Biology and management of thrips and the viruses they spread

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2023 Organic Seminar Series
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USDA Agricultural Research Service

Biology and management of thrips and the viruses they spread

Thrips/tospovirus biology

- Virus symptomology
- Thrips life cycle and virus transmission

Thrips and INSV host range

- Thrips dispersal and abundance in crops and non-crops
- Top 10 INSV hosts

Optimizing organic solutions for managing thrips and INSV

- Immune priming
- Precision sprayers

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Thrips as vectors for viruses affecting agriculture

Order: Thysanoptera; Family: Thripidae (thrips, >2,000 species)

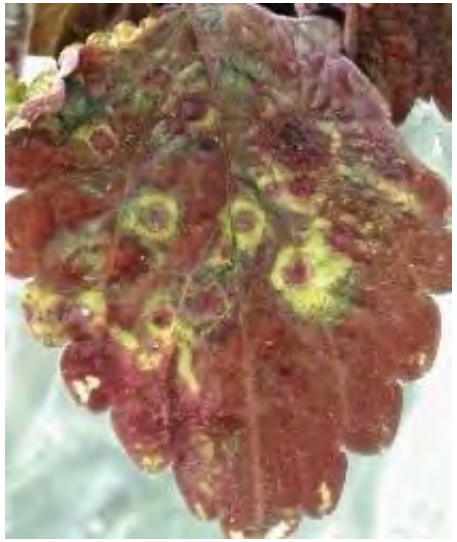
Insect vector: Western flower thrips, *Frankliniella occidentalis,* numerous

- **Diseases: Numerous**
- **Viruses: *Tomato spotted wilt virus* (TSWV), *Impatiens necrotic spot virus* (INSV), >20 (Family: Tospoviridae)**
- **Crops: Tomatoes, pepper, lettuce, onions, maize, ornamentals (orchid, begonia, petunia, etc.) , >800 plant species**
- **Losses: Billions of dollars annually, globally**

Adult: 1-2 mm in length

TSWV in tomato and pepper

INSV in lettuce



INSV in coleus

Rotenberger et al., 2020

Monterey County's Top Crops: 2021

Crop	Gross Production Value	Acres	~U.S. contribution
Strawberries	$968,086,000	10,044	28%
Leaf Lettuce	$741,598,000	57,483	61%
Head Lettuce	$451,556,000	37,808	56%
Broccoli	$309,490,000	38,936	48%
Wine Grapes	$218,591,000	44,886	3.6%
Spinach	$173,882,000	16,430	38%
Cauliflower	$155,983,000	18,404	30%
Celery	$146,641,000	9,861	57%
Livestock/poultry	$113,434,000	-	-
Brussels Sprout	$105,616,000	6,094	-

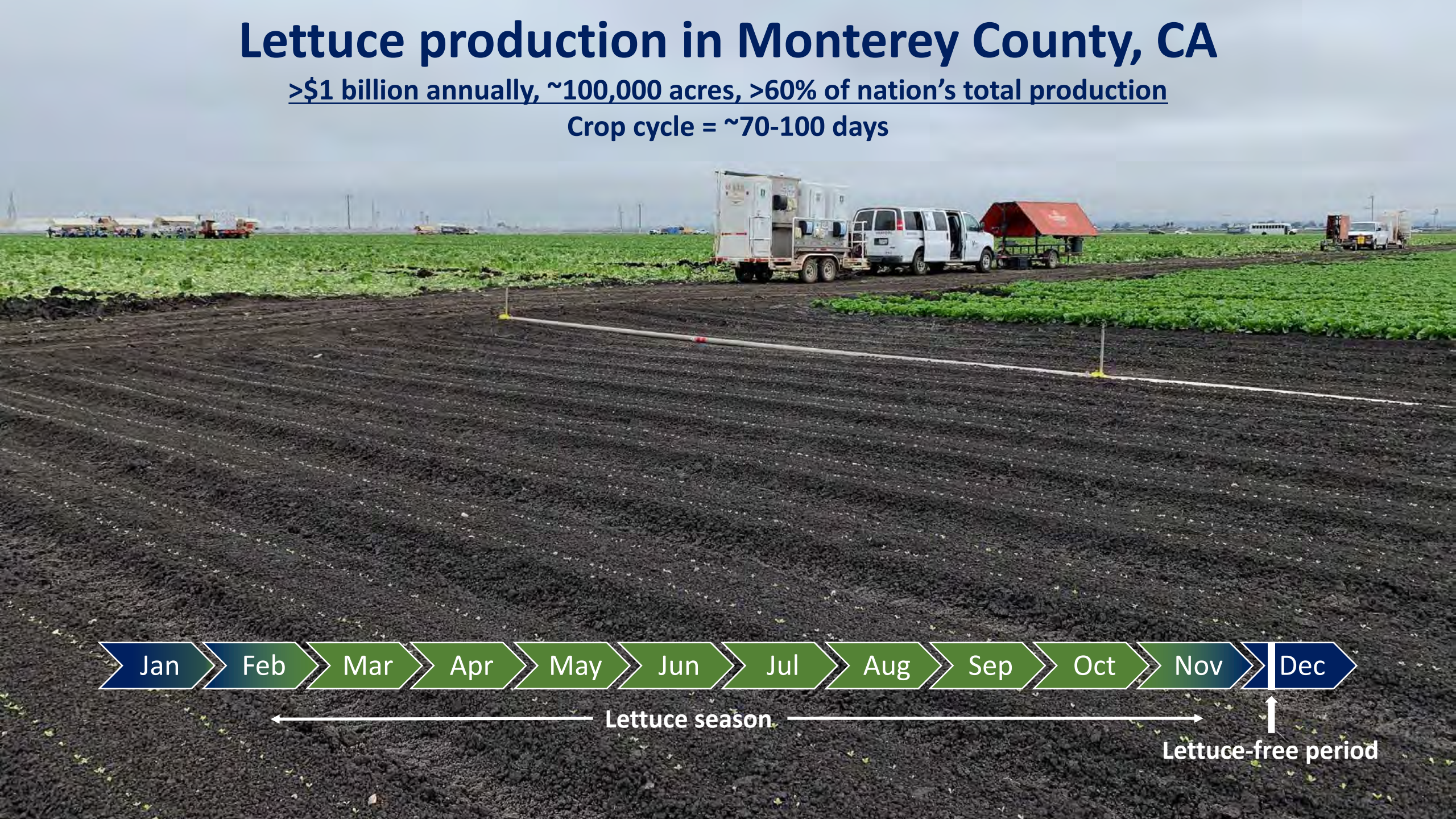
>100 different crops grown in Monterey County

FARM BUREAU MONTEREY

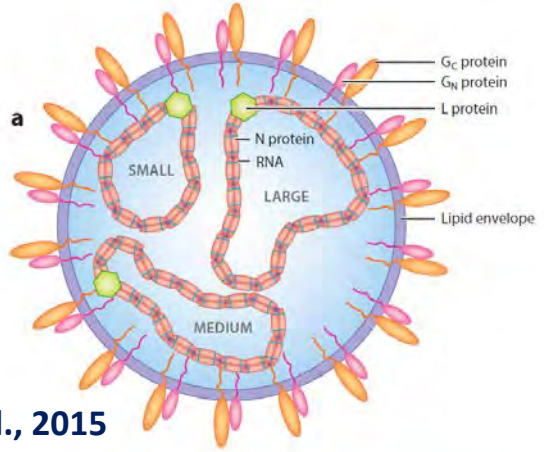
Lettuce production in Monterey County, CA

>$1 billion annually, ~100,000 acres, >60% of nation's total production

Crop cycle = ~70-100 days



Impatiens necrotic spot virus (INSV) and it's occurrence in CA lettuce

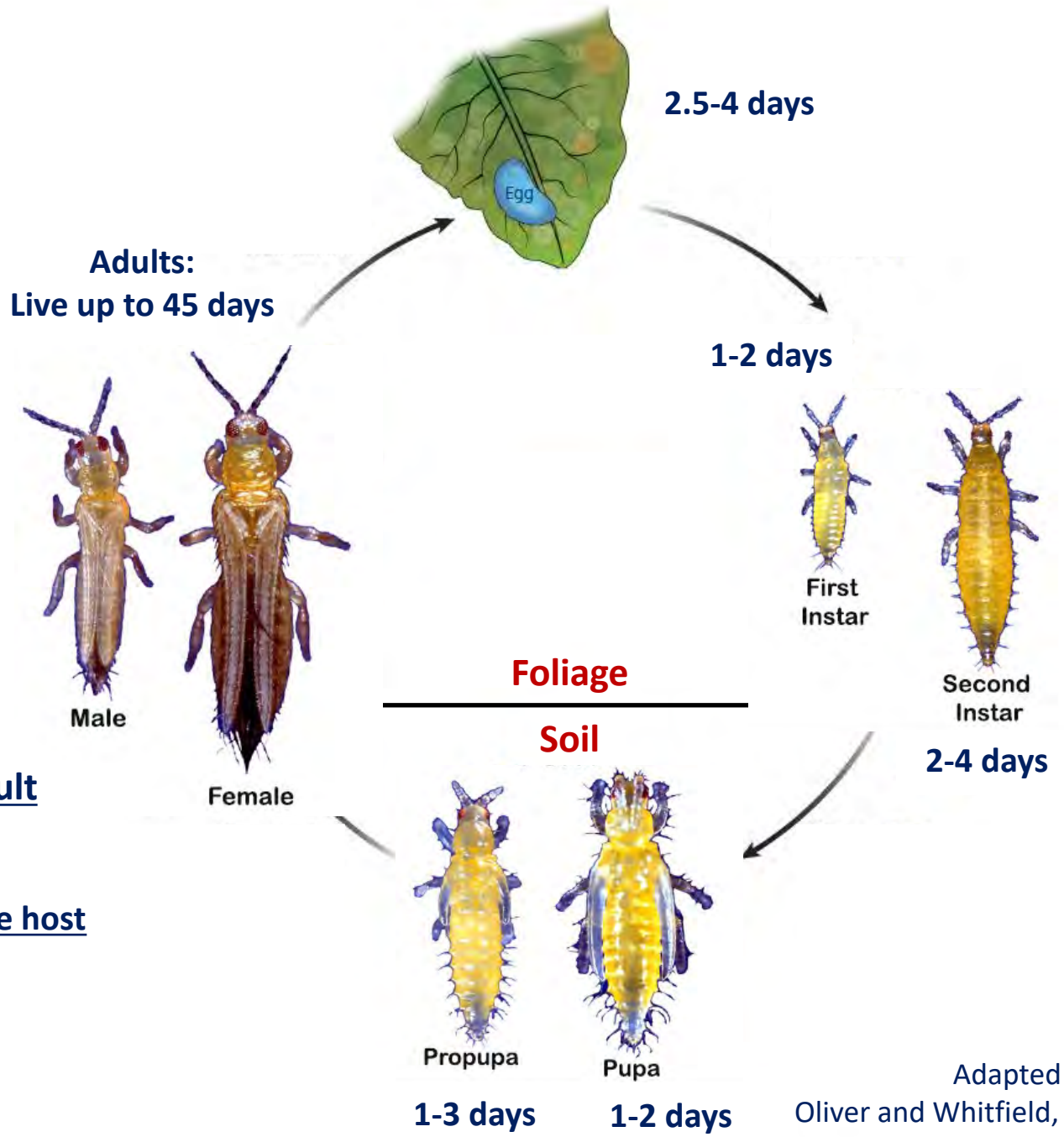


Rotenberg et al., 2015

- Historically considered a pathogen of ornamental crops, but increasing importance in vegetables in Europe and North America
- 2006: INSV first reported in lettuce in the Salinas Valley
- 2006 - 2012: Minor to severe isolated outbreaks of INSV in lettuce
- 2019 - 2022: Severe outbreaks in the Salinas Valley. Up to 100% crop losses.
- 2022: >$150 million dollars lost

Western flower thrips: vector for INSV

Western flower thrips, *Frankliniella occidentalis*



Adapted from
Oliver and Whitfield, 2016
Rotenberger et al., 2020

Vector management challenges:

- Small (1-2 mm), cryptic, high fecundity
- Limited chemical options in CA lettuce
  - ~20% organic production in 2021
- Host range = 100s of plants

