Areawide Approach to Vine Mealybug Control (& Reduce GLRaVs)

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Brian Hogg, Monica Cooper,
Luca Brilliante, Glenn Yokota
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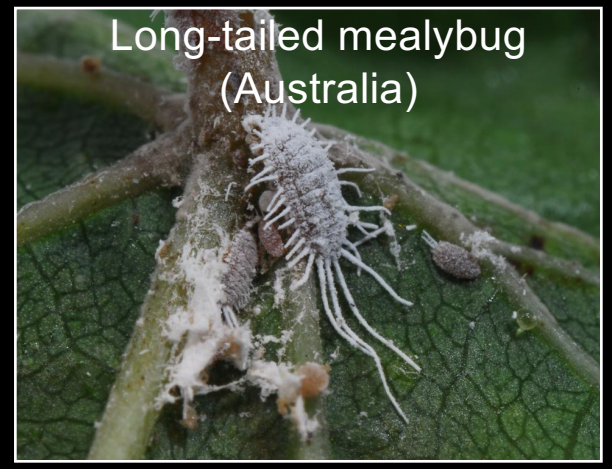
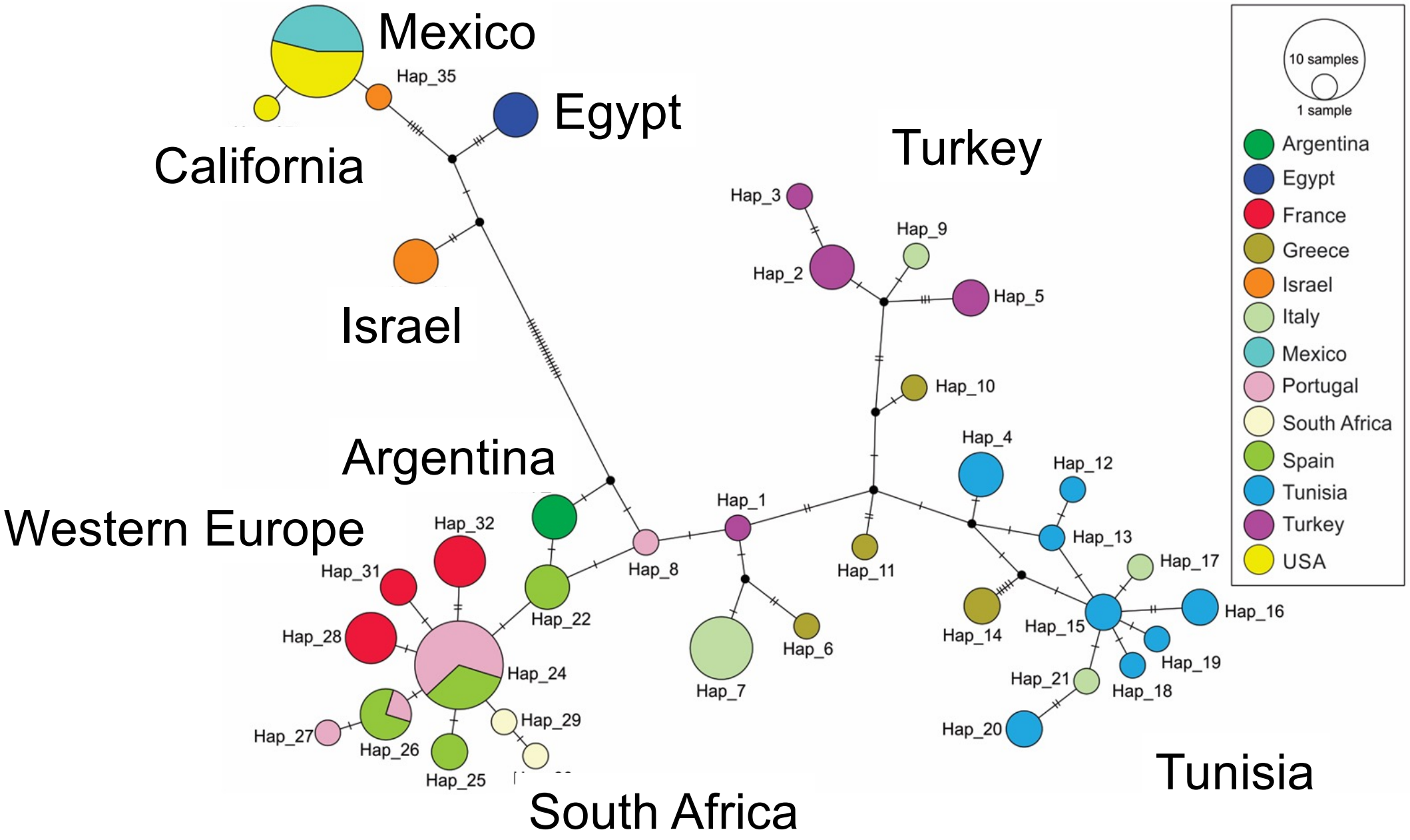
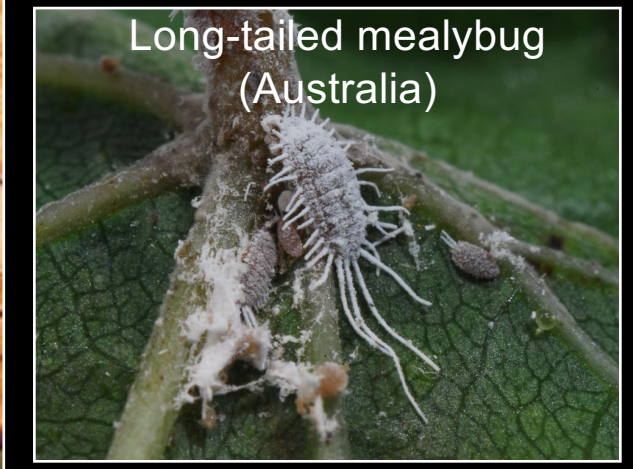
Vine MB is 1 of 4 important invasive mealybug species in California vineyards



Vine MB is an invasive species from Israel – probably brought by a grower

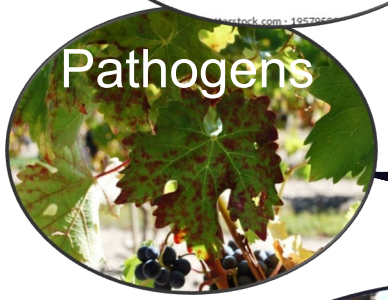

Mexico
California
Egypt
Israel
Turkey
Argentina
Western Europe
South Africa
Tunisia
Hap_35
Hap_3
Hap_9
Hap_2
Hap_5
Hap_10
Hap_4
Hap_12
Hap_1
Hap_13
Hap_32
Hap_8
Hap_11
Hap_17
Hap_31
Hap_22
Hap_16
Hap_28
Hap_6
Hap_14
Hap_15
Hap_24
Hap_7
Hap_19
Hap_21
Hap_18
Hap_29
Hap_27
Hap_26
Hap_20
Hap_25
10 samples
1 sample
Argentina
Egypt
France
Greece
Israel
Italy
Mexico
Portugal
South Africa
Spain
Tunisia
Turkey
USA

Vine MB causes more damage
1) more eggs, more generations
2) feeds on leaves
3) more honeydew excretion

