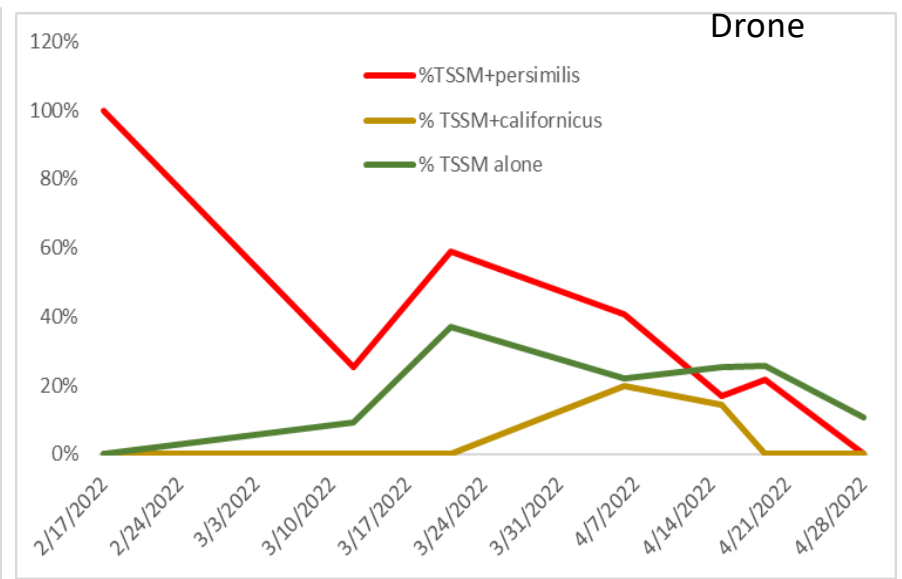
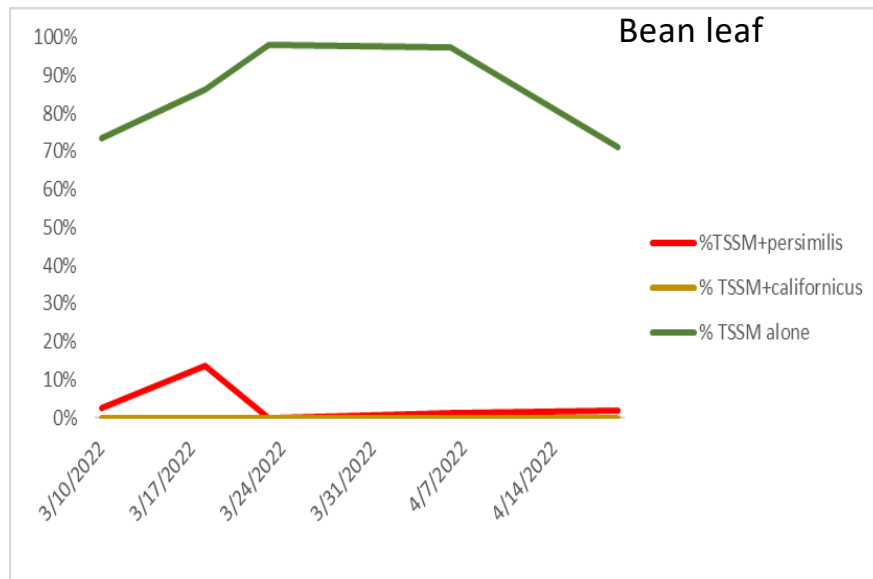
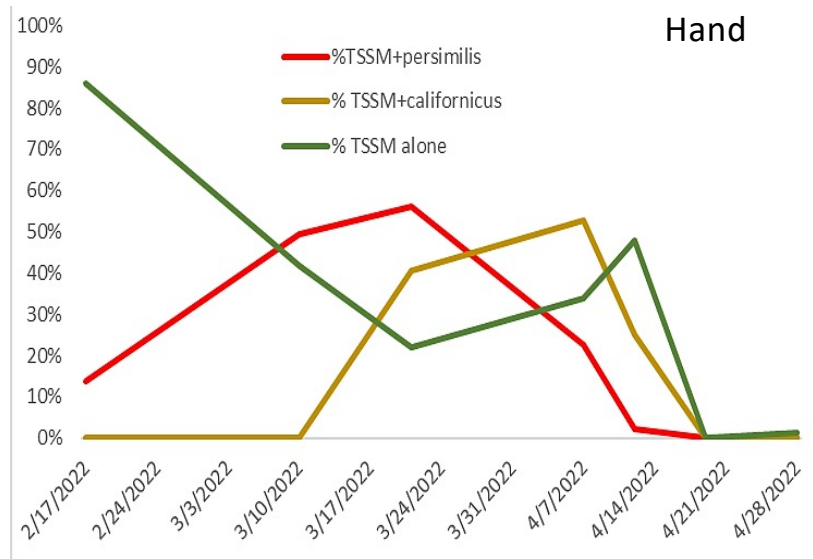






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# Spotted Wing Drosophila



*Gnaspis brasiliensis*  
(Gb for short)





## Honey bees foraging preference in strawberry



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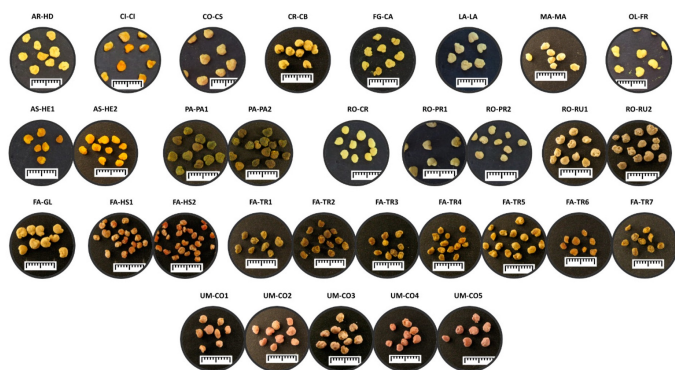
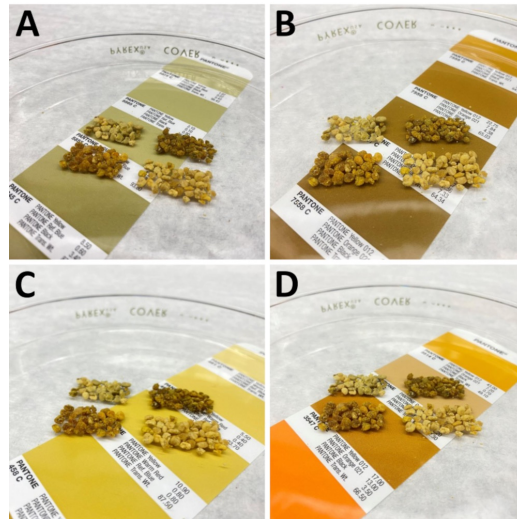


## Honey bees foraging preference in strawberry





# Honey bees foraging preference in strawberry







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