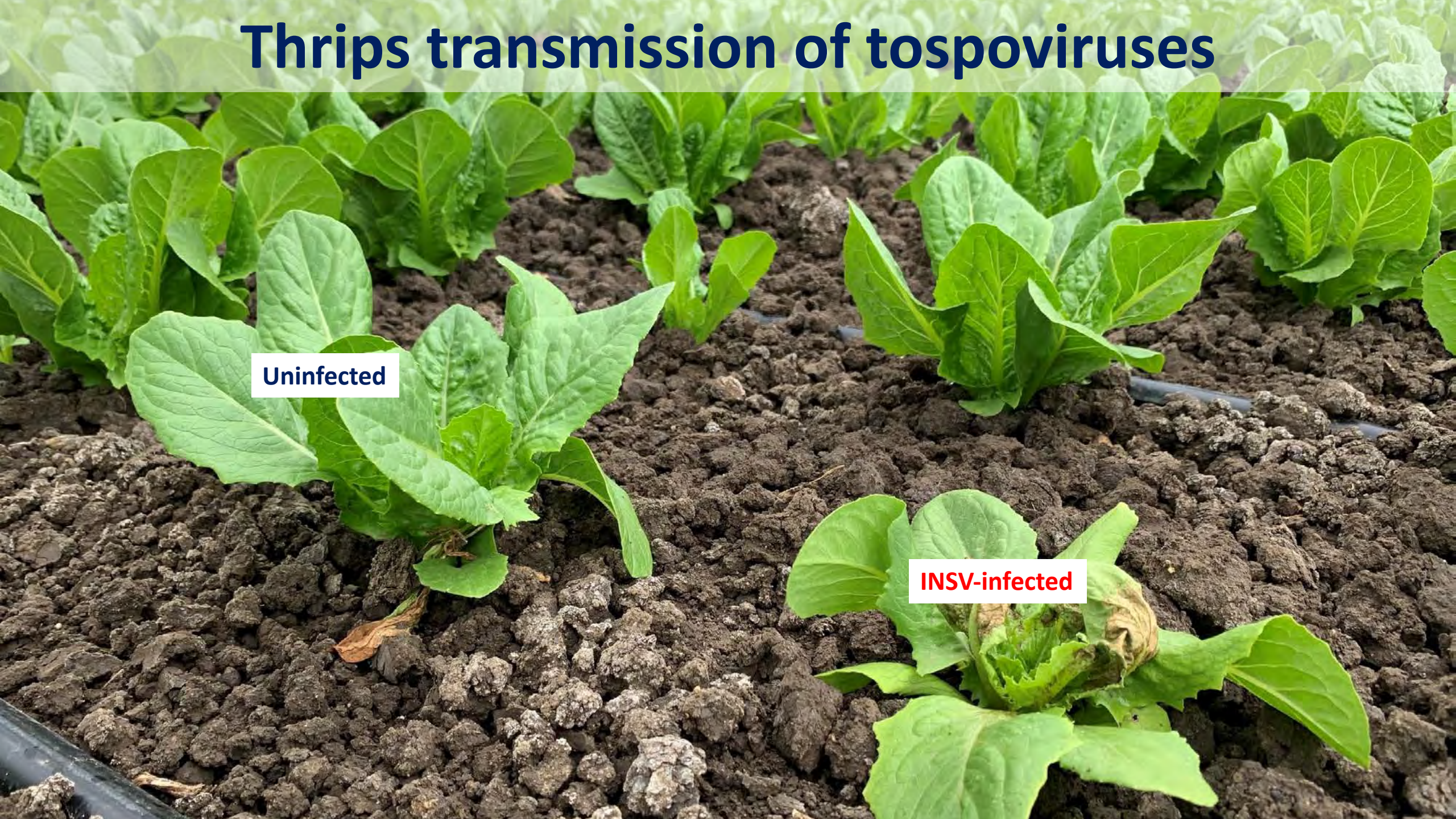
Virus Management challenges:

- Lack of genetic-based resistance to INSV in lettuce
- Host range = 100s of plants

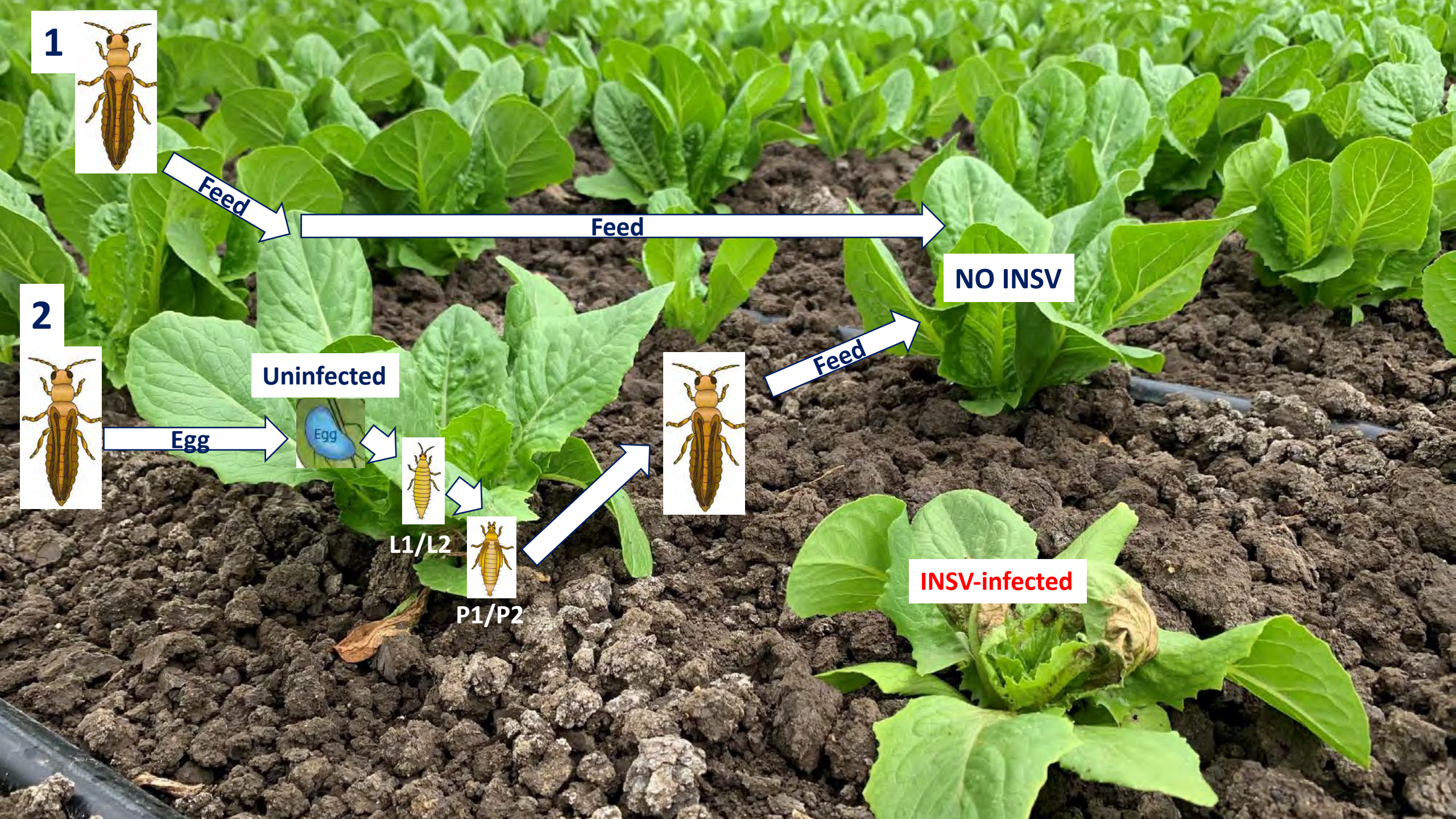
Virus must be acquired as larvae to transmit as an adult

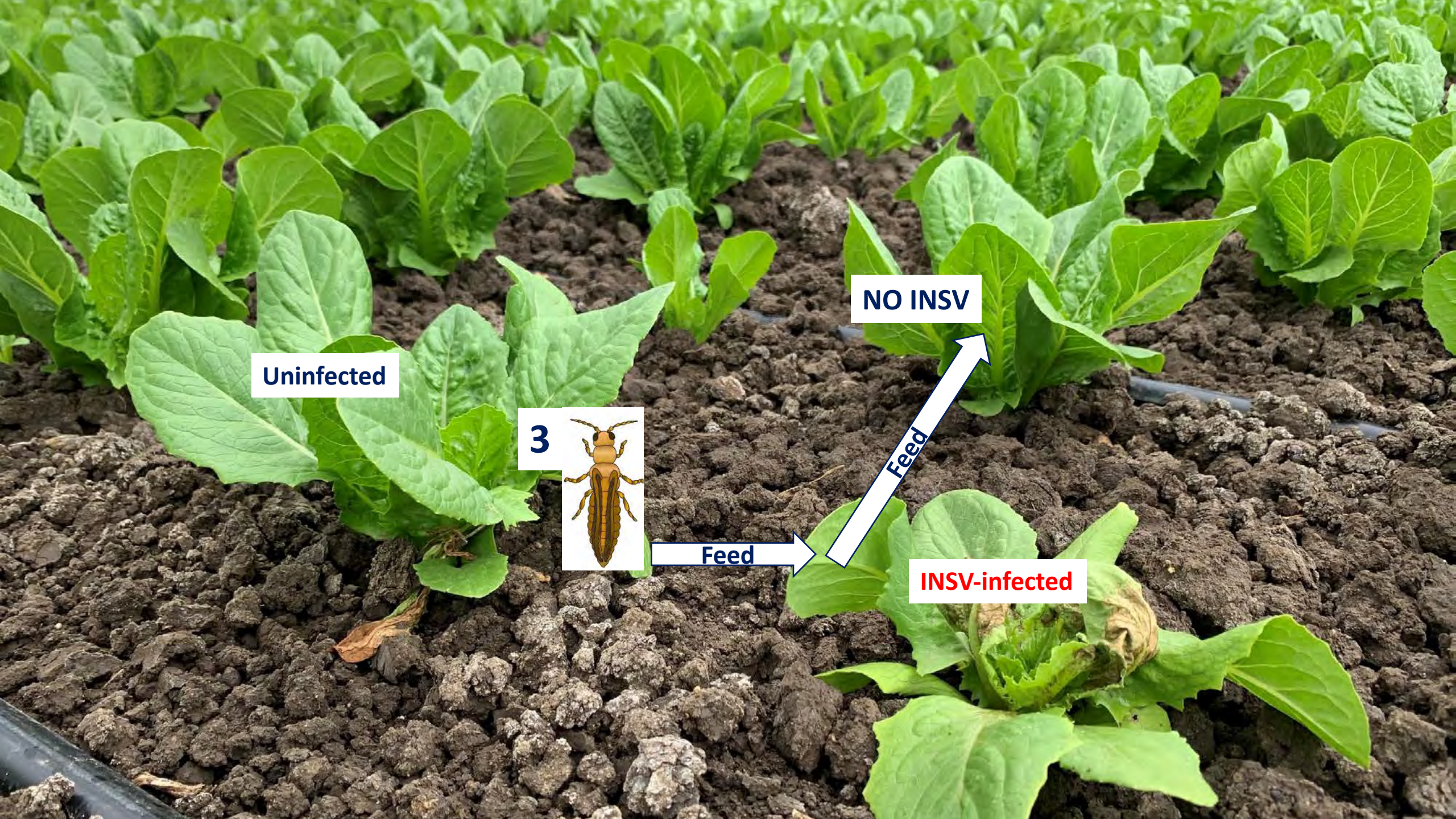
- Adults transmit the virus.
- Virus is not passed from adult to offspring.
- Plants that are infected with INSV must be a reproductive host for western flower thrips for virus acquisition to occur.