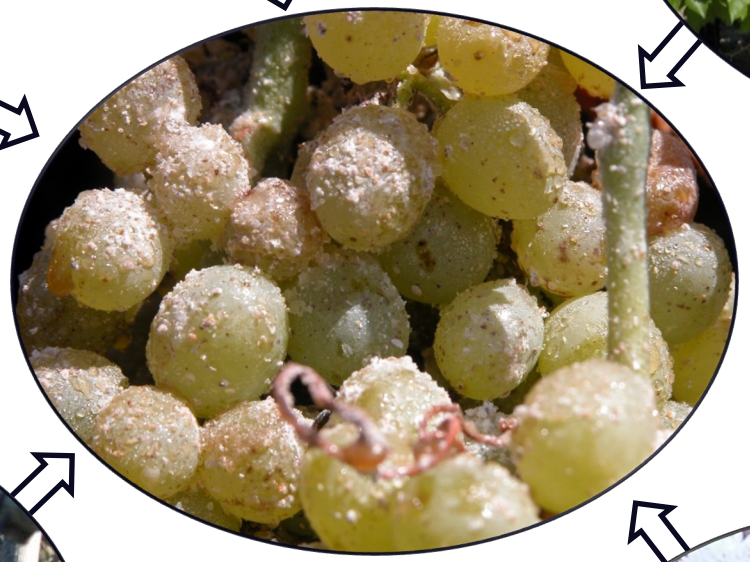


Commodity
Region
Vineyard

Pathogens



Monitoring &
Vineyard
history



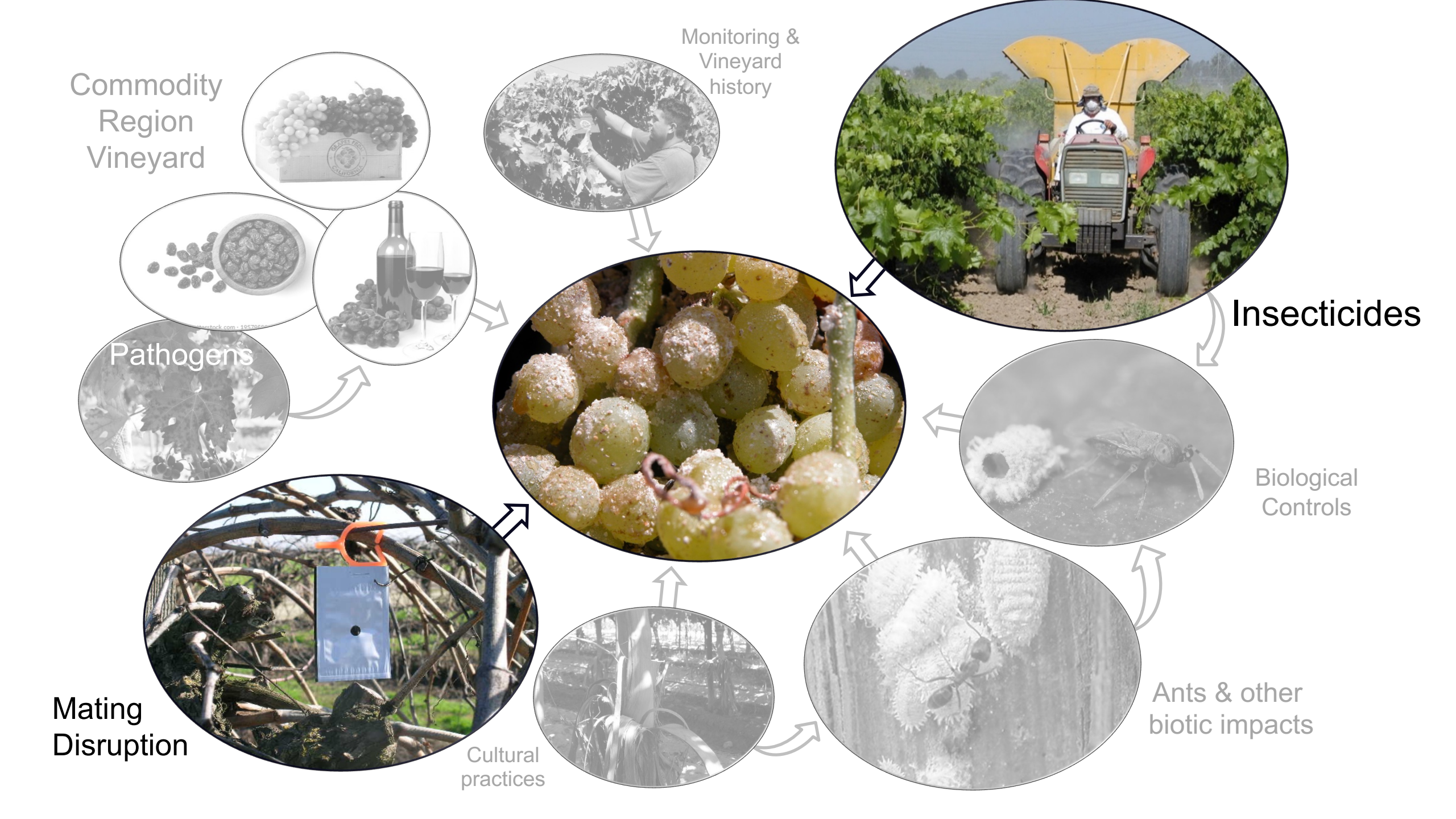
Insecticides

Biological
Controls

Ants & other
biotic impacts

Cultural
practices

Mating
Disruption


Commodity
Region
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Insecticides
Pathogens
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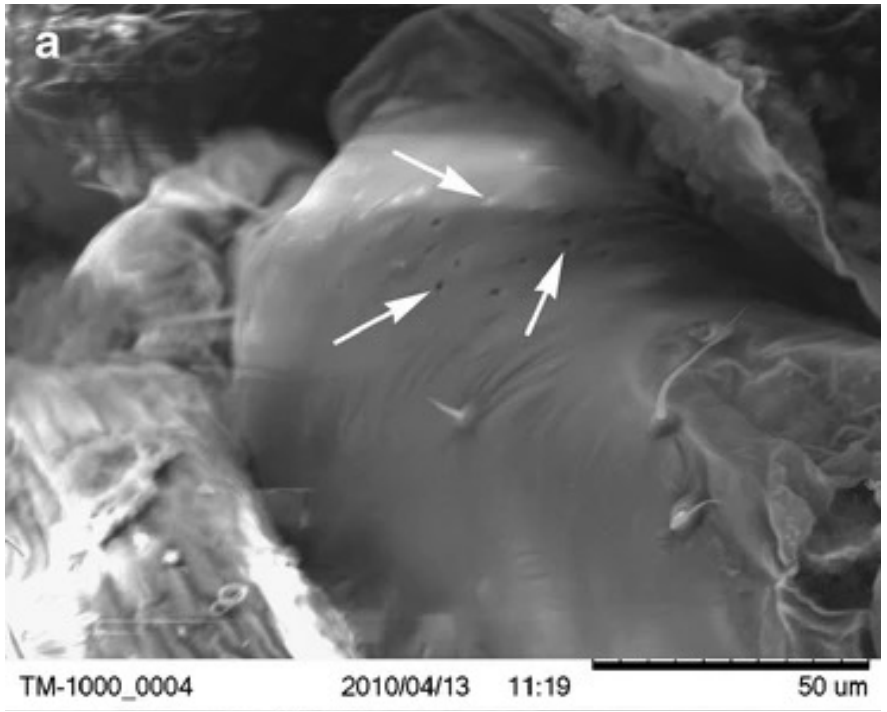
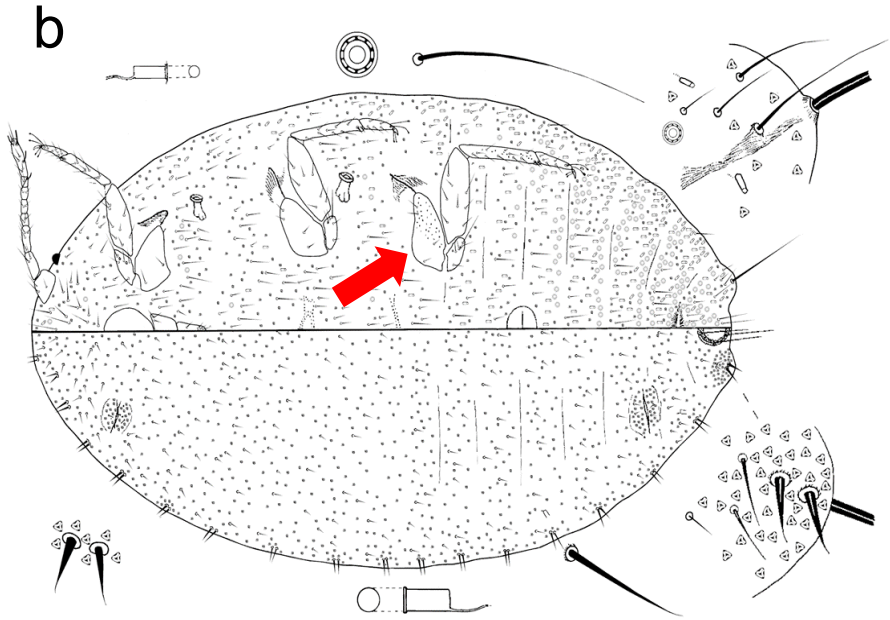
Controls
Mating
Disruption
Cultural
practices
Ants & other
biotic impacts

Mealybugs, Pheromones and Mating

Video of adult male VMB attempting to mate with a tiny slice of a pheromone lure.
A live female mealybug in the same container will be ignored.





Reproductive Biology of Three Cosmopolitan Mealybug (Hemiptera: Pseudococcidae) Species, *Pseudococcus longispinus*, *Pseudococcus viburni*, and *Planococcus ficus*

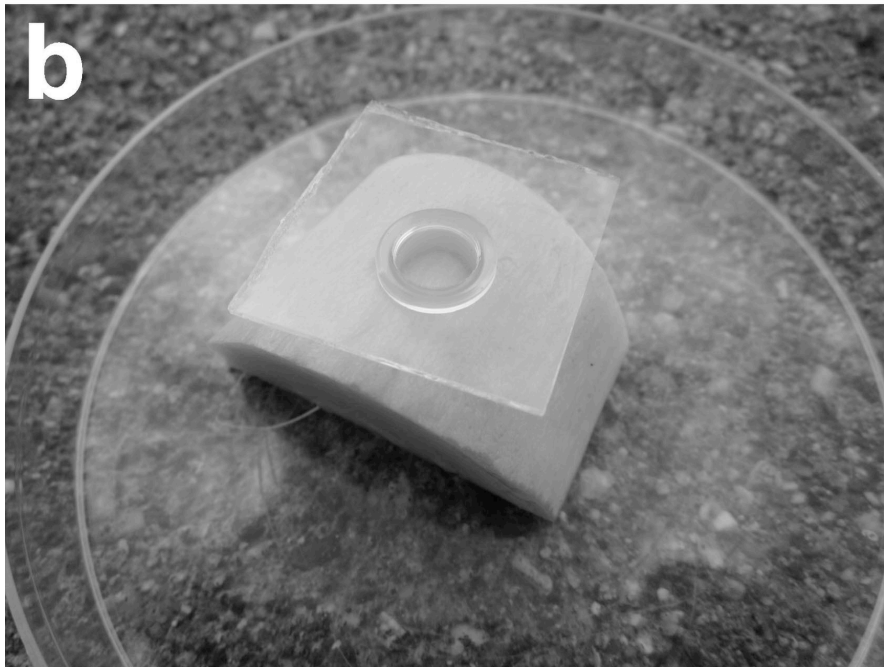
REBECCAH A. WATERWORTH,[1] IAN M. WRIGHT, AND JOCELYN G. MILLAR

Department of Entomology, University of California, Riverside, CA 92521

Ann. Entomol. Soc. Am. 104(2): 249–260 (2011); DOI: 10.1603/AN10139

(a) Electron micrograph of the [hind leg] coxa of an adult female [vine mealybug] at 1200x. Translucent pores are apparent as small openings on the surface.

(b) Top and bottom view of mealybug, showing location of the ‘coxa’ segment of the hind leg.



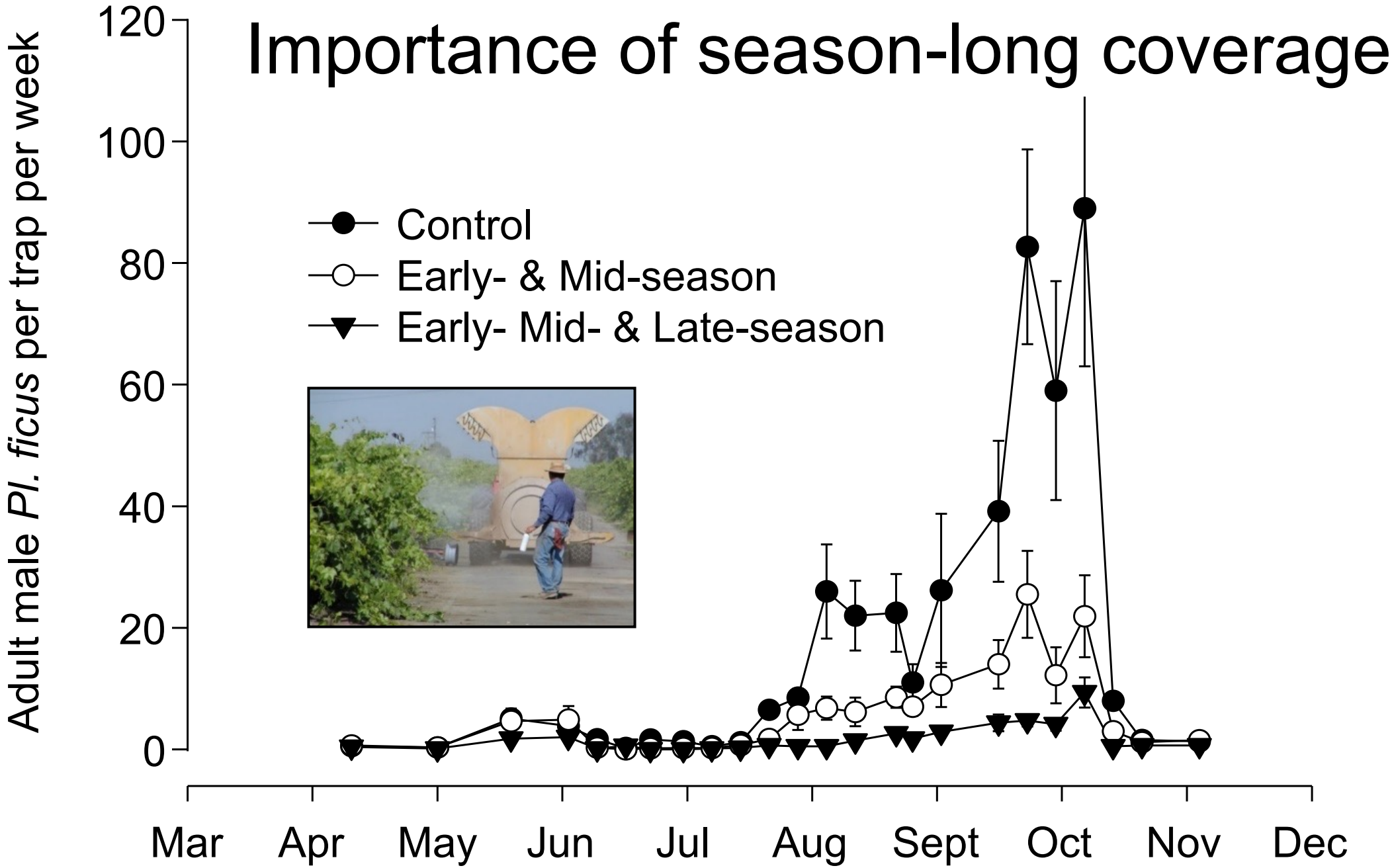
- Results confirmed that females [longtailed, obscure & vine MB] must [mate] to reproduce.
- 19 of 27 unmated VMB females produced ovisacs with eggs, but crawlers never emerged.
- Females can mate multiple times in a single day, but this did not increase egg production
- Unmated females lived a long time, up to 100 days
- Males mated multiple times, about 15-20 times
- Adult males are short-lived, 4.5 d for VMB (room T)

What Impacts MD Success?

Block size and shape
Mealybug density
Repeated annual use
Full-season coverage

- Saturate a field with sex pheromones to reduce and delay mating
- Plastic dispensers, puffers, sprayable and isomate dispensers
- Works best when pest population is low, and when used over a larger area (multiple vineyards)

Importance of season-long coverage



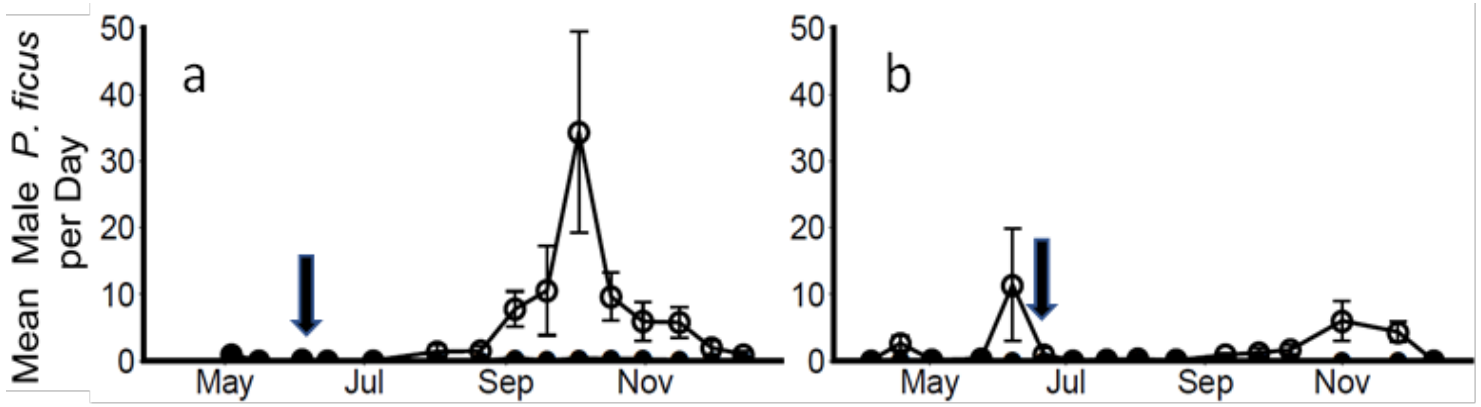


Figure 1. Season long male *P. ficus* captures (mean ± SE) in 2018 (a) and 2019 (b) from control (○) and mating disruption plots (●). Arrow indicates time of spirotetramat application.