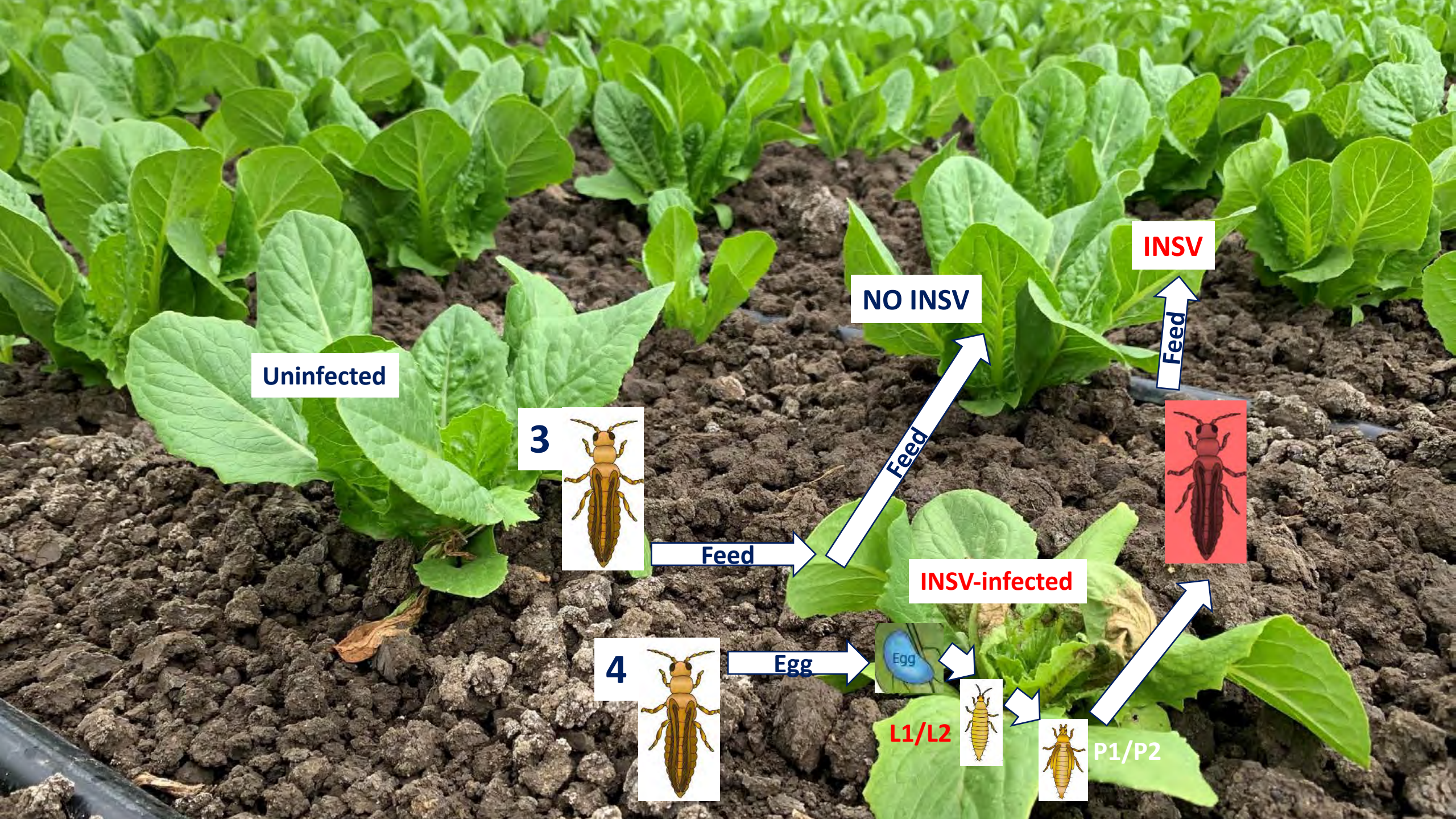
Thrips transmission of tospoviruses



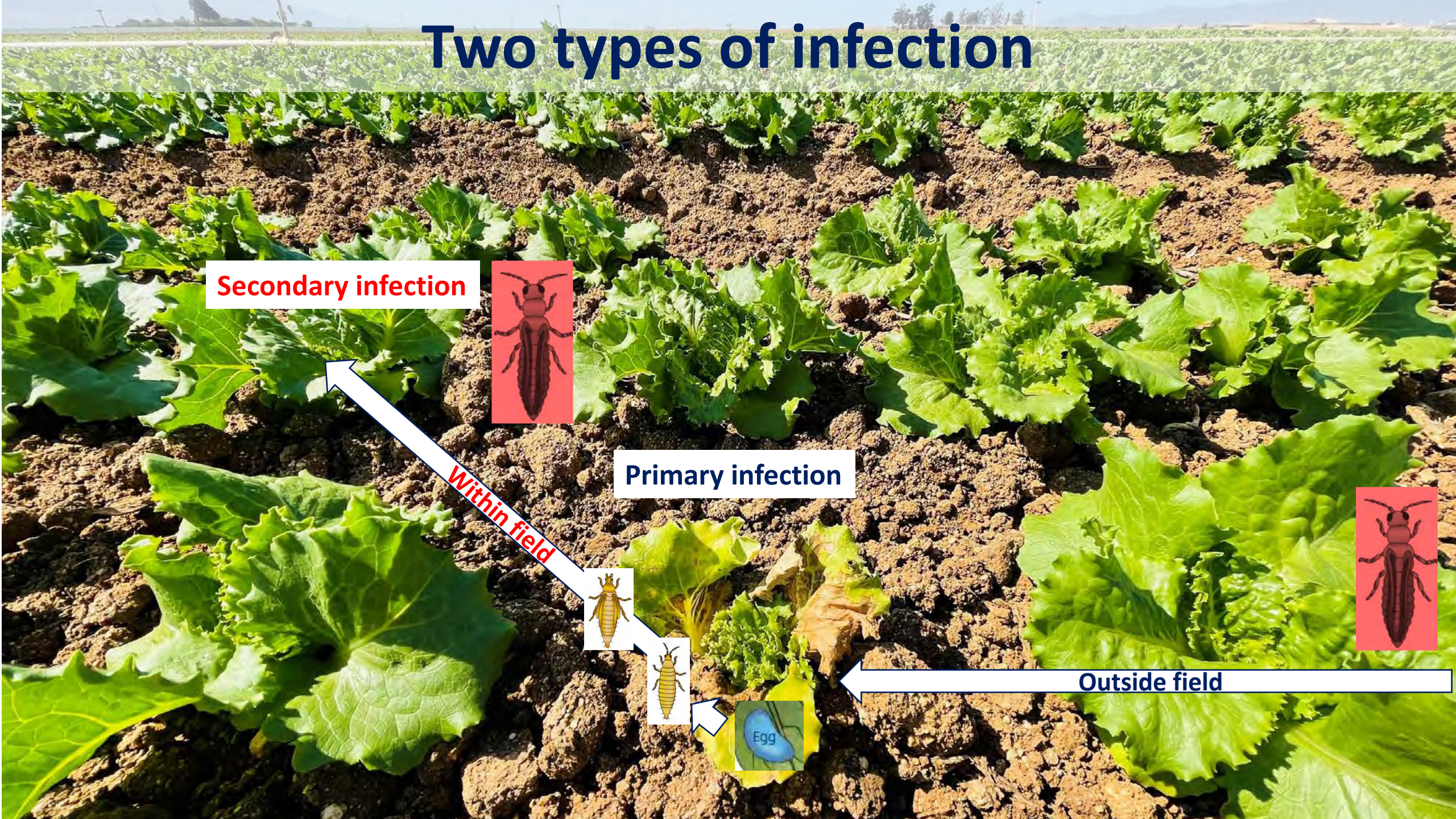

1
Feed
Feed
NO INSV
Uninfected
INSV-infected


1
Feed
Feed
NO INSV
2
Uninfected
Egg
Egg
L1/L2
P1/P2
Feed
INSV-infected


Uninfected
3
Feed
NO INSV
Feed
INSV-infected


Uninfected
3
Feed
NO INSV
Feed
INSV
Feed
INSV-infected
4
Egg
Egg
L1/L2
P1/P2

Two types of infection



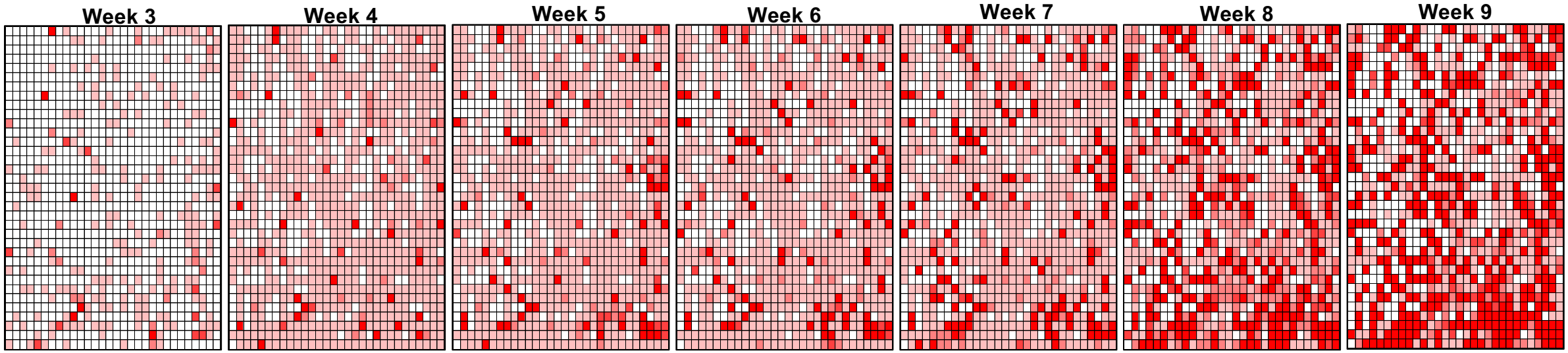
INSV incidence strongly aggregates

INSV severity
0 1 2 3 4 5

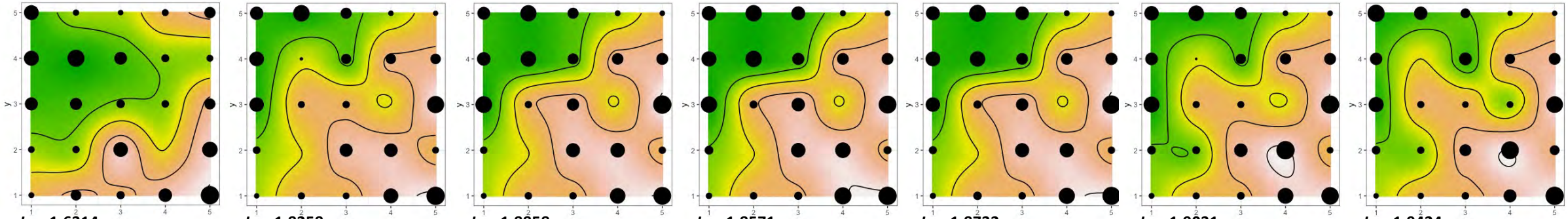
INSV Severity

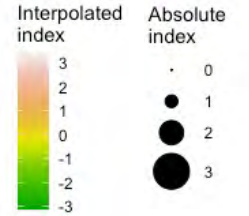
Planting: Week 1

Harvest: Week 10



INSV Incidence

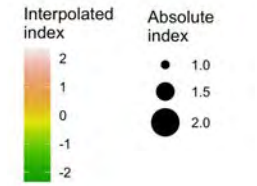




CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

Hasegawa and Del-Pozo, 2022

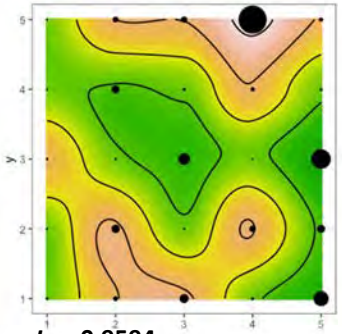
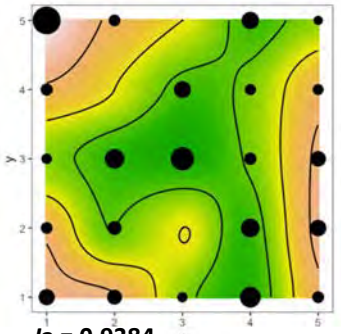
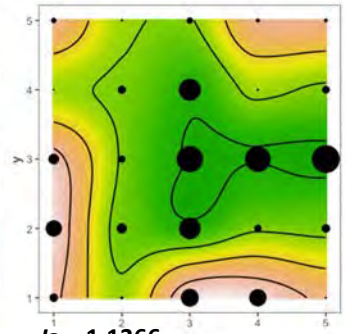
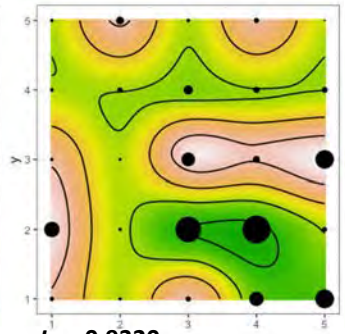
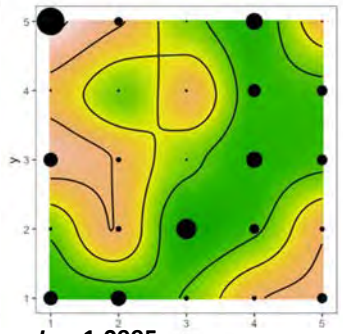
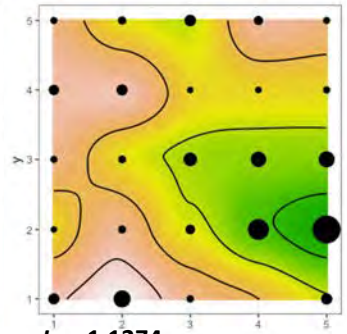
INSV incidence strongly aggregates