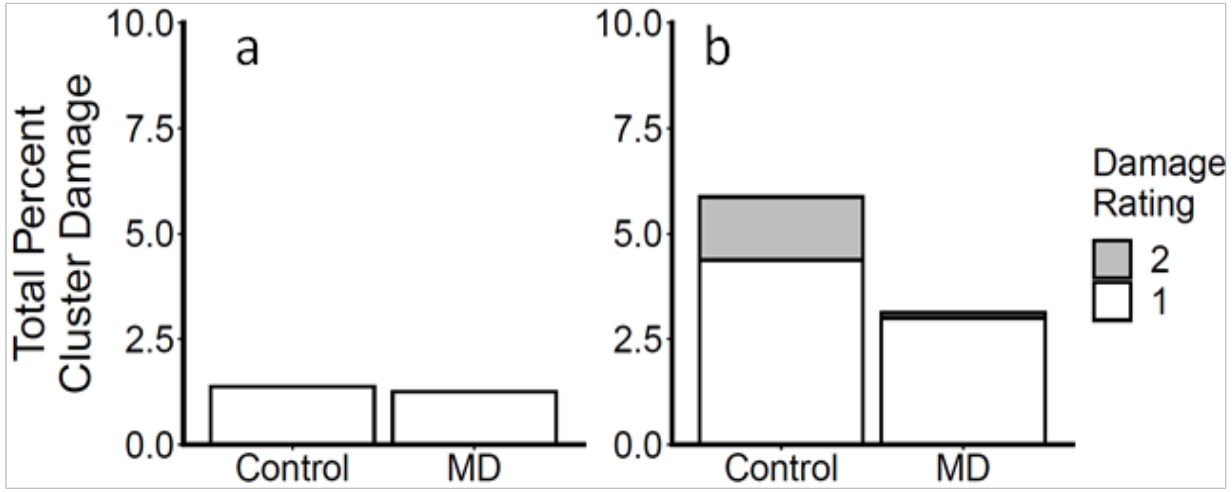


Figure 2. Percent grape clusters damaged by *P. ficus* in 2018 (a) and 2019 (b) between control plots and mating disruption plots (MD). Percent of clusters with 0 damage rating not shown.

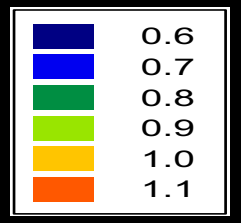
Pacific Biocontrol Isomate rope

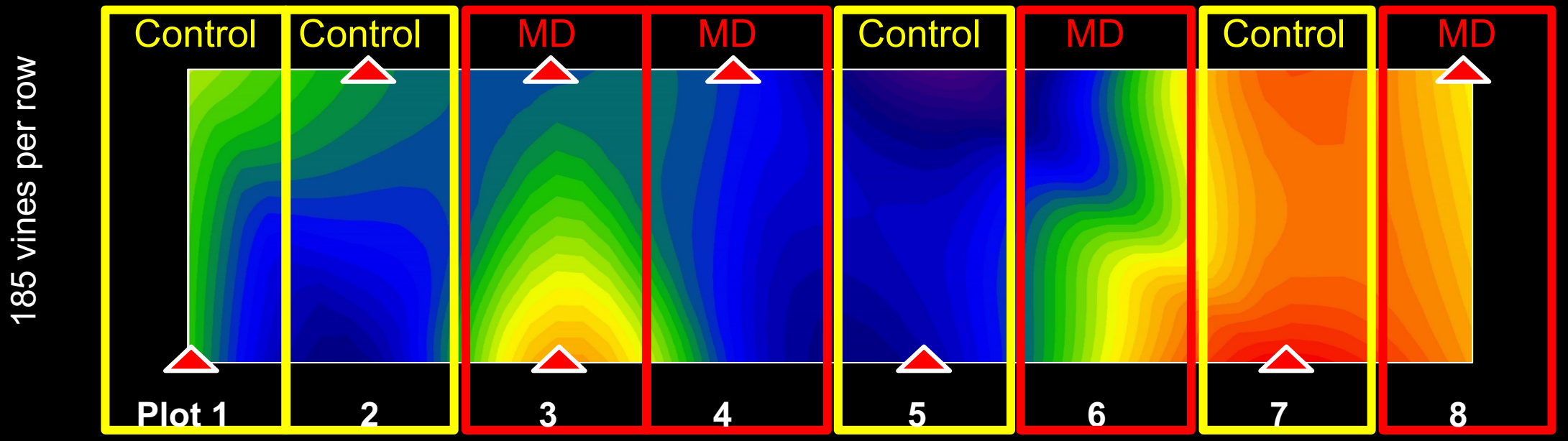
May application; High density (200/ac)

2018: 20-person crew provided by grower
40 ac hung in 2 hr ($11/hr) = $11.50/ac
(some issues with deployment)

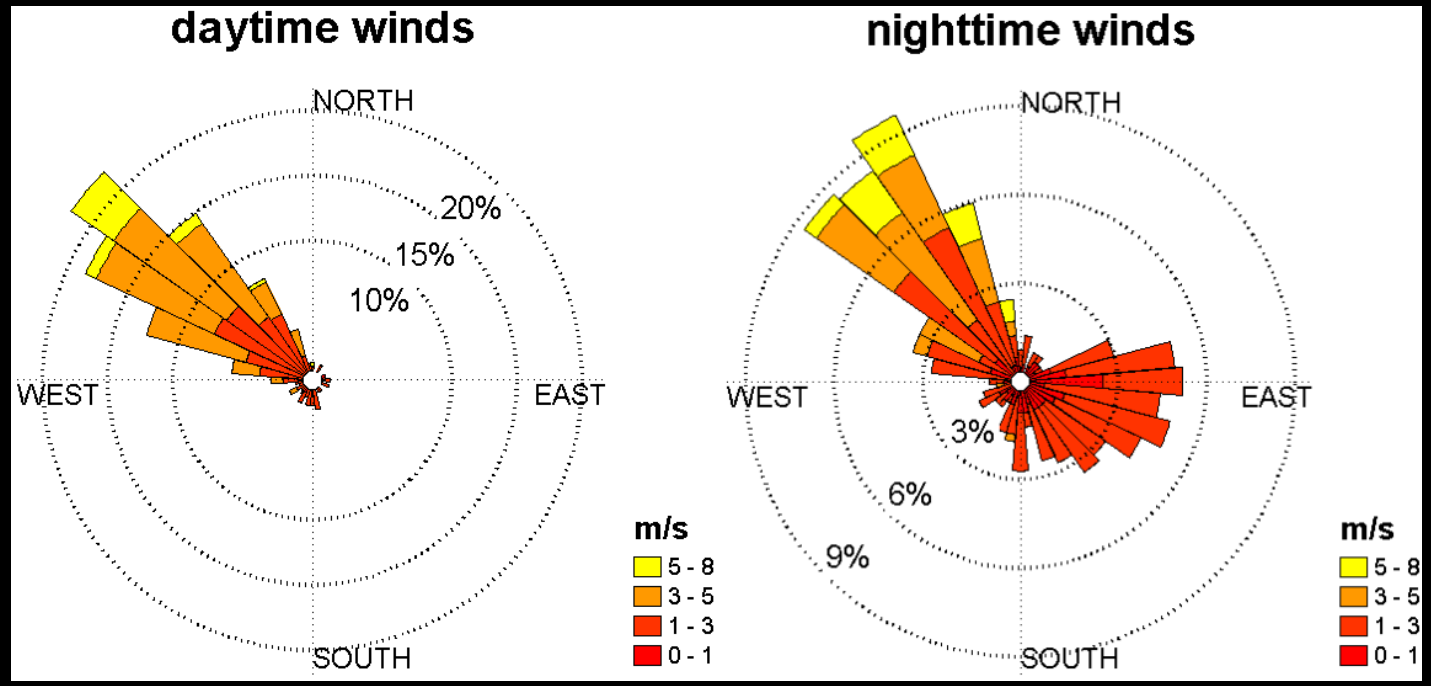
2019: 10-person crew provided by grower
40 ac hung in 3.5 h ($12/hr) = $13.70/ac

May
2018

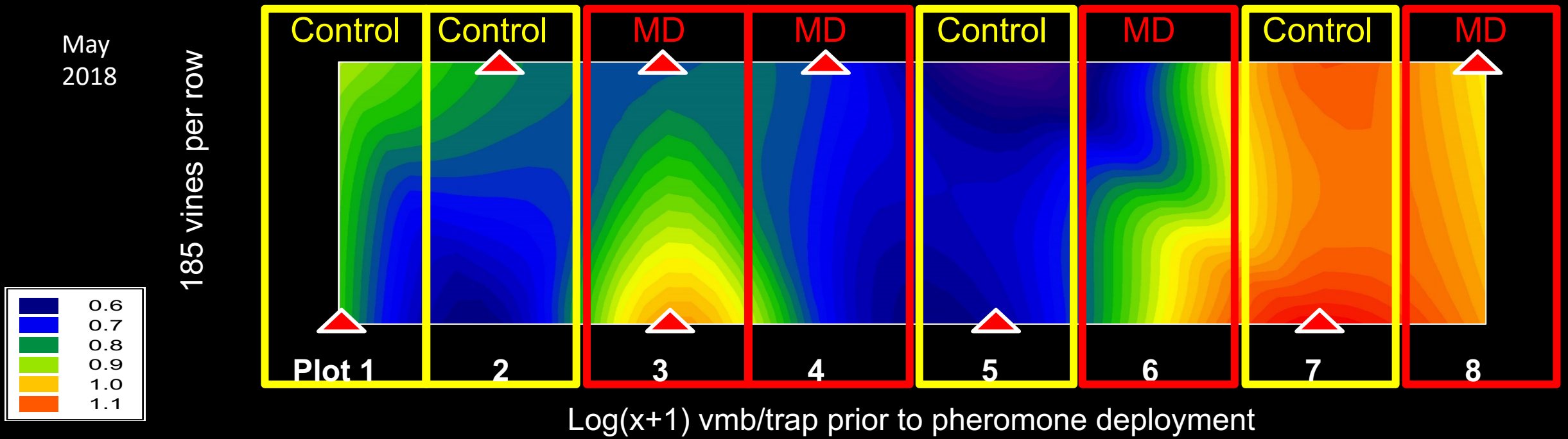




Log(x+1) vmb/trap prior to pheromone deployment

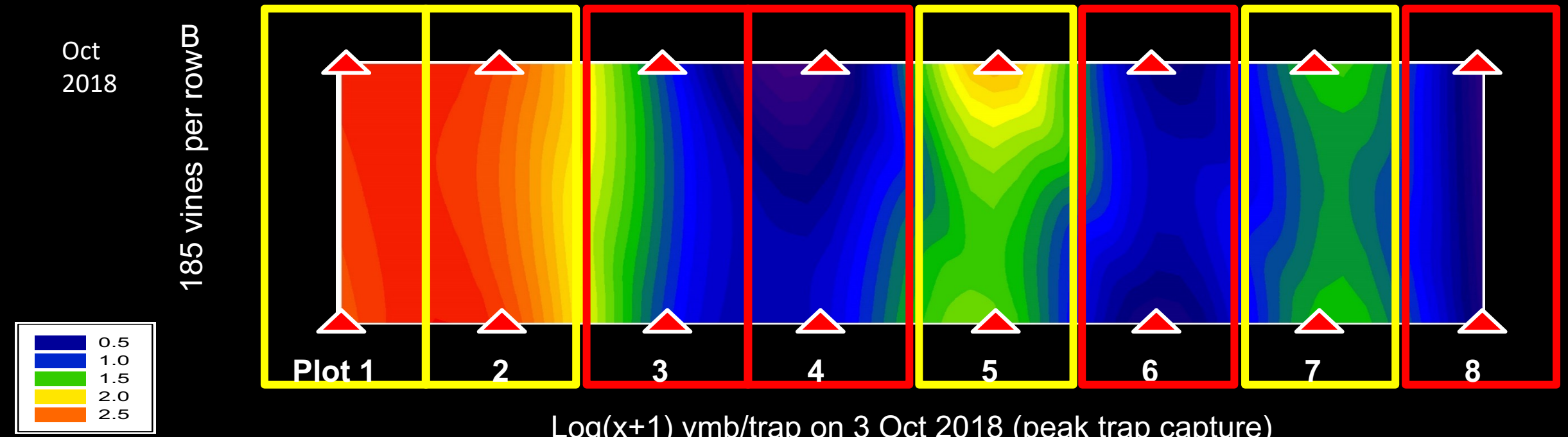


May 2018



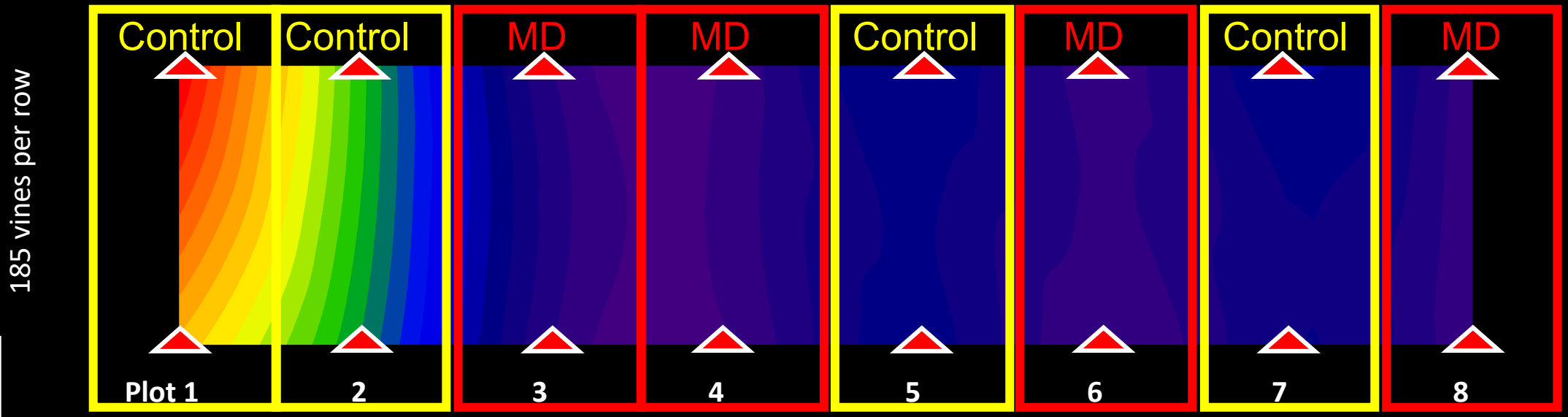
Log(x+1) vmb/trap prior to pheromone deployment