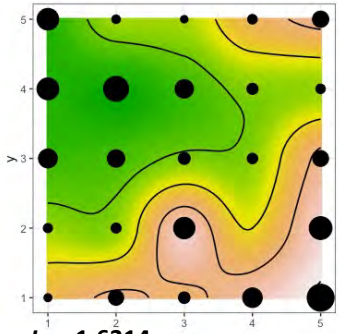
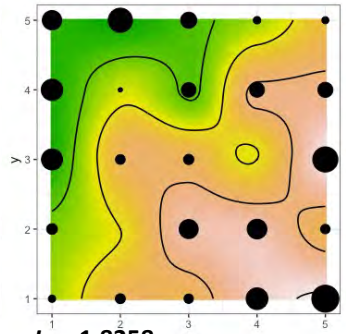
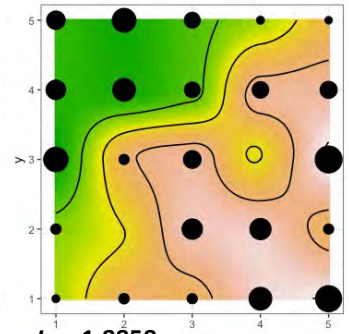
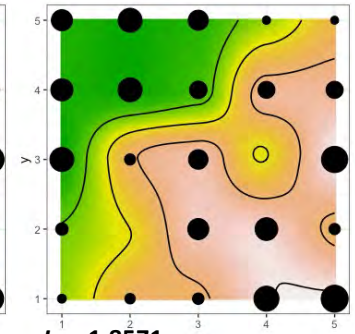
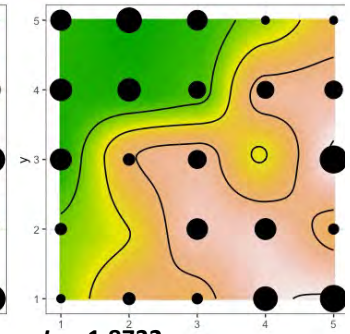
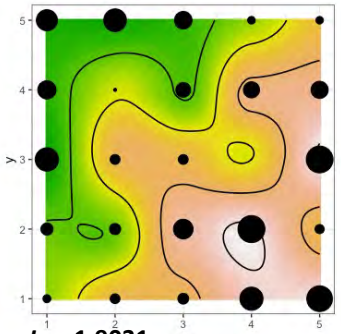
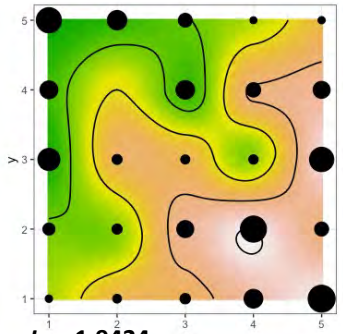
Planting: Week 1

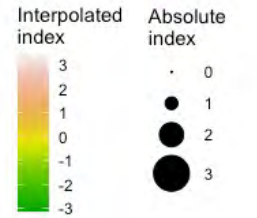
Harvest: Week 10

Thrips Abundance

Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Thrips not recovered in sampling						
	Ia = 0.9594 *Pa* = 0.5400	*Ia* = 0.9384 *Pa* = 0.6700	*Ia* = 1.1366 *Pa* = 0.1500	*Ia* = 0.9320 *Pa* = 0.6300	*Ia* = 1.0995 *Pa* = 0.2600	*Ia* = 1.1274 *Pa* = 0.1700

INSV Incidence

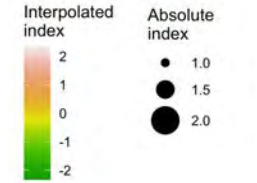
						
Ia = 1.6314 *Pa* = 0.0100	*Ia* = 1.8258 *Pa* < 0.0001	*Ia* = 1.8858 *Pa* < 0.0001	*Ia* = 1.8571 *Pa* < 0.0001	*Ia* = 1.8732 *Pa* < 0.0001	*Ia* = 1.9031 *Pa* < 0.0001	*Ia* = 1.9424 *Pa* < 0.0001



Thrips distribution does not *always* equal INSV distribution

Hasegawa and Del-Pozo, 2022

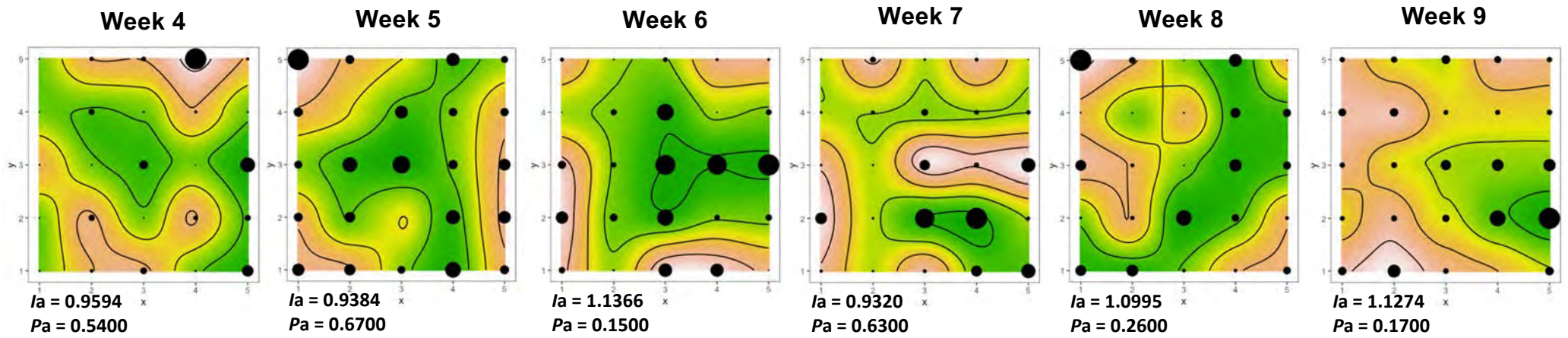
Thrips abundance increases over time

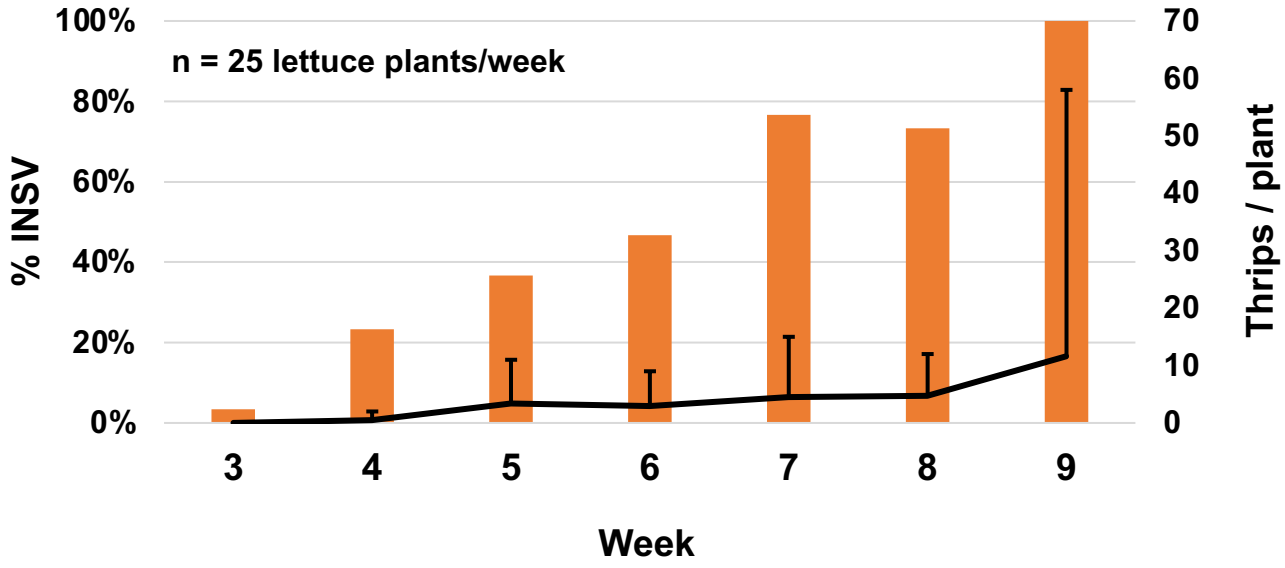


Thrips Abundance

Planting: Week 1

Harvest: Week 10





Hasegawa and Del-Pozo, 2022

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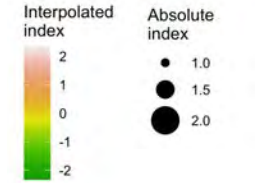

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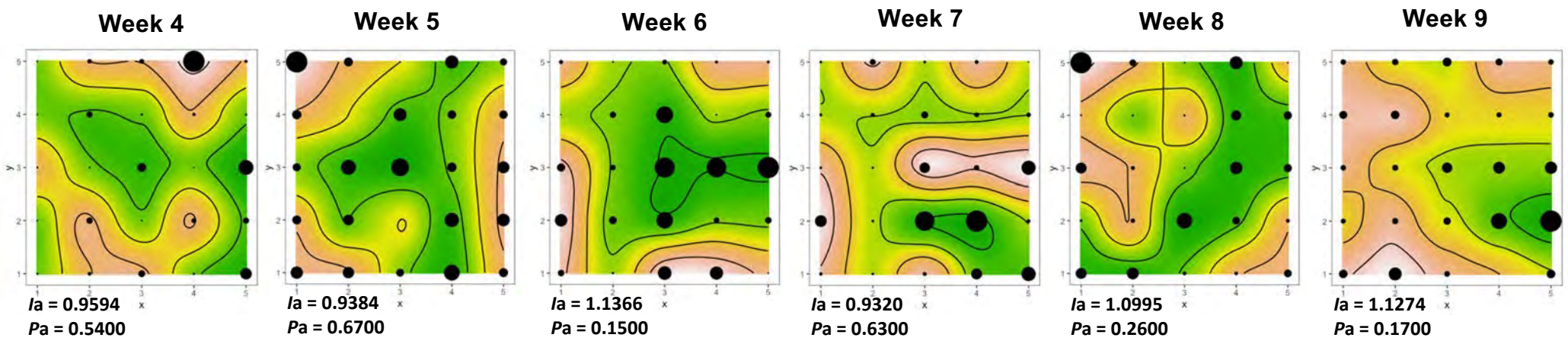
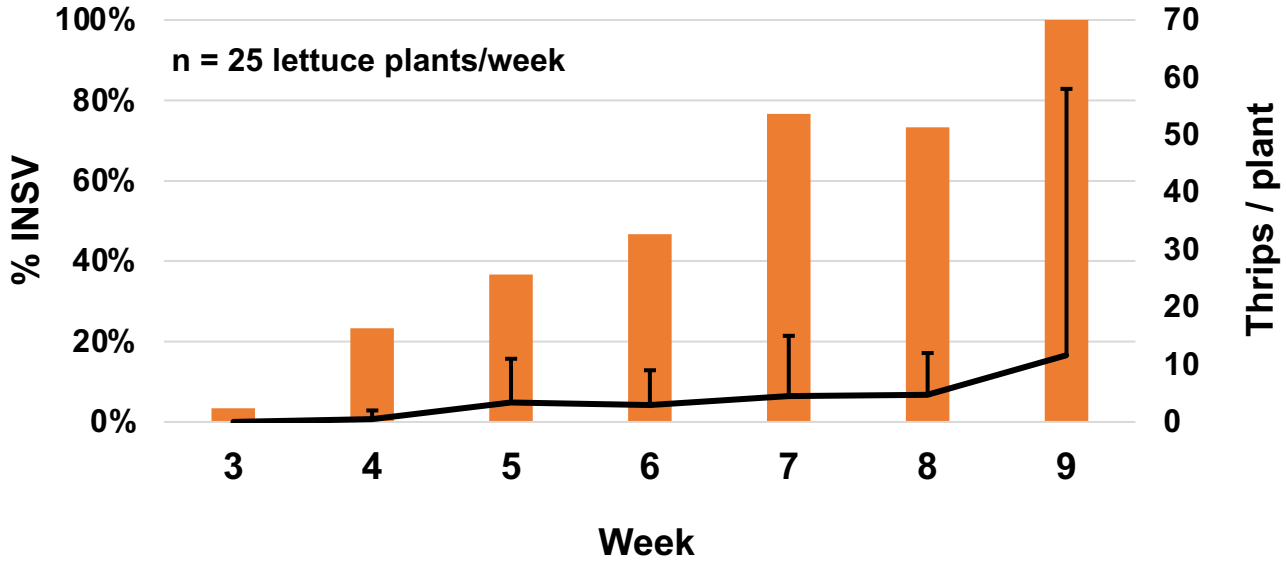
Week 3