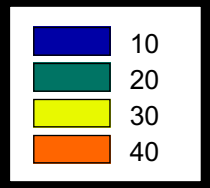
Oct 2018



Log(x+1) vmb/trap on 3 Oct 2018 (peak trap capture)

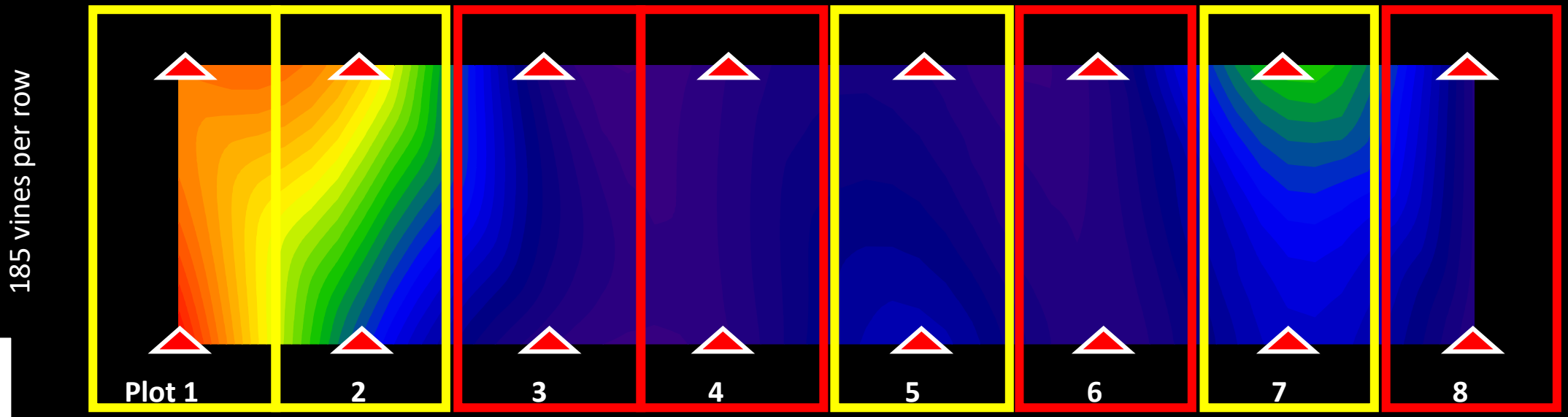
April
2019

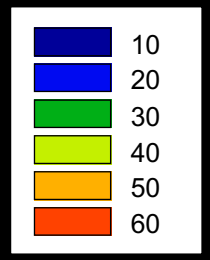




VMB/trap/week prior to pheromone deployment

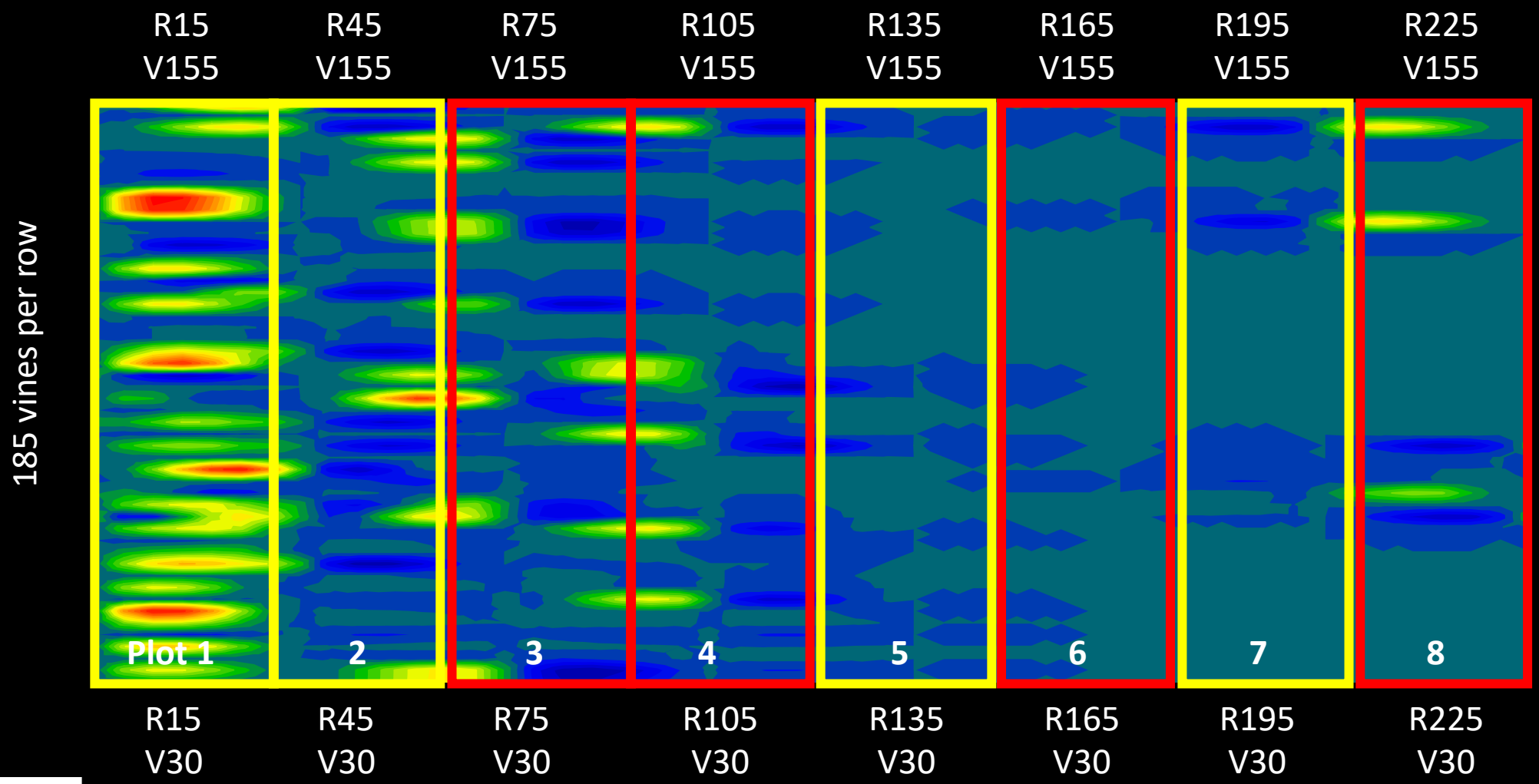
Nov
2019



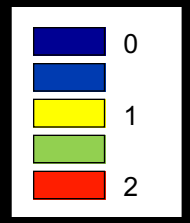


VMB/trap/week in November 2019 (VMB recovering from pesticides)

Harvest damage -2019

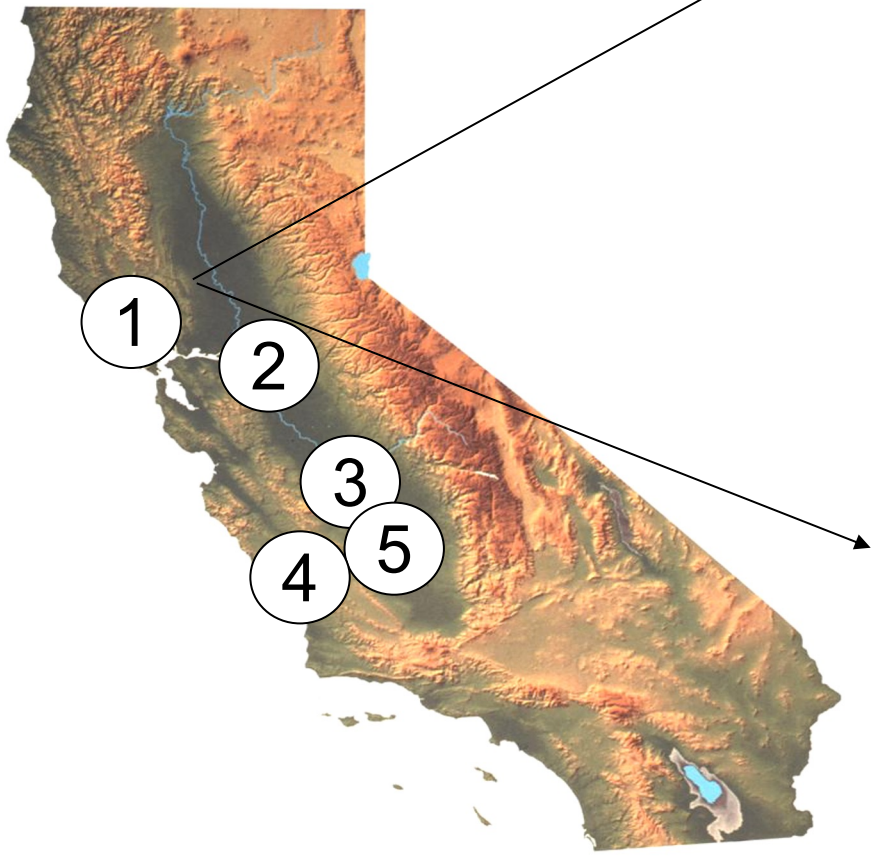


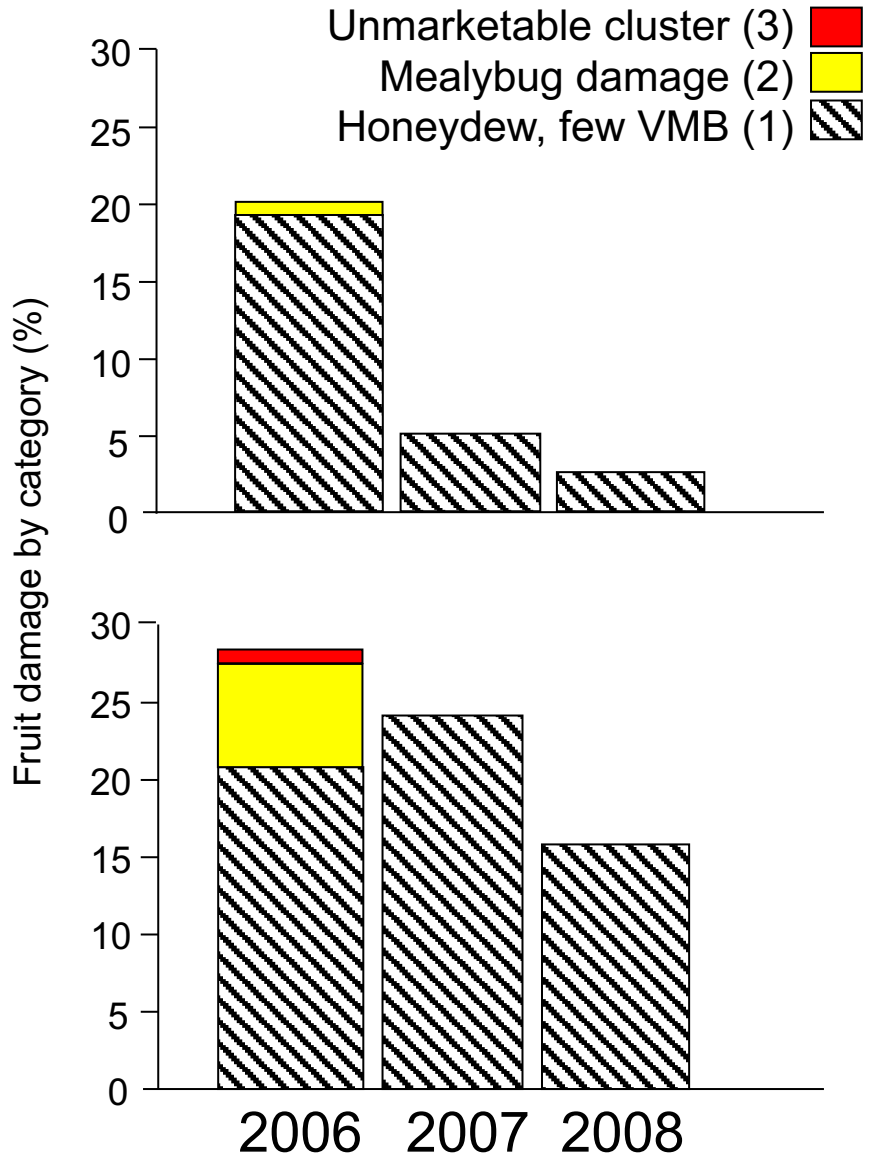
240 rows, traps every 15 rows, 30 vines from edge



VMB damage rating

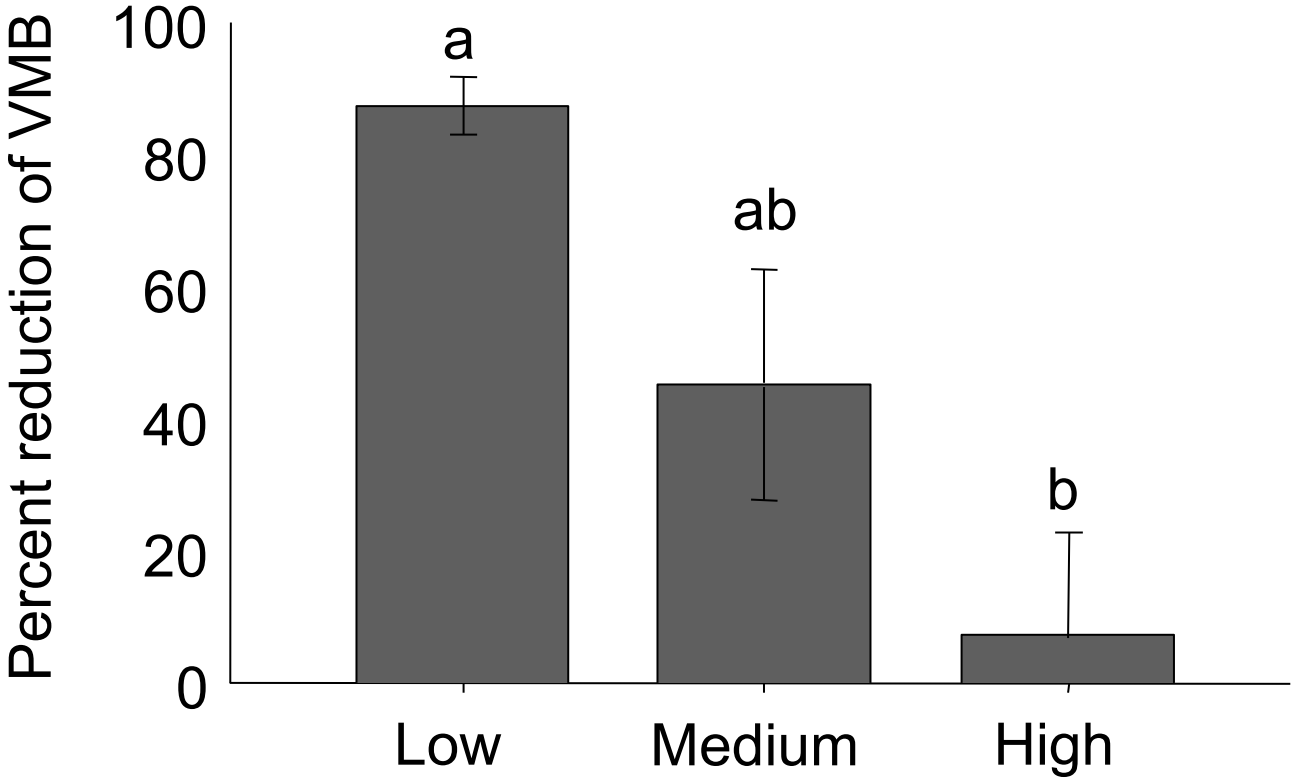
Large-plot studies with plastic dispensers





Studies conducted throughout California
Pesticide use varied among plots
True controls were difficult to obtain
But generally there was a reduction in damage & annual improvement

Impact of mealybug density – like other MD programs



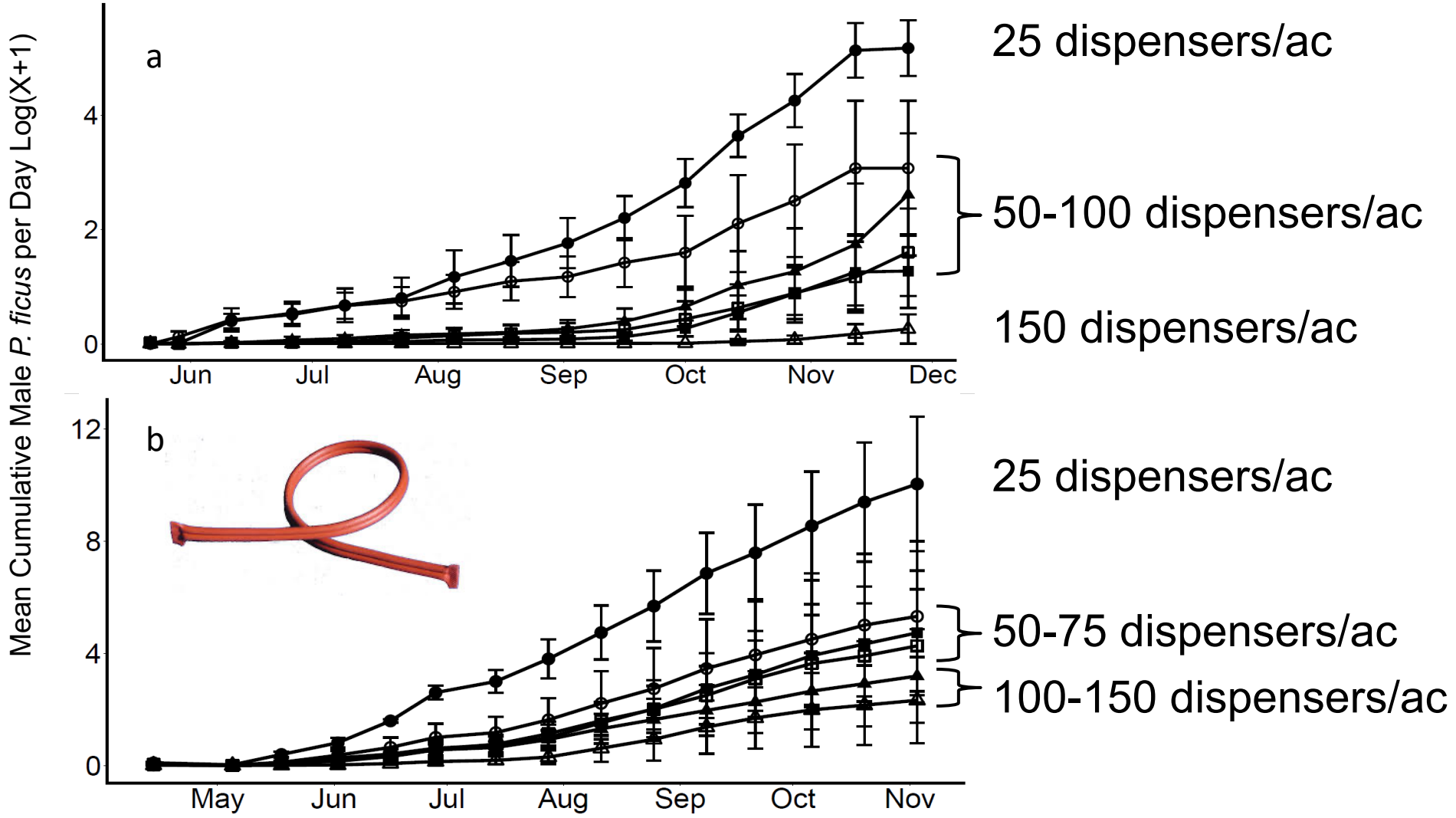
This is why MD and insecticides are best used in combination

Can MD Costs be Lower?

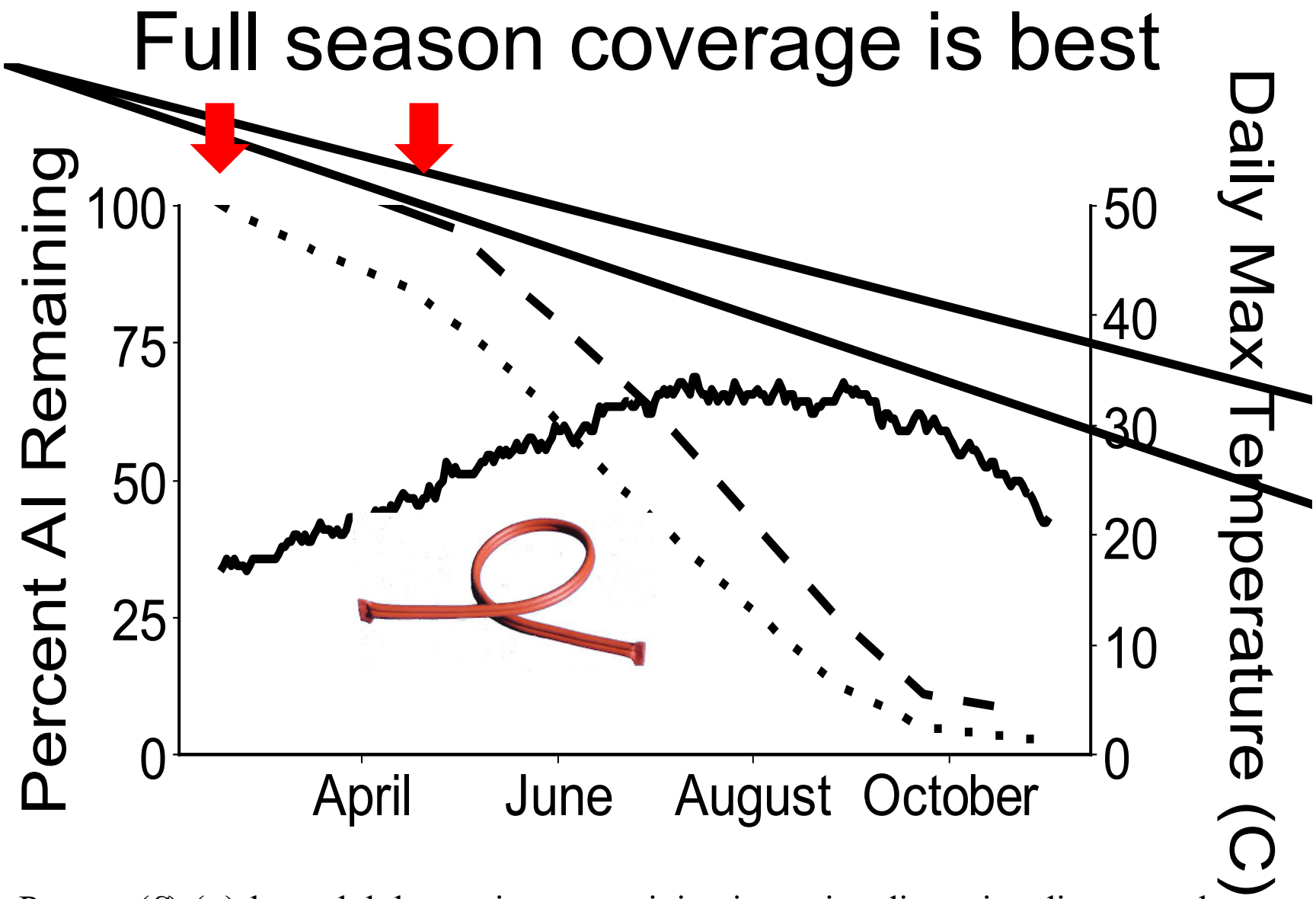
Application rate
Dispenser type

(application of other tools, ants, etc.)

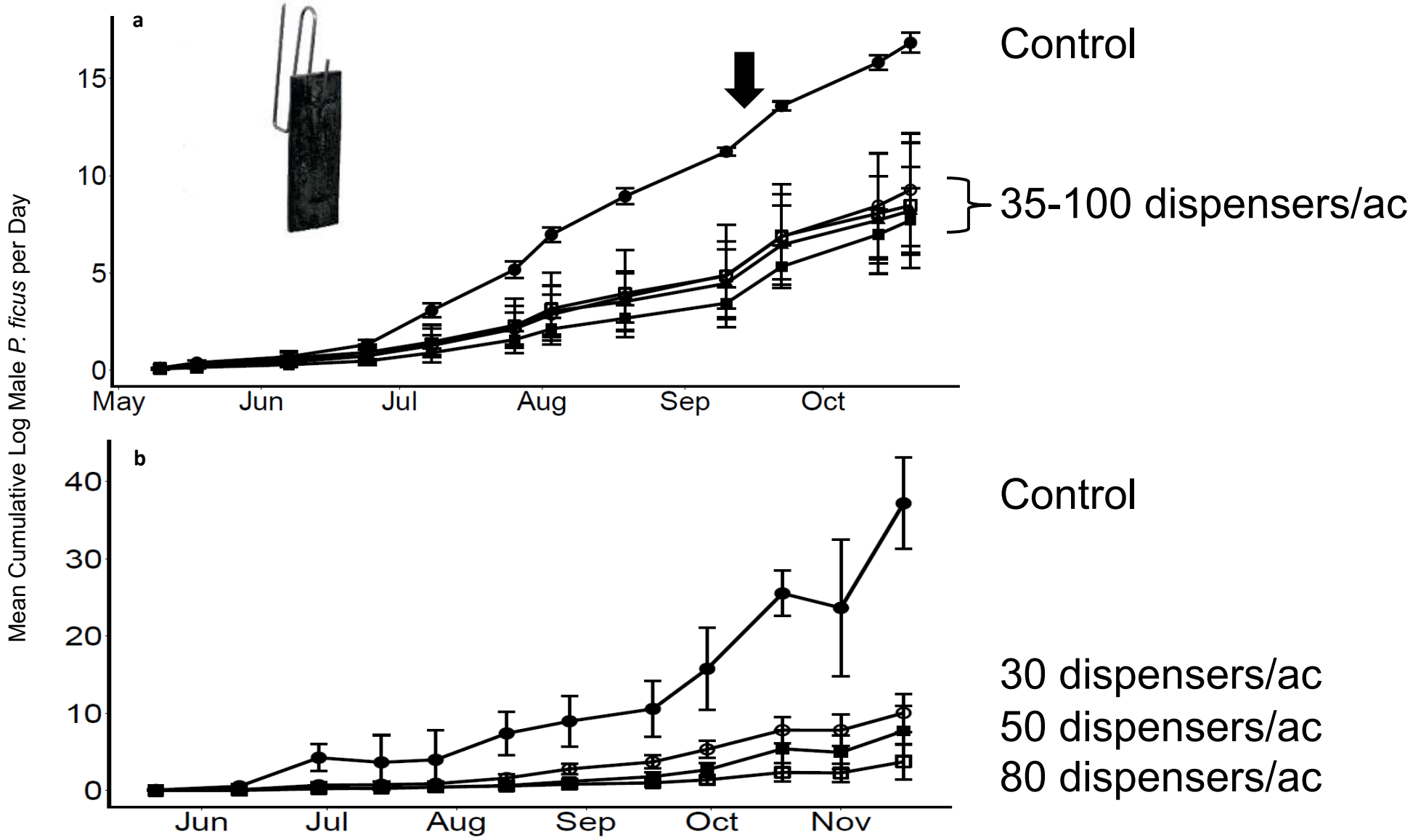
Pheromone rate



Cumulative season long male *P. ficus* captures (mean ± SE) in controls (●), 25 (○), 50 (■), 75 (□), 100 (▲) and 150 (Δ) in 2020 (a) and 2021 (b).