Thrips not recovered in sampling

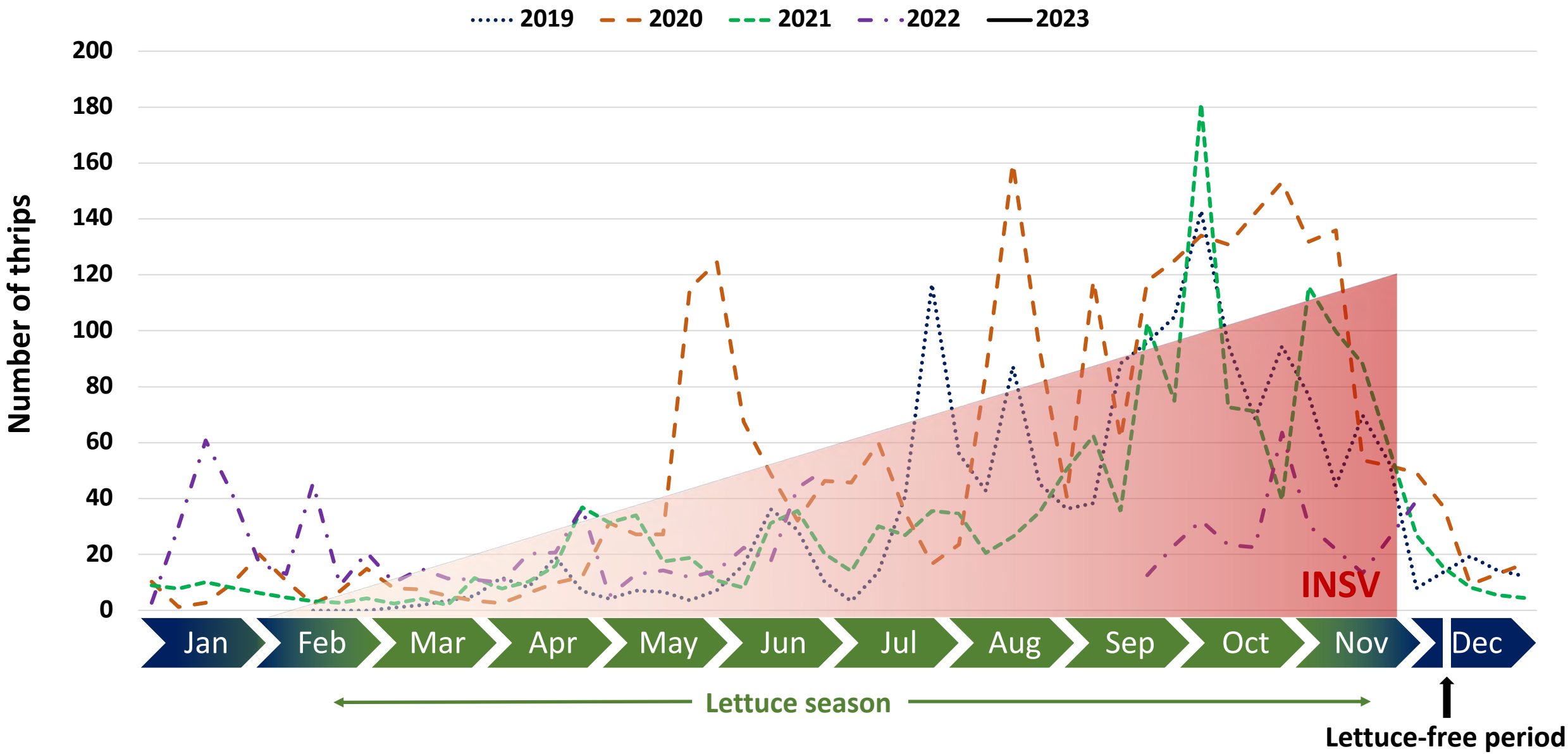




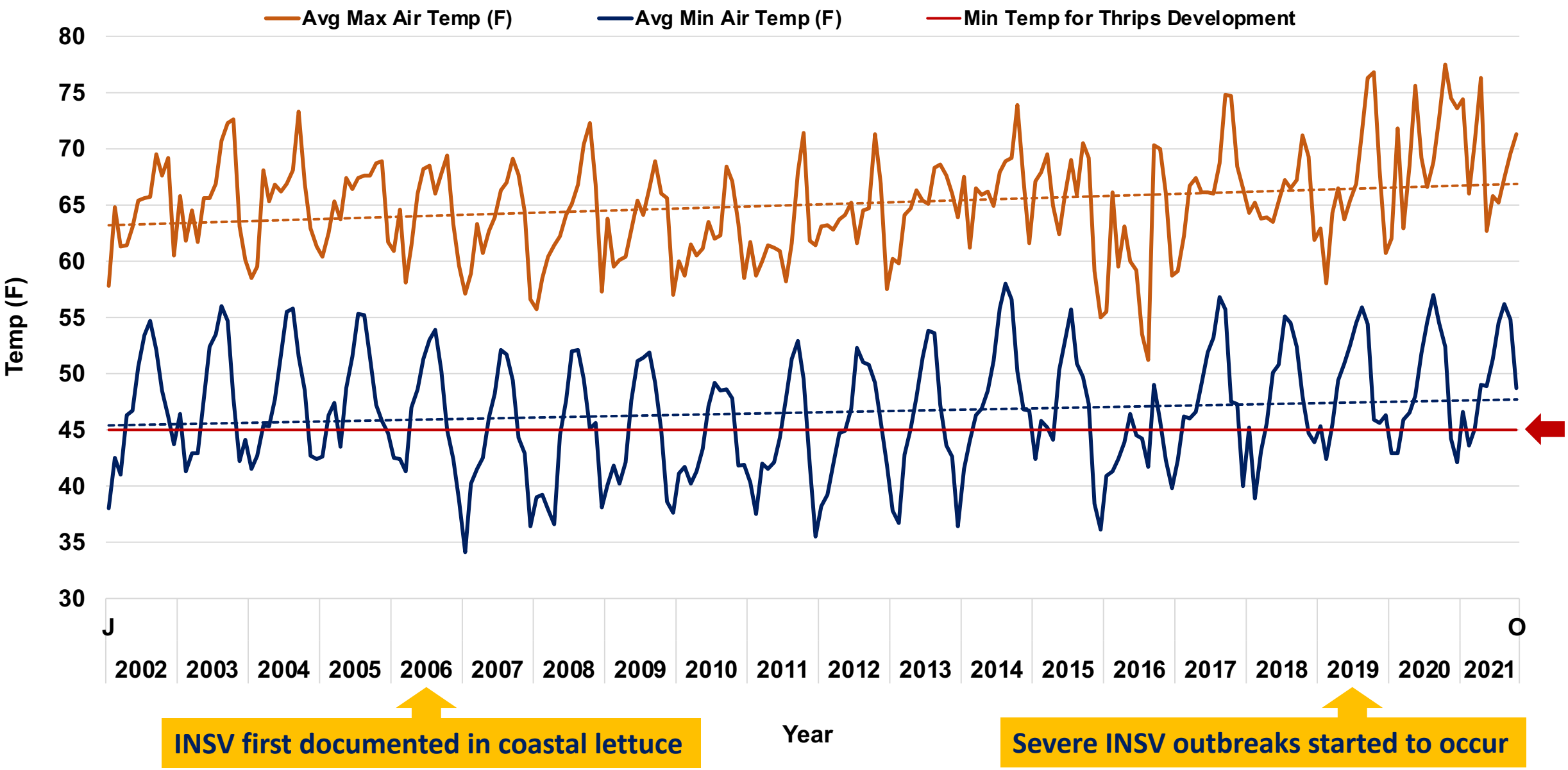
Hasegawa and Del-Pozo, 2022

Salinas Valley thrips monitoring network

Thrips/sticky card/week (21 total, average)



Air temperature: 20 years



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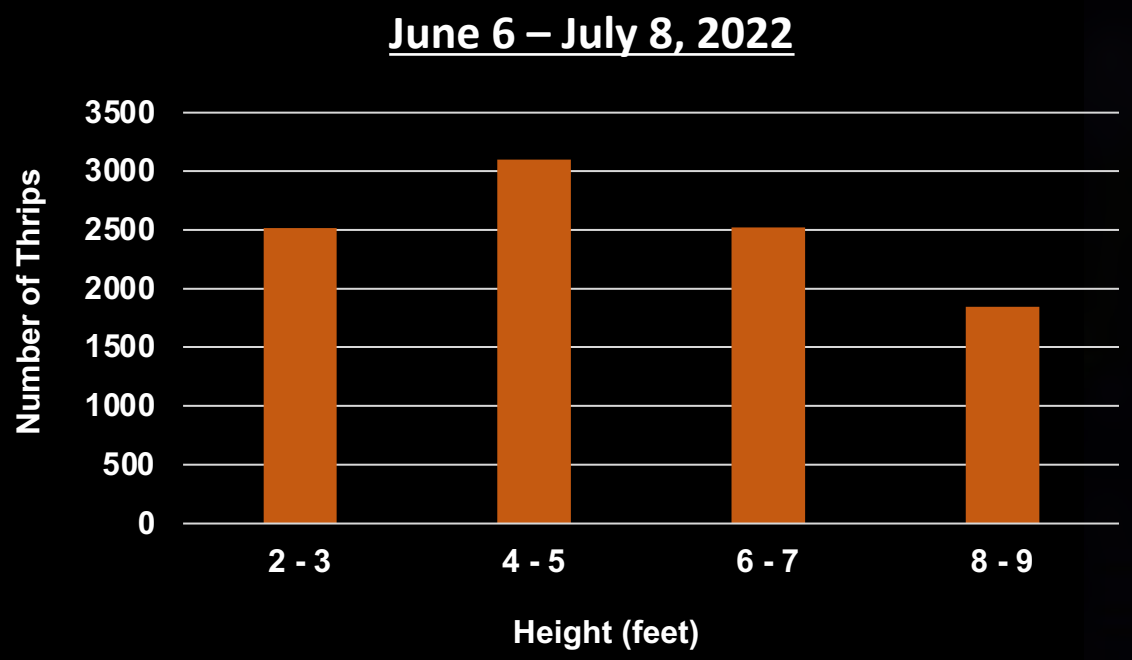
Optimizing organic solutions for managing thrips and INSV