Percent (*S*)-(+)-lavandulyl senecioate remaining in mating disruption dispensers hung either in February (Early, dotted line) or April (Late, dashed line) as well as daily maximum temperature (solid line).

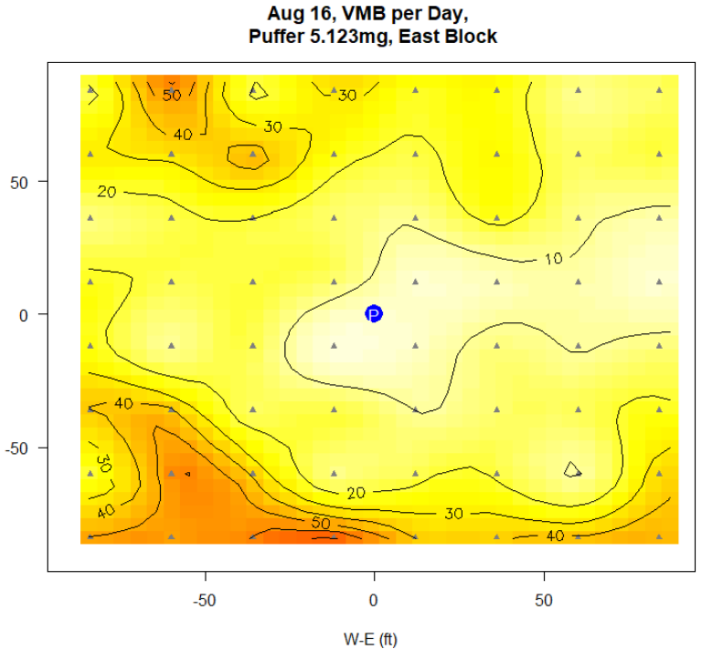


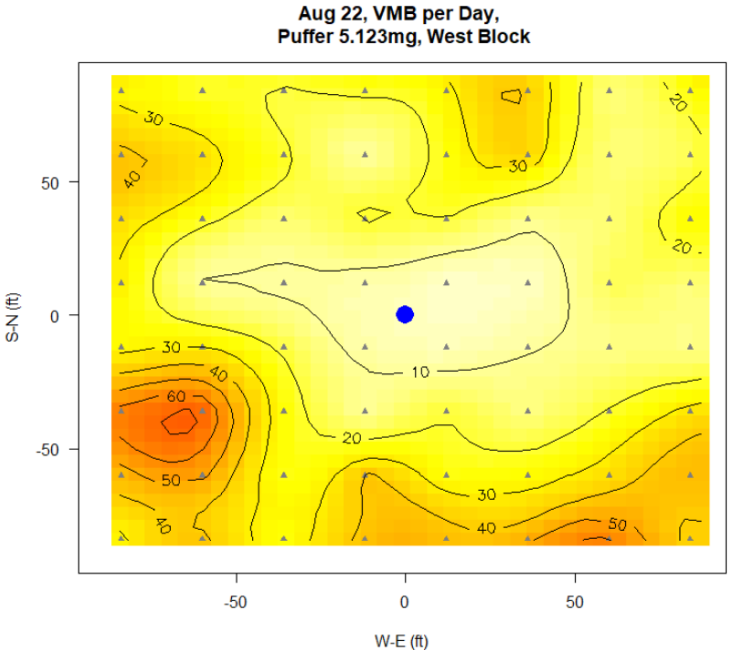
Mean ± SE cumulative log transformed *P. ficus* trap catches for 2021 (a) and 2022 (b) in meso dispenser trials. For 2021: control (●), 36 (○), 50 (■), 80 (□), 100 (▲). For 2022: Control (●), 25 (○), 36 (■) and 50 (□). Arrow indicates meso dispenser's removal from all plots.

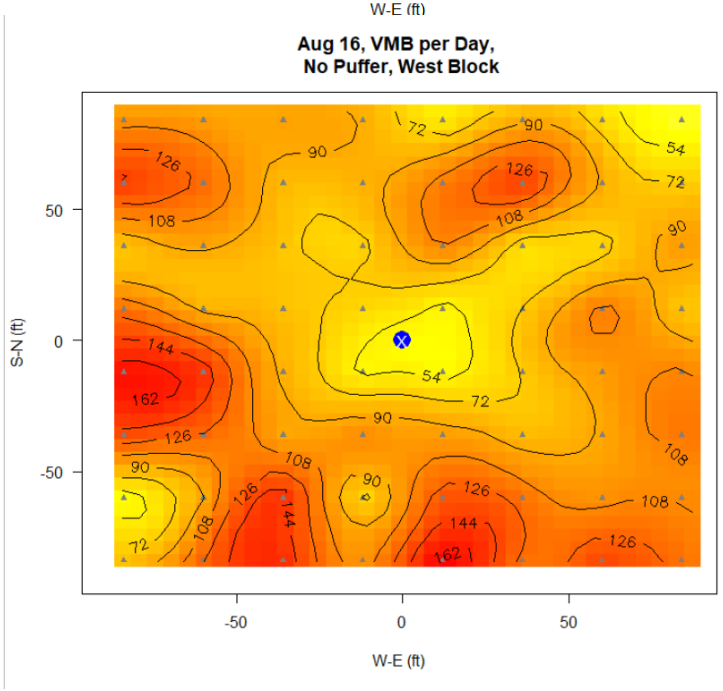
Grape Harvest Damage

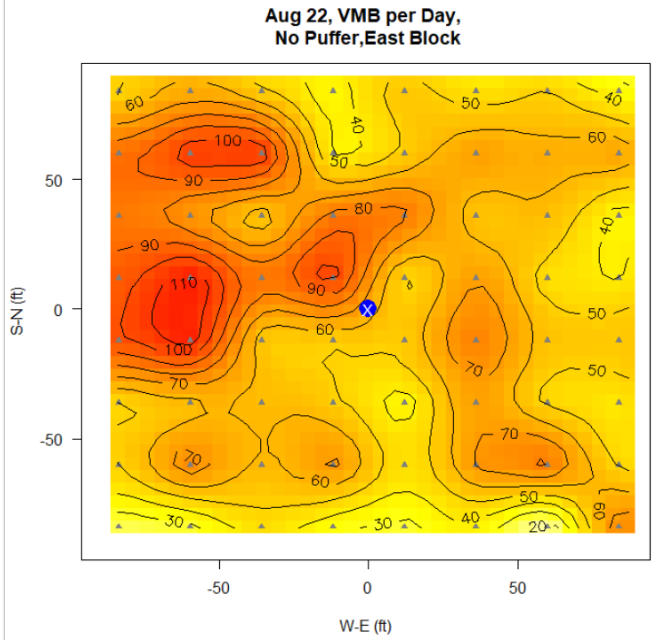
- Grower Standard (GS) was lower than 25 MESO
- 50 MESO different from GS, slightly lower and fewer DR 3

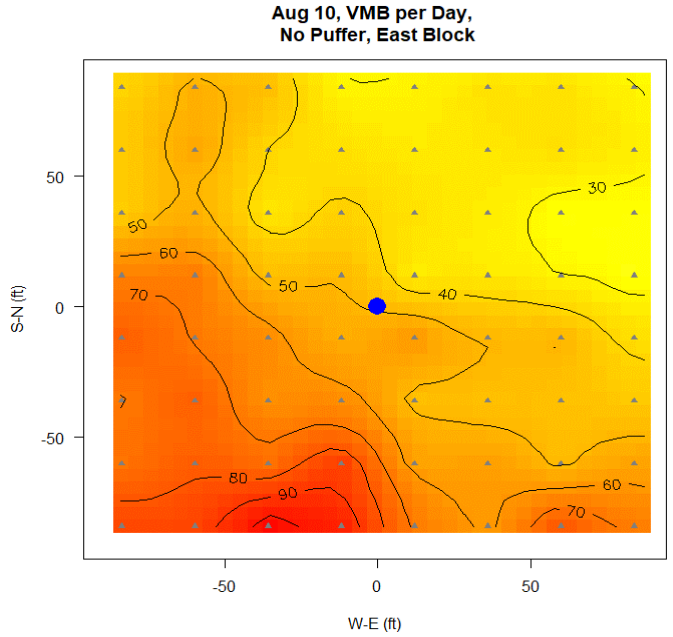

CheckMate
Puffer VMB
NOT FOR RESALE
For Experimental Use Only
A BIOCHEMICAL FOR
MATING DISRUPTION OF
KEEP OUT OF REACH OF CHILDREN
CAUTION

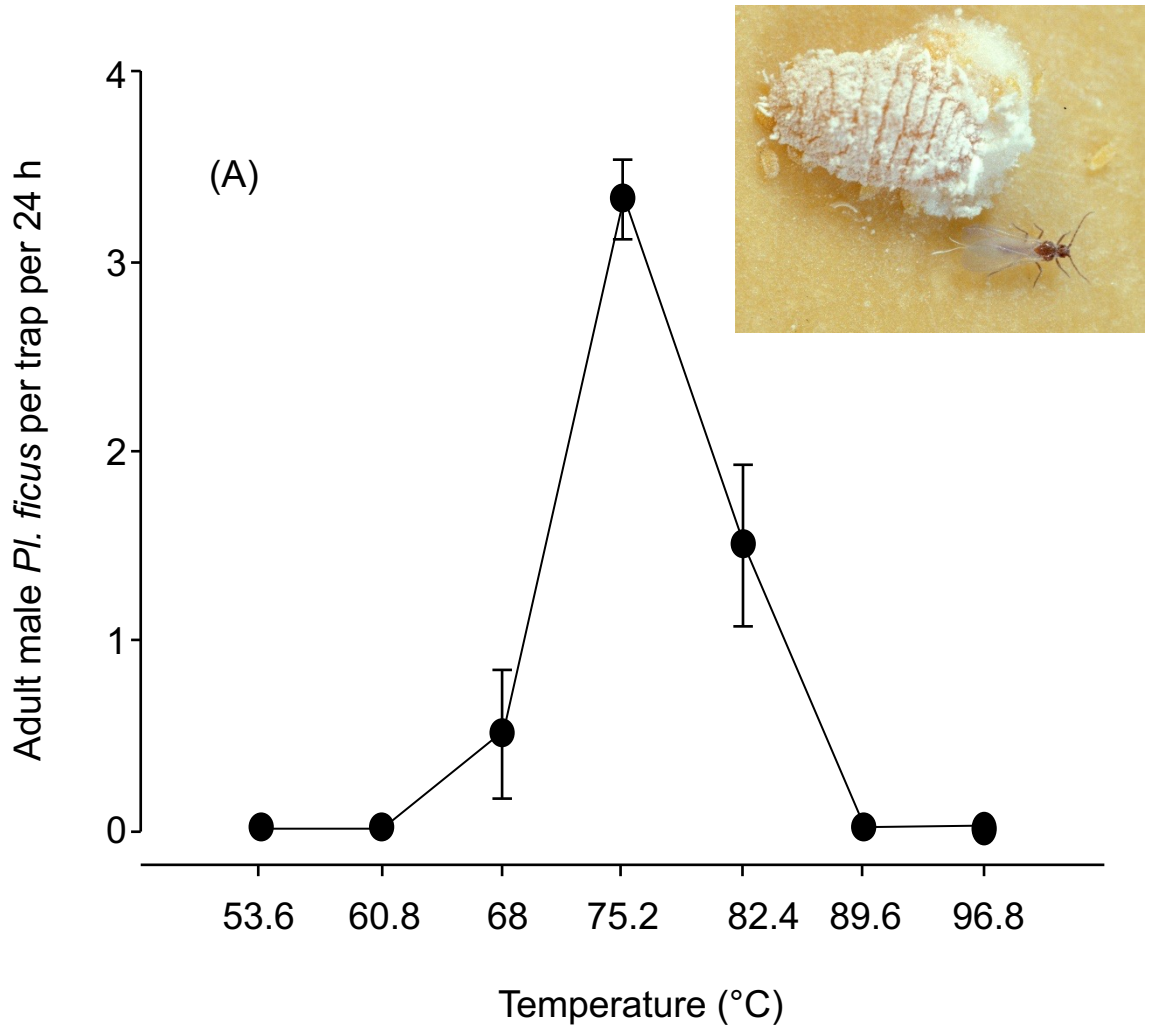

Aug 16, VMB per Day,
Puffer 5.123mg, East Block
W-E (ft)

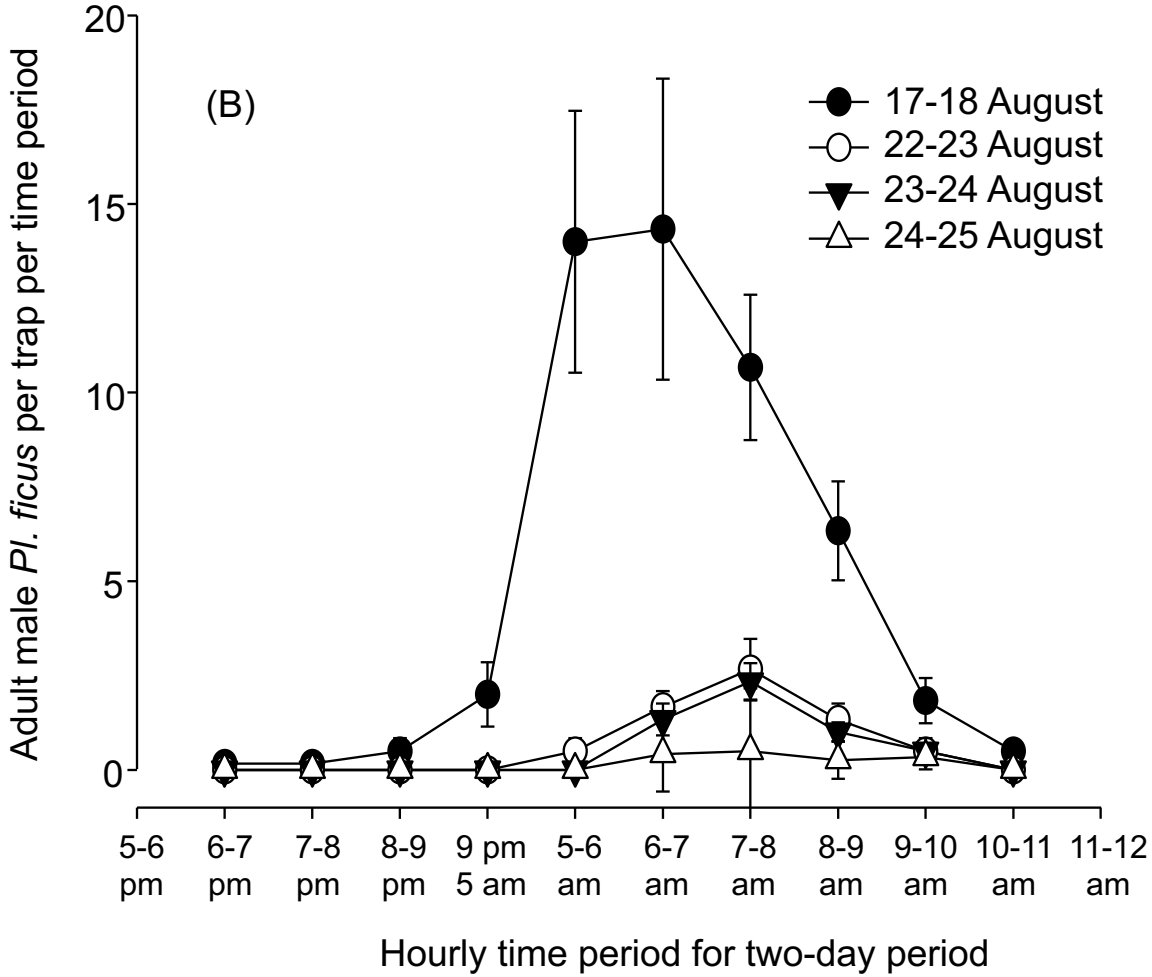

Aug 22, VMB per Day,
Puffer 5.123mg, West Block
S-N (ft)
W-E (ft)


Aug 16, VMB per Day,
No Puffer, West Block
S-N (ft)
W-E (ft)


Aug 22, VMB per Day,
No Puffer,East Block
S-N (ft)
W-E (ft)

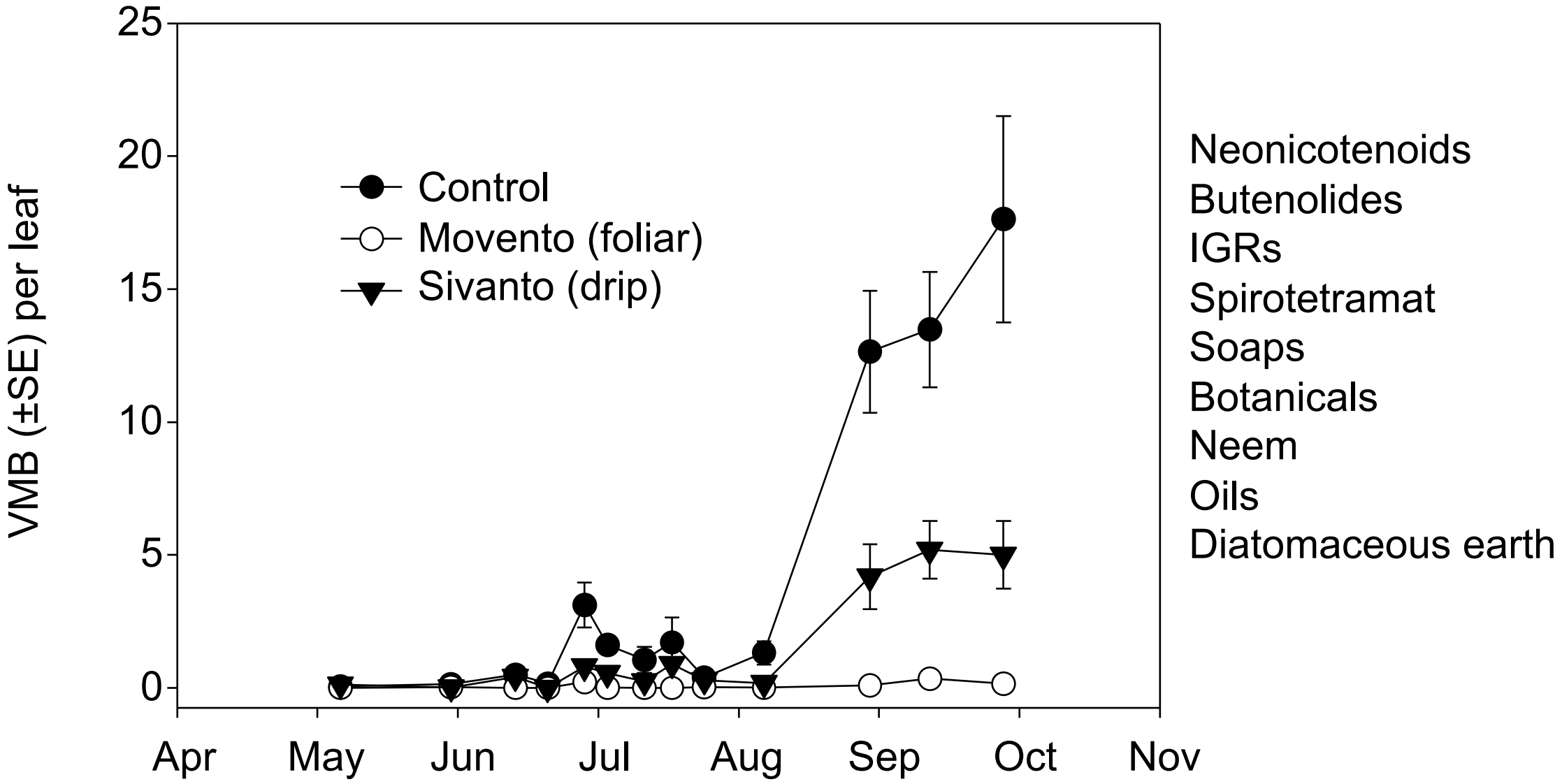

Aug 10, VMB per Day,
No Puffer, East Block
S-N (ft)
W-E (ft)


(A)
Adult male Pl. ficus per trap per 24 h
0
1
2
3
4
53.6
60.8
68
75.2
82.4
89.6
96.8
Temperature (°C)

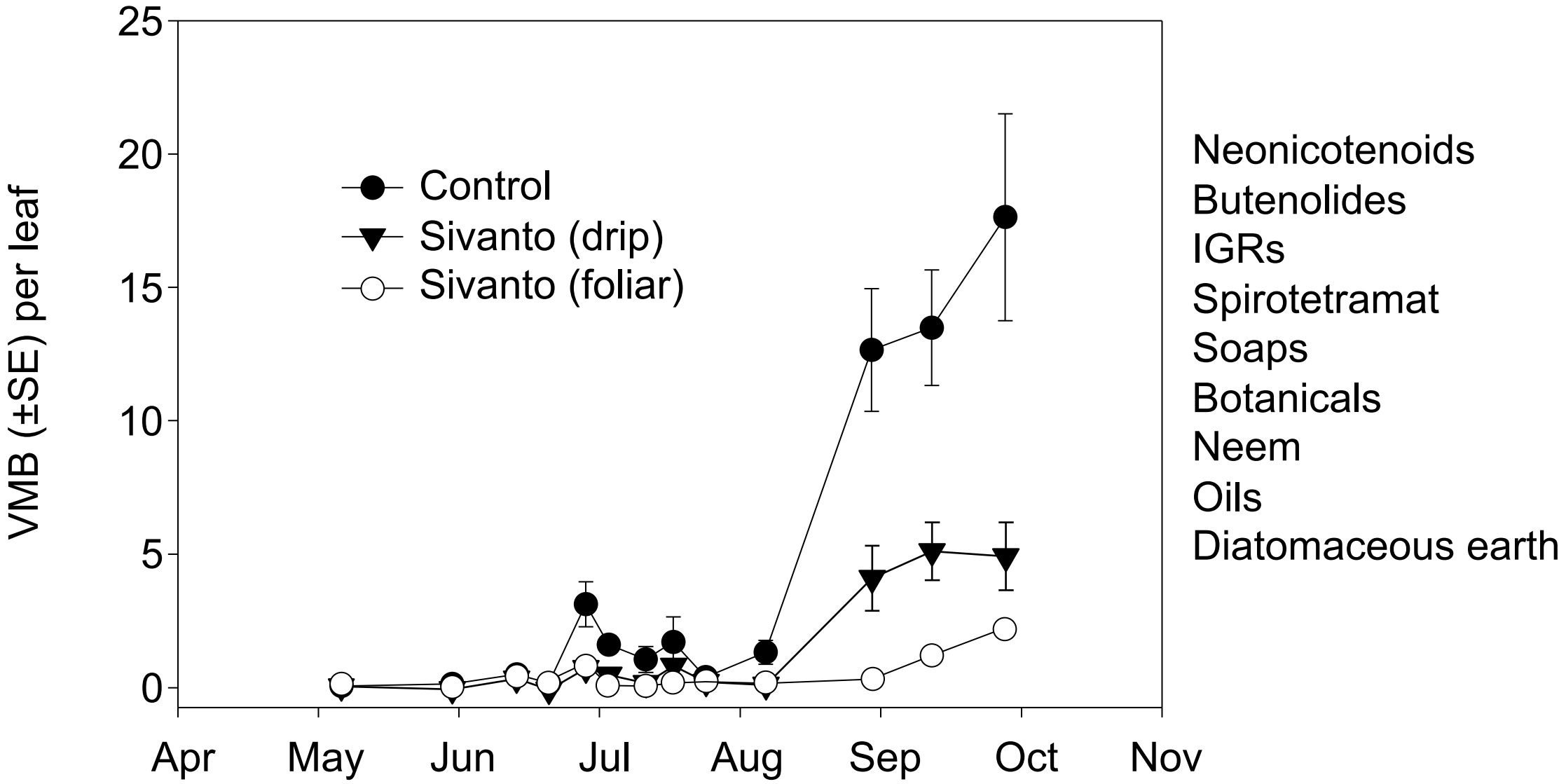

(B)
17-18 August
22-23 August
23-24 August
24-25 August
Adult male Pl. ficus per trap per time period
0
5
10
15
20
5-6 pm
6-7 pm
7-8 pm
8-9 pm
9 pm 5 am
5-6 am
6-7 am
7-8 am
8-9 am
9-10 am
10-11 am
11-12 am
Hourly time period for two-day period

Insecticides

Brief comments about Movento
Controlling VMB on the trunk
1 vs 2 MOA application(s)
Trial result consistency
OMRI materials