- Immune priming
- Precision sprayers

Thrips dispersal

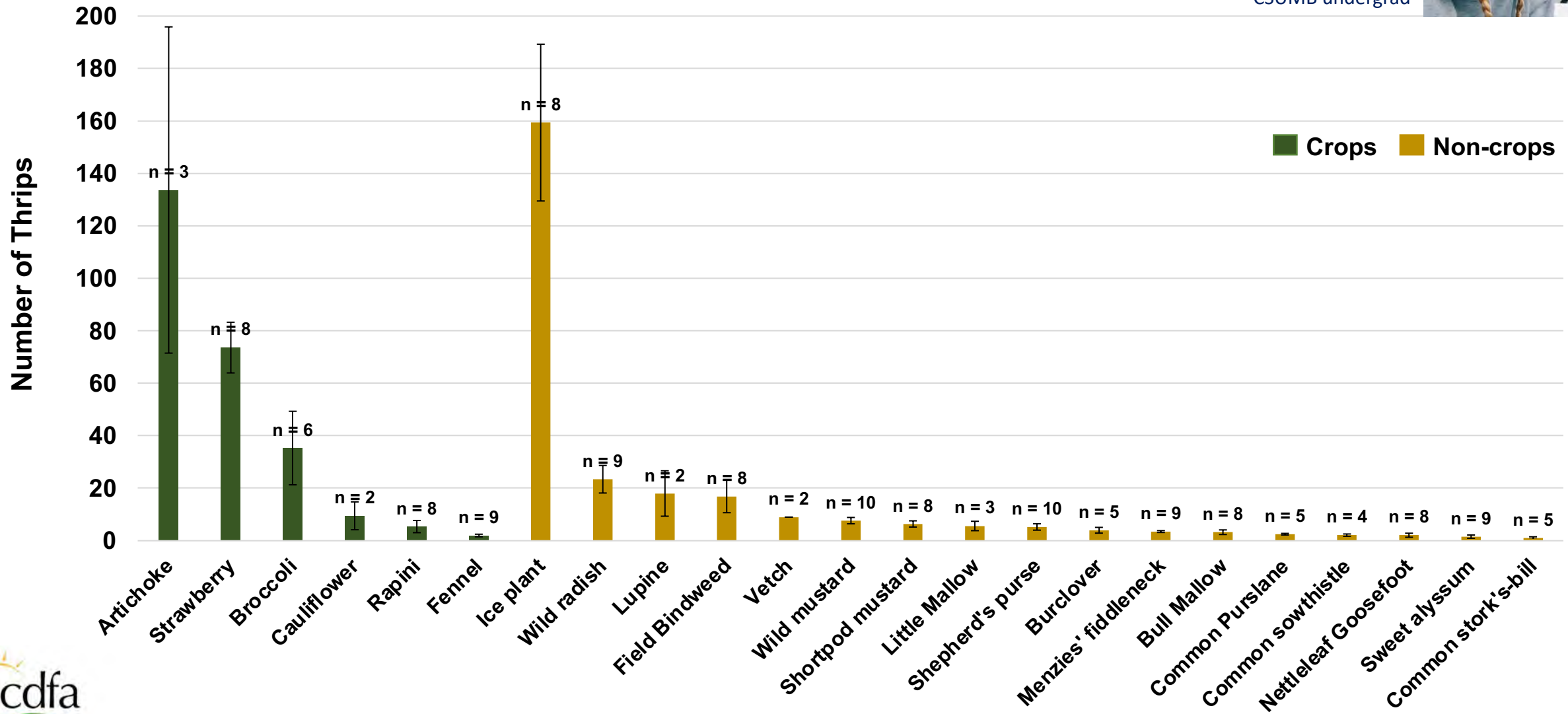
- Thrips are poor flyers
- Rely heavily on wind for dispersal
- Distance is hard to estimate



Thrips abundance in crops and non-crops

Average number of adult thrips/10 flowers

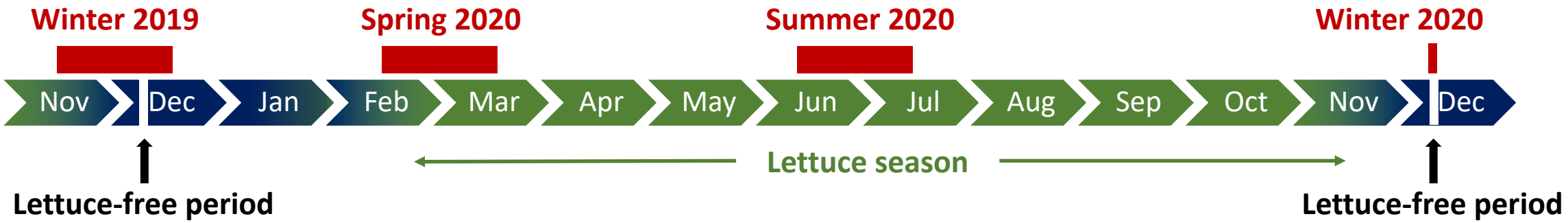
Kiara Gable
USDA, Salinas
CSUMB undergrad



cdfa
CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Field surveys to identify hosts for INSV: Salinas Valley

Sampling summary:
>3,000 plant samples tested for INSV
73 species: majority weeds, native plants, vegetable crops

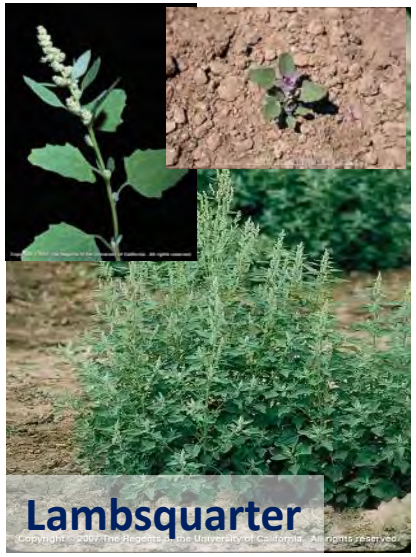


Primary detection of INSV:
Serological: TAS-ELISA

Validation:
Serological: Lateral flow rapid strip tests
Genetic: RT-PCR

CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

Top 10 hosts



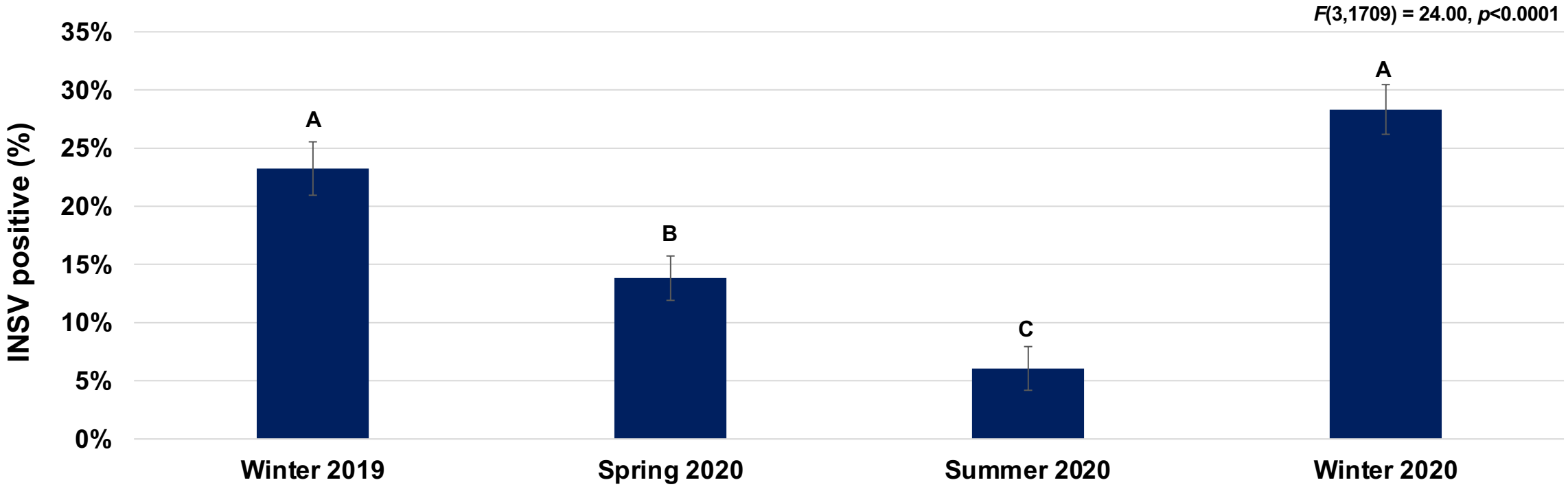
Pictures courtesy of Richard Smith and UC ANR

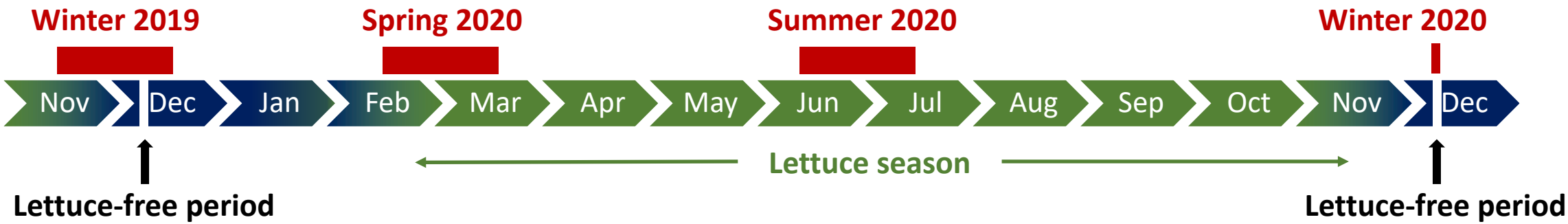
Top 10 non-lettuce hosts for INSV on the Central Coast of CA

				Seasonal abundance			
Common name	**Scientific name**	**Family**	**Category**	**Winter**	**Spring**	**Summer**	**Fall**
Little Mallow	*Malva parviflora*	Malvaceae (Mallow Family)	Broadleaf	++	++	++	++
Annual Sowthistle	*Sonchus oleraceus*	Asteraceae (Sunflower Family)	Broadleaf	++	++	++	++
Nettleleaf goosefoot	*Chenopodium murale*	Chenopodiaceae (Goosefoot Family)	Broadleaf	+	++	++	++
Mare's Tail	*Conyza canadensis*	Asteraceae (Sunflower Family)	Broadleaf	+	++	++	++
Field Bindweed	*Convolvulus arvensis*	Convolvulaceae (Morning glory Family)	Broadleaf	0	++	++	++
Shepherds Purse	*Capsella bursa-pastoris*	Brassicaceae (Mustard Family)	Broadleaf	++	++	++	++
Common Purslane	*Portulaca oleracea*	Portulacaceae (Purslane Family)	Broadleaf	0	+	++	++
Hairy Fleabane	*Conyza bonariensis*	Asteraceae (Sunflower Family)	Broadleaf	+	++	++	++
Burning Nettle	*Urtica urens*	Urticaceae (Nettle Family)	Broadleaf	++	++	++	++
Common Lambsquarter	*Chenopodium album*	Chenopodiaceae (Goosefoot Family)	Broadleaf	0	++	++	++

http://ipm.ucanr.edu/PMG/weeds_all.html

Top 10 non-lettuce hosts for INSV on the Central Coast of CA





Hasegawa et al., in prep

SALINAS VALLEY AGRICULTURE
Highlighting agricultural developments, problems, research, & issues for central coast CA

Non-INSV Host Plants for Habitat Plantings

Author: Richard Smith **Published on: March 3, 2023**

Non- Impatiens Necrotic Spot Virus (INSV) Plants for Habitat Plantings

Richard Smith[1], Daniel Hasegawa[2], Kirsten Pearsons[1] and Yu-Chen Wang[1]

1 - UCCE Monterey County and 2 - USDA ARS, Salinas

Species	No. tested with zero positives	Comments
Insectary Planting		
Alyssum	14	
Cover crops[1]		
Cereals (Rye, triticale and oats)	10	Oats and barley were surveyed. Cereals generally not been found to be hosts for INSV
Bell beans and other legumes	10	Bell bean tested negative in the survey, but beans and peas are considered good hosts for INSV, and to be safe, legumes are not recommended.
Slope Stabilization		
Hottentot fig (ice plant)	91	Was not found to be a host of INSV, but the flowers are good habitat for thrips
Annual grasses	10	Samples evaluated were from the foothills east of Chualar (likely bromes, fescues and/or wild oats)
Hedgerow plantings[2]		
Coyote bush	19	
Willows	10	Only Arroyo Willow (*Salix lasiolepis*) was tested.
Deerweed	14	*Acmispon glaber*

Biology and management of thrips and the viruses they spread

Thrips/tospovirus biology

- Virus symptomology
- Thrips life cycle and virus transmission

Thrips and INSV host range

- Thrips dispersal and abundance in crops and non-crops
- Top 10 INSV hosts

Optimizing organic solutions for managing thrips and INSV

- Immune priming
- Precision sprayers

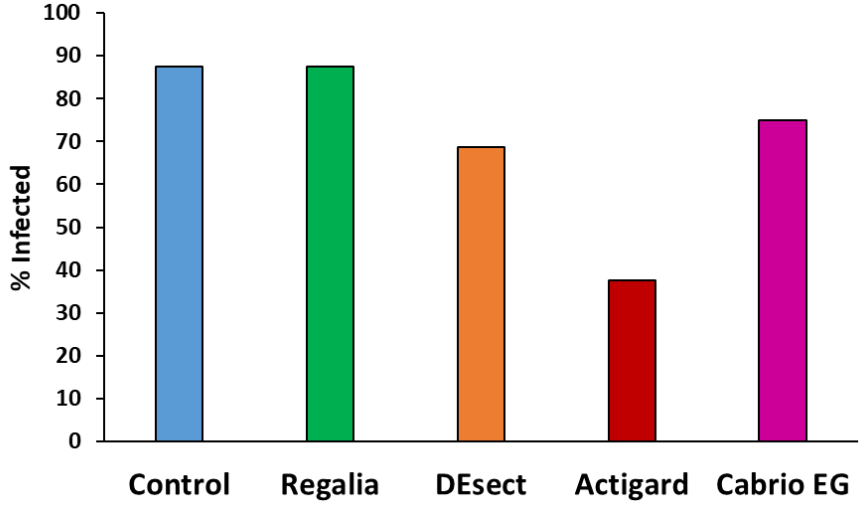
Enhancing Virus Control in Lettuce and Melons by Optimizing Immunity Priming Approaches

2.5 years (2021 – 2024); Year 1: Greenhouse trials

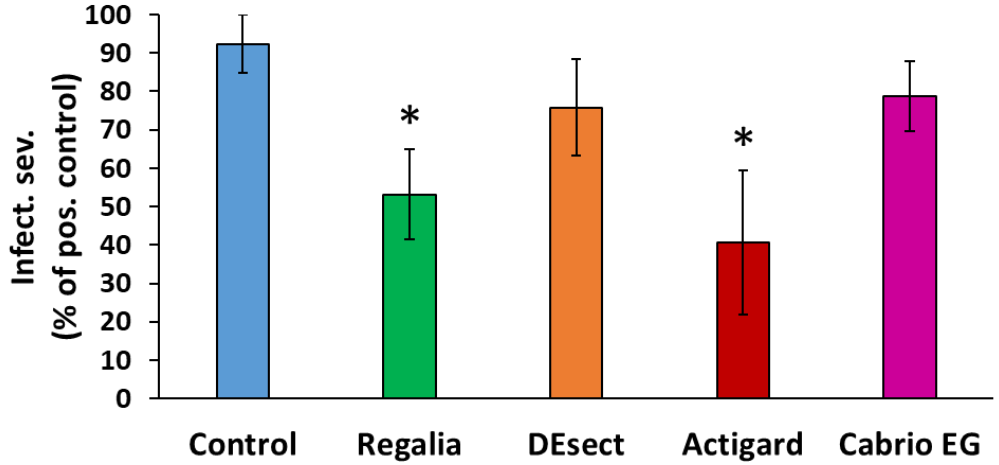
Dr. Kerry Mauck
Assistant Professor of
Entomology, UC Riverside

1. Actigard (AI = acibenzolar-*S*-methyl [ASM]).
2. Regalia (AI = extract of Giant Knotweed *Reynoutria sachalinensis*).
3. Cabrio EG (AI = pyraclostrobin).
4. DEsect (AI = silicon dioxide).

INSV incidence



INSV severity



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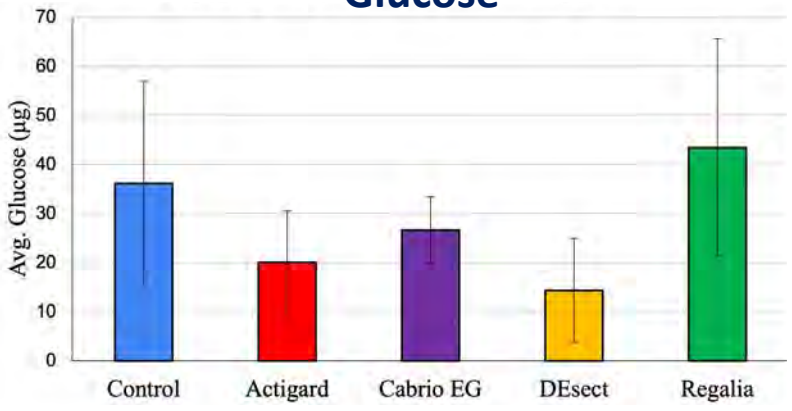
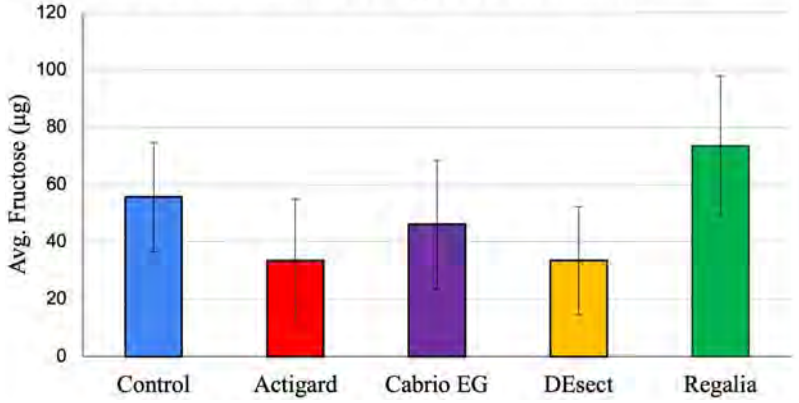
Plant metabolites

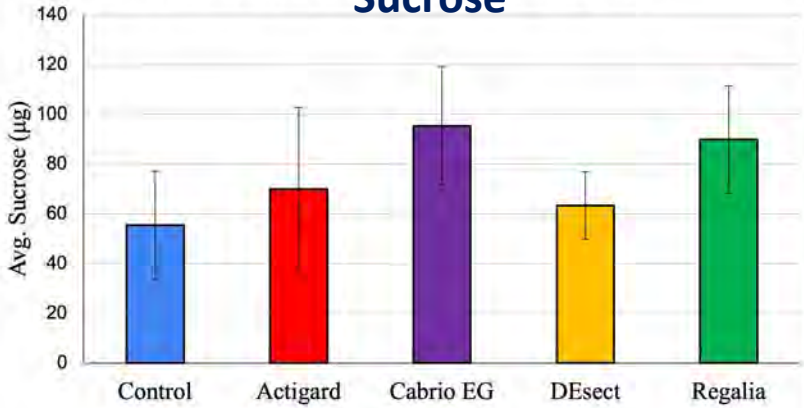
Glucose



Fructose



Sucrose



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Dr. Ian Grettenberger
UC Davis

Mantis sprayer experiments

Addie Abrams
UC Davis

Organic insecticides for aphid and thrips control

2 trials

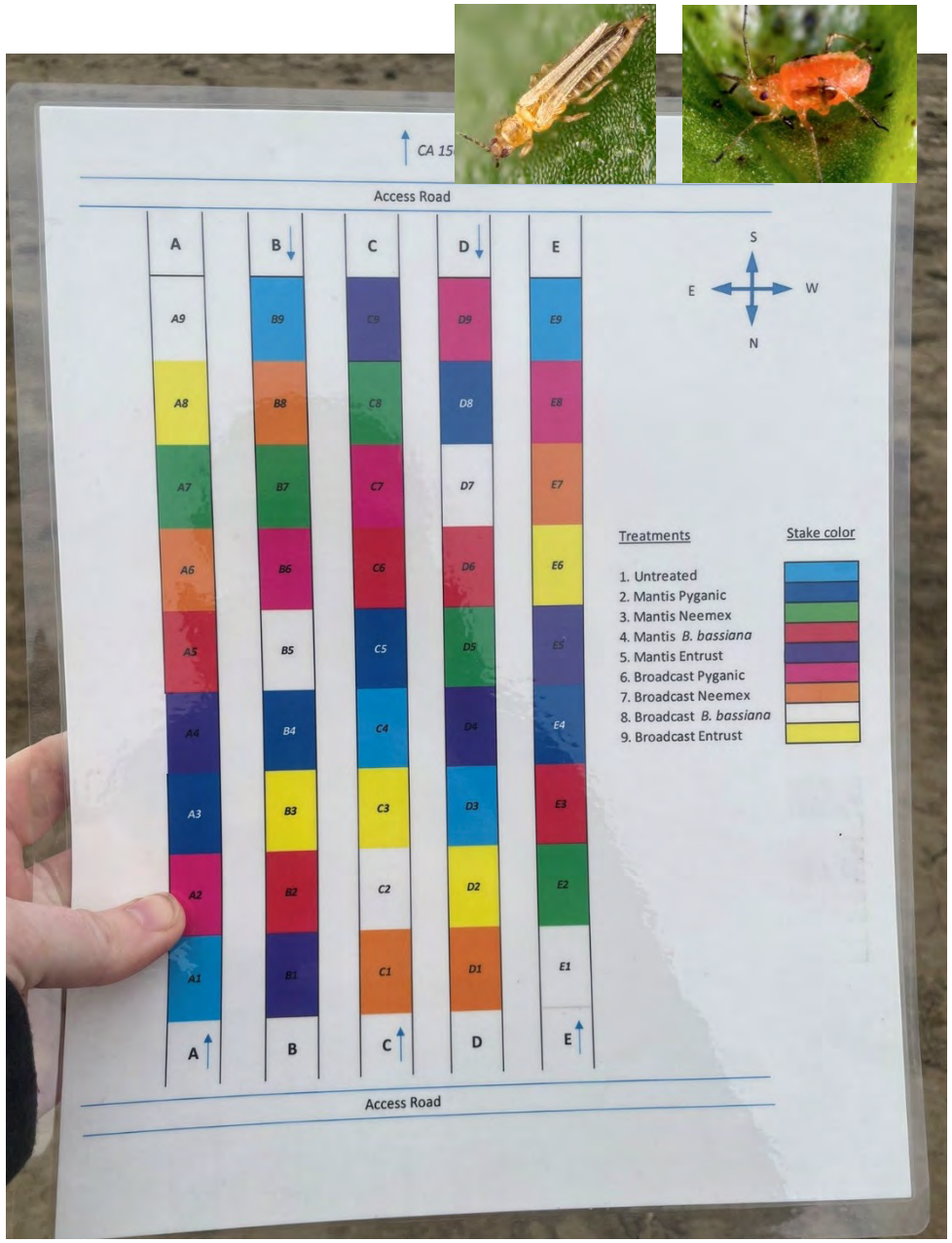
4 products tested

2 application systems

mantis ag technology

Mantis with organic insecticides

- Organic romaine lettuce
- Two trials at different sites
- 2 applications
  - Manual thinning stage
  - 7-10 days after spray 1
- 4 products tested with both systems
  - Pyganic (pyrethrin)
  - Entrust (spinosad)
  - Neemex (azadirachtin)
  - Mycotrol ESO (B. bassiana)
- All products applied at per acre label max