2019, Fresno Co. (westside)
material applied with backpack sprayer

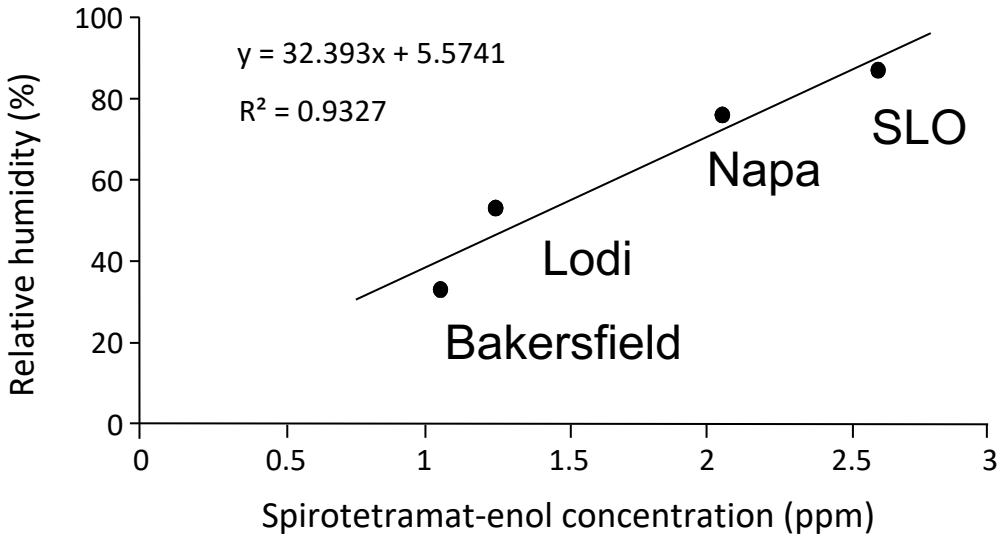


2019, Fresno Co. (westside)
material applied with backpack sprayer

(A)

VMB Population	Movento rate applied & VMB Mortality (%)			
	8oz	6oz	4oz	2oz
Organic (Control)	100%	100%	100%	-
Central Coast	100%	100%	96%	-
Lodi-Woodbridge	100%	100%	100%	-

(B)



Lodi wine grape trial: Field with heavy VMB pressure

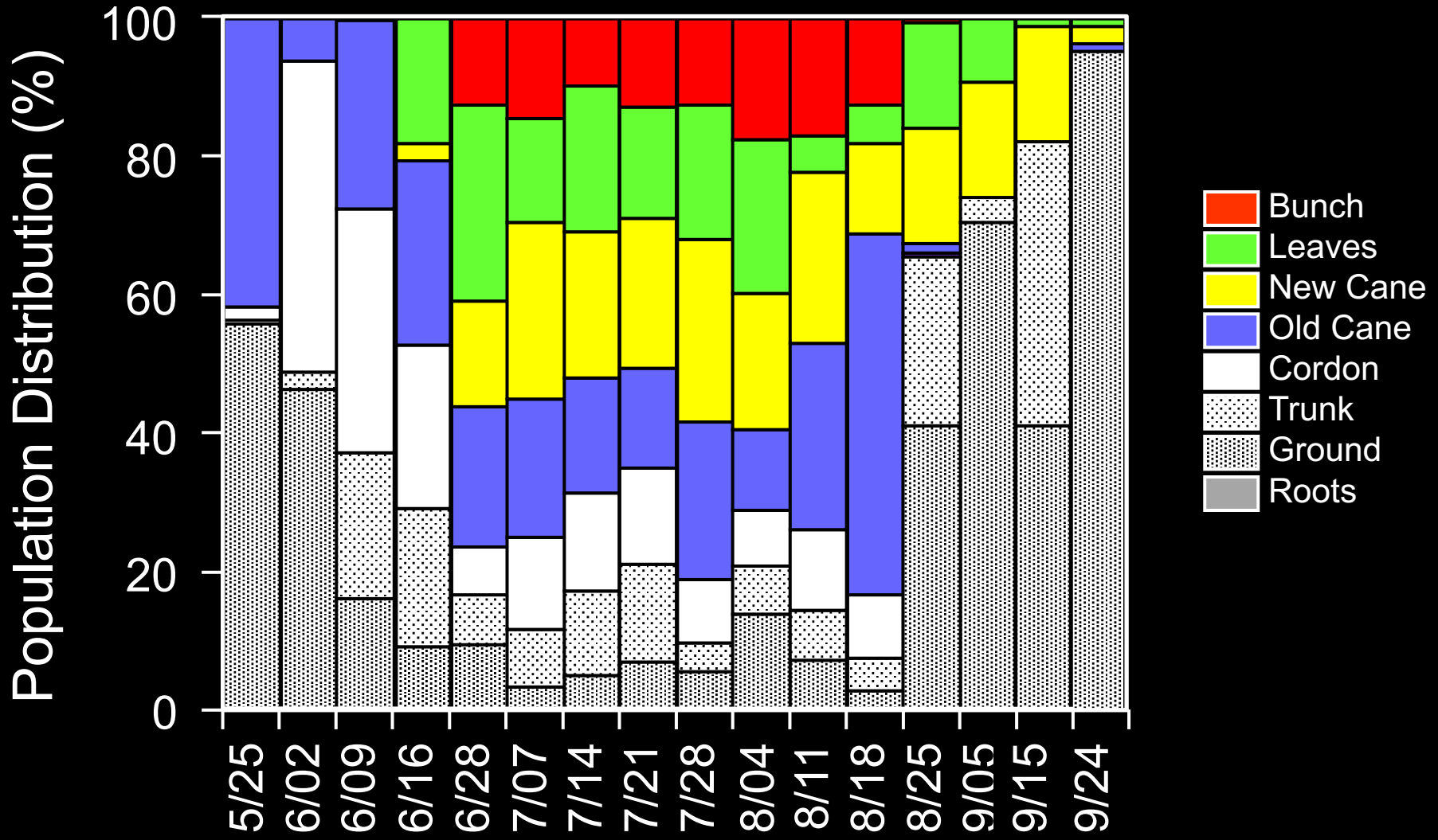
VMB underground on roots, or under bark on the trunk, cordon, and canes remains a problem. Creates a ‘refuge’ from controls – even insecticides.

Sampling methodology “whole vine” and “timed” counts

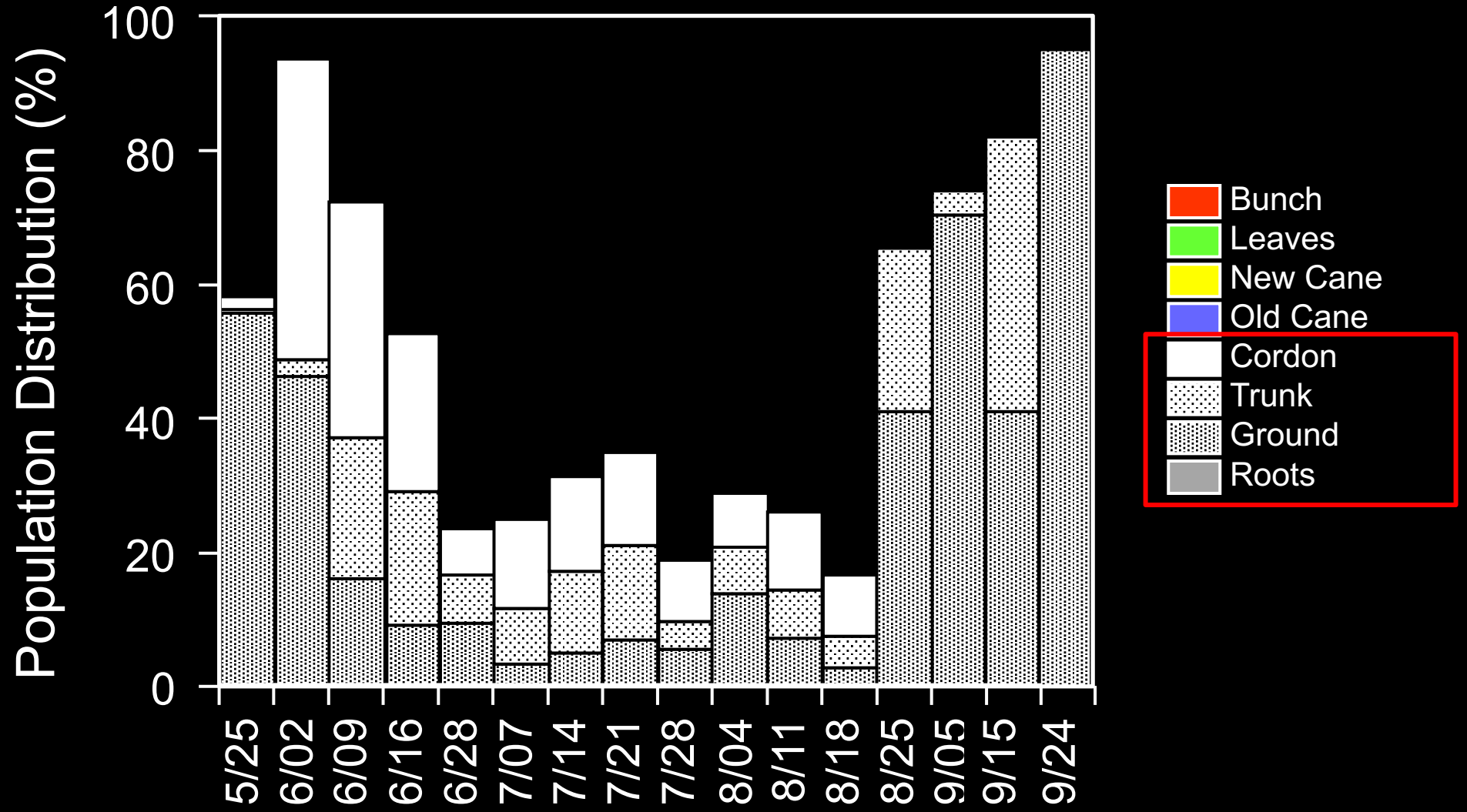
SJV and Coachella Valley

Whole vine - monthly
Timed counts – weekly
Rate damage at harvest
Count ants on trunk

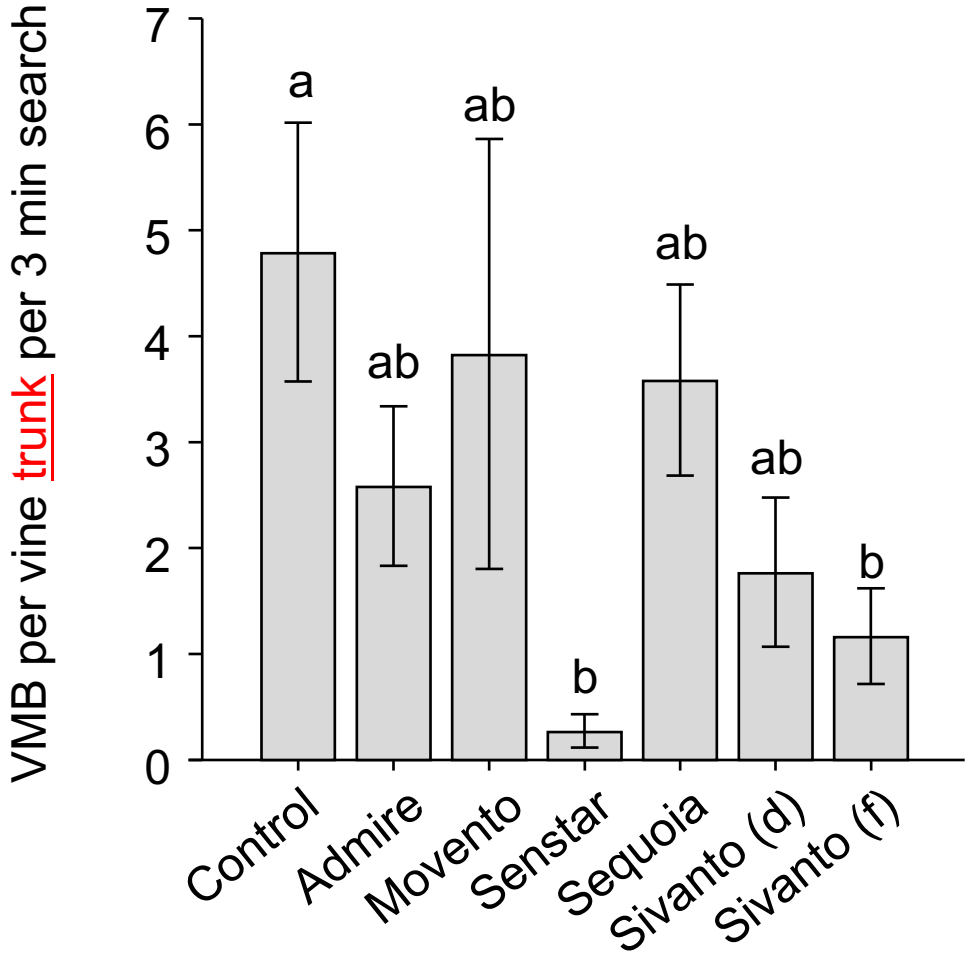
Vine Mealybug Distribution: San Joaquin Valley



Vine Mealybug Distribution: San Joaquin Valley