Mantis with organic insecticides

Application 1 : Manual thinning stage

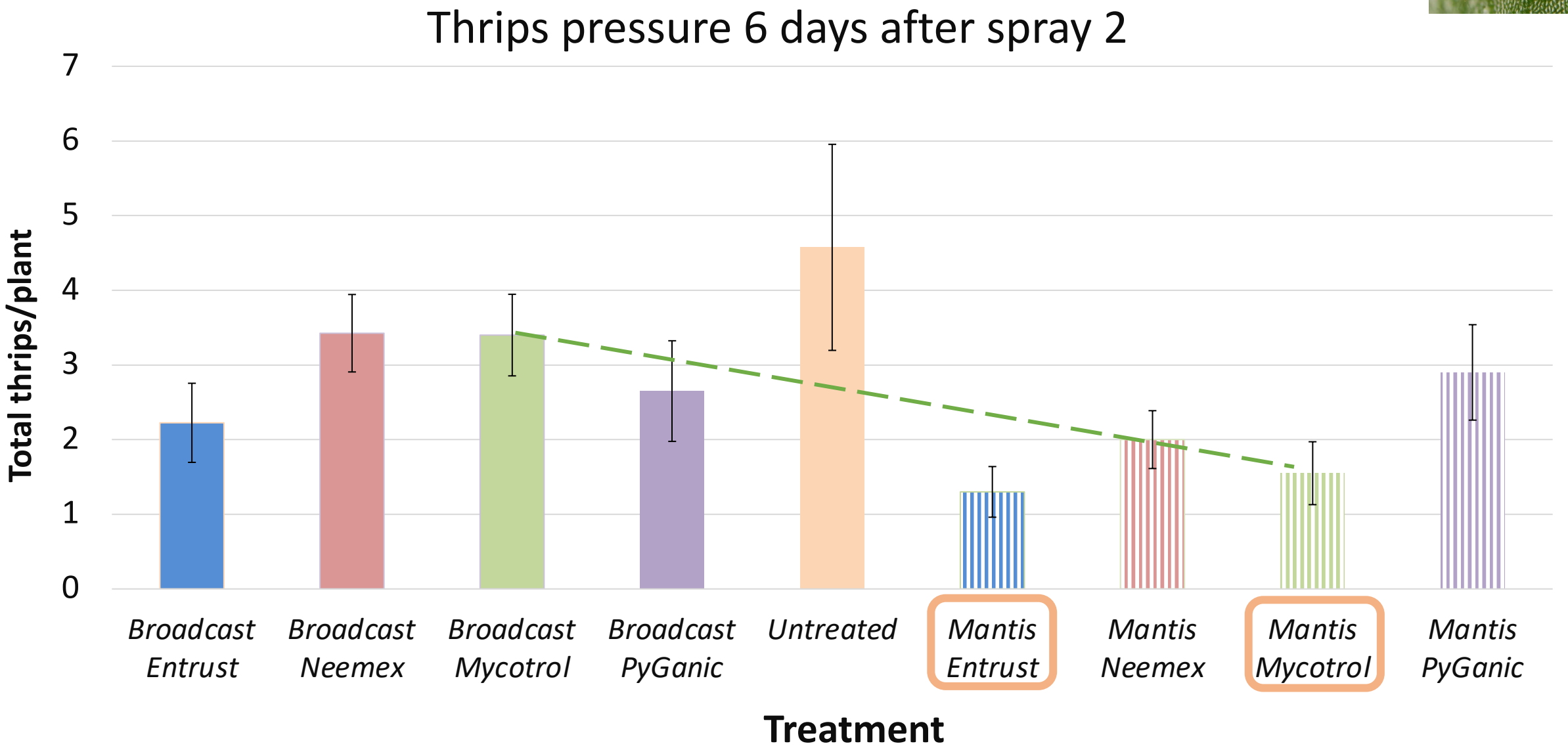
Application 2 : 7-10 days later

Mantis with organic insecticides

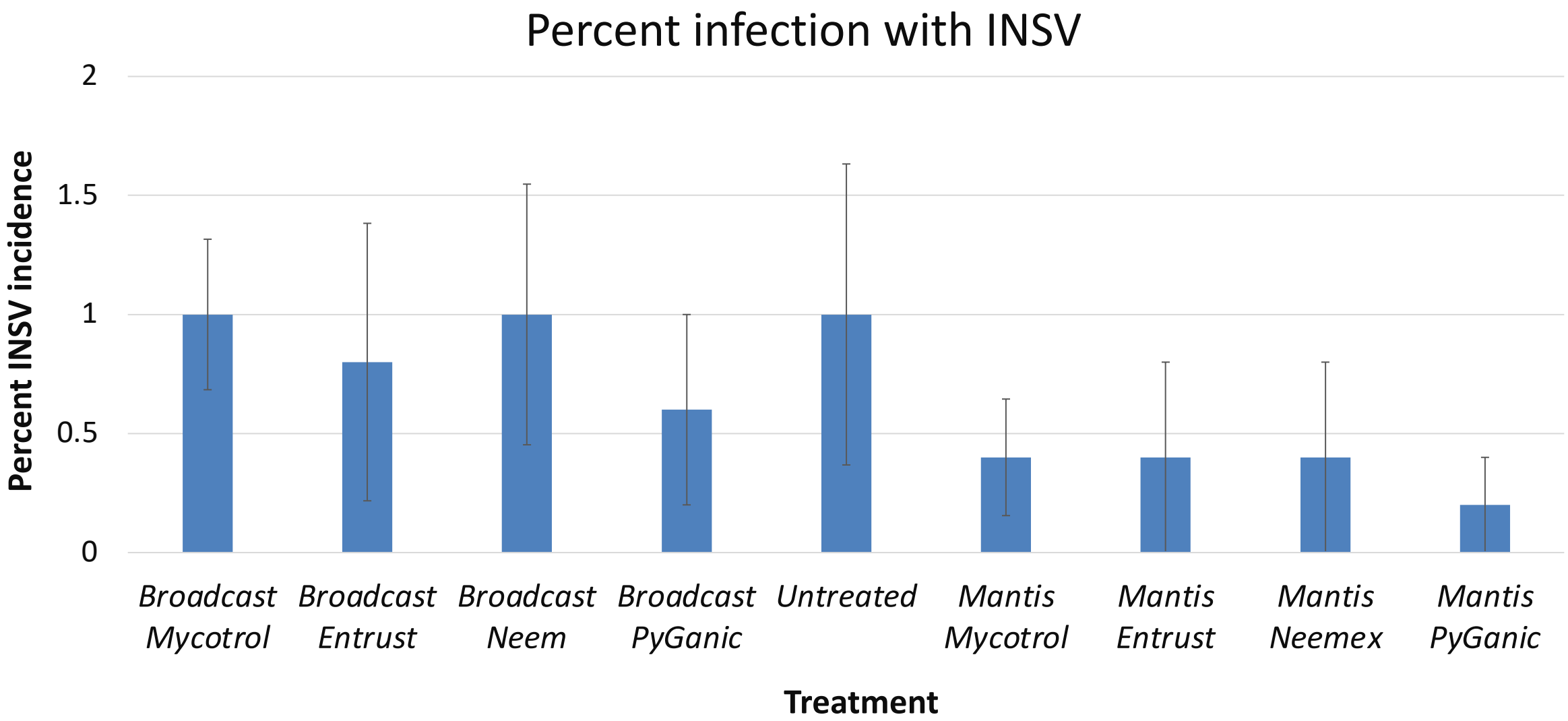
Sampling <24 hrs prior to and 6 days after each spray

Pre-harvest evaluation of INSV incidence

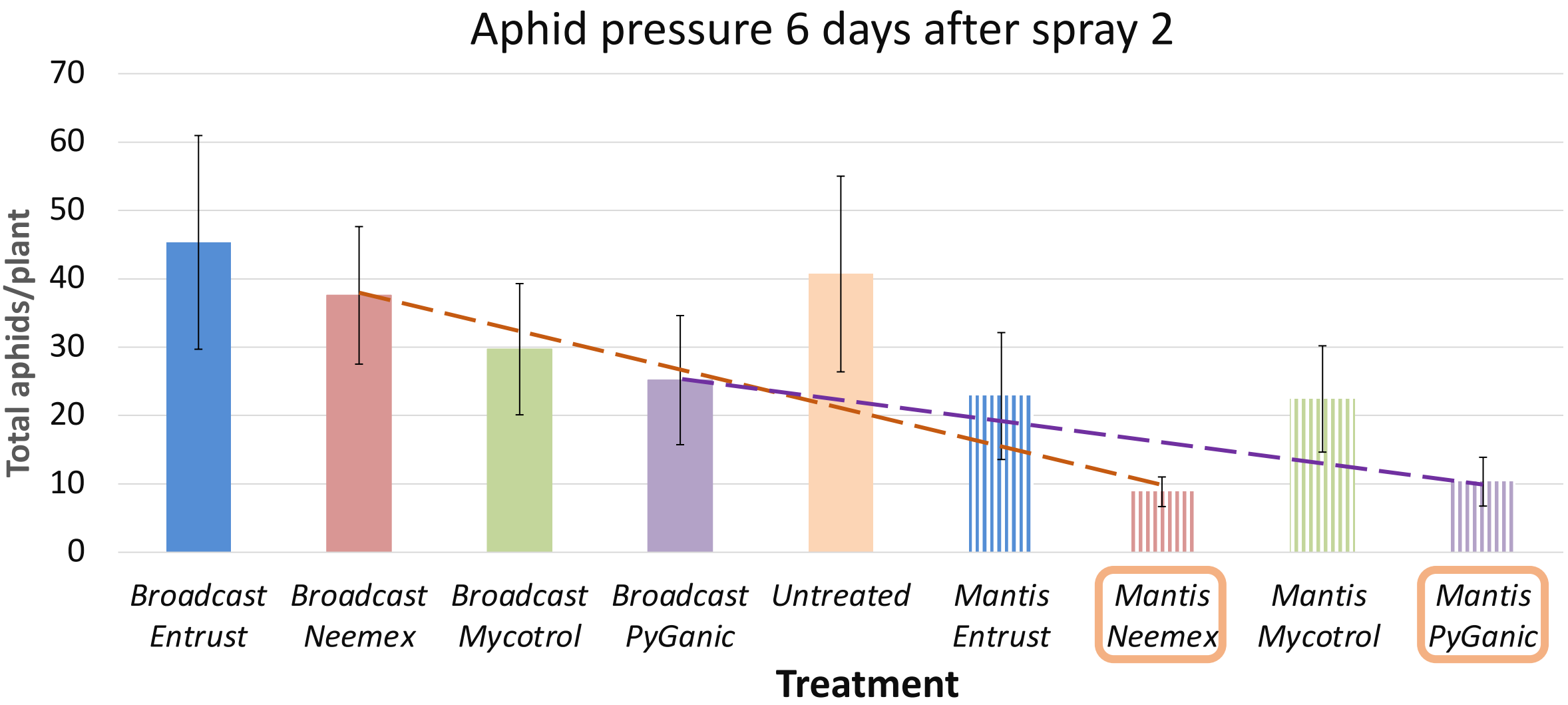
Preliminary results: Thrips



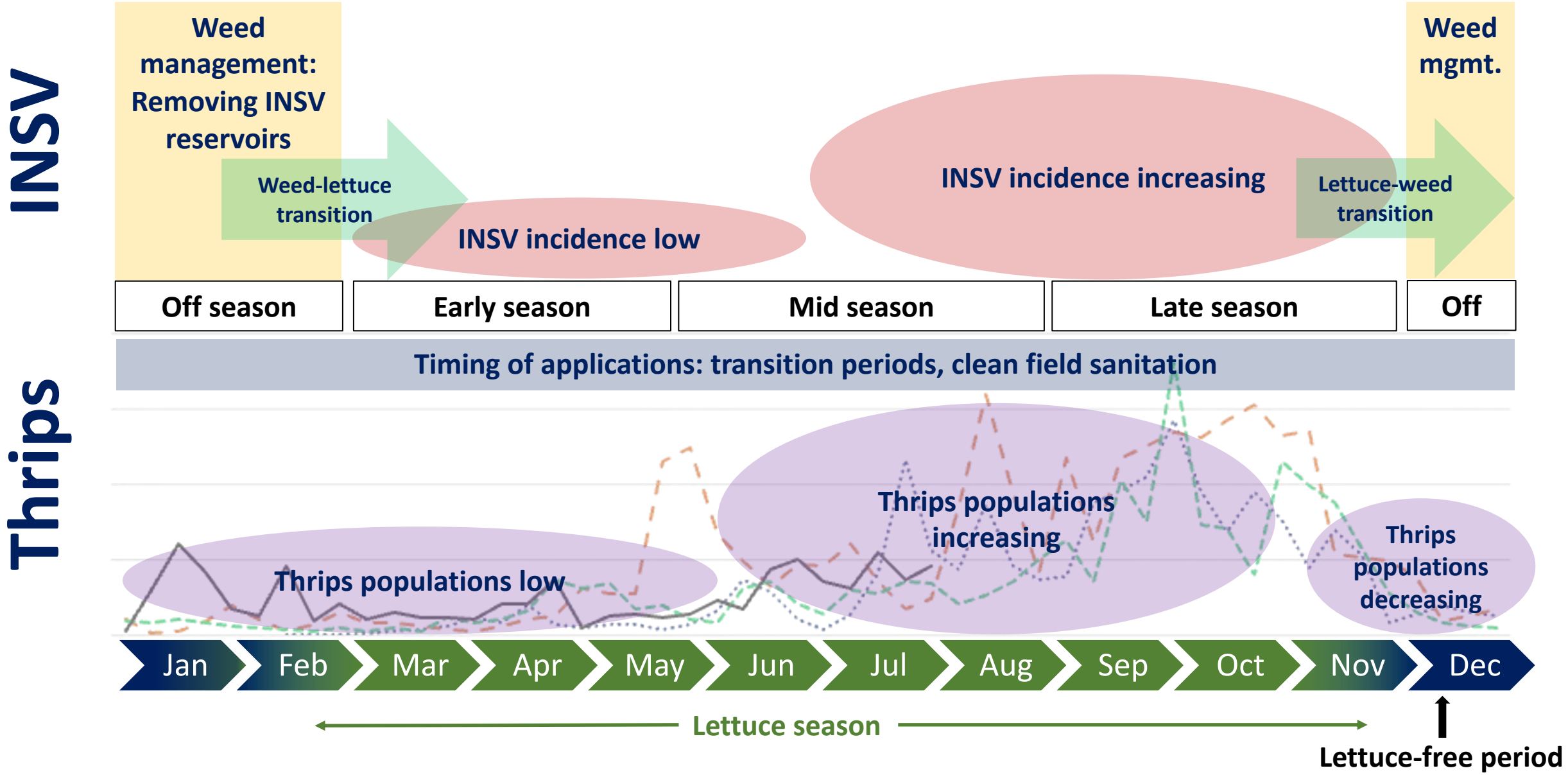
Preliminary results: INSV incidence



Preliminary results: Aphids



Thrips/INSV IPM model: Salinas Valley



Thank you

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Mary Zischke, INSV/Pythium Task Force leader

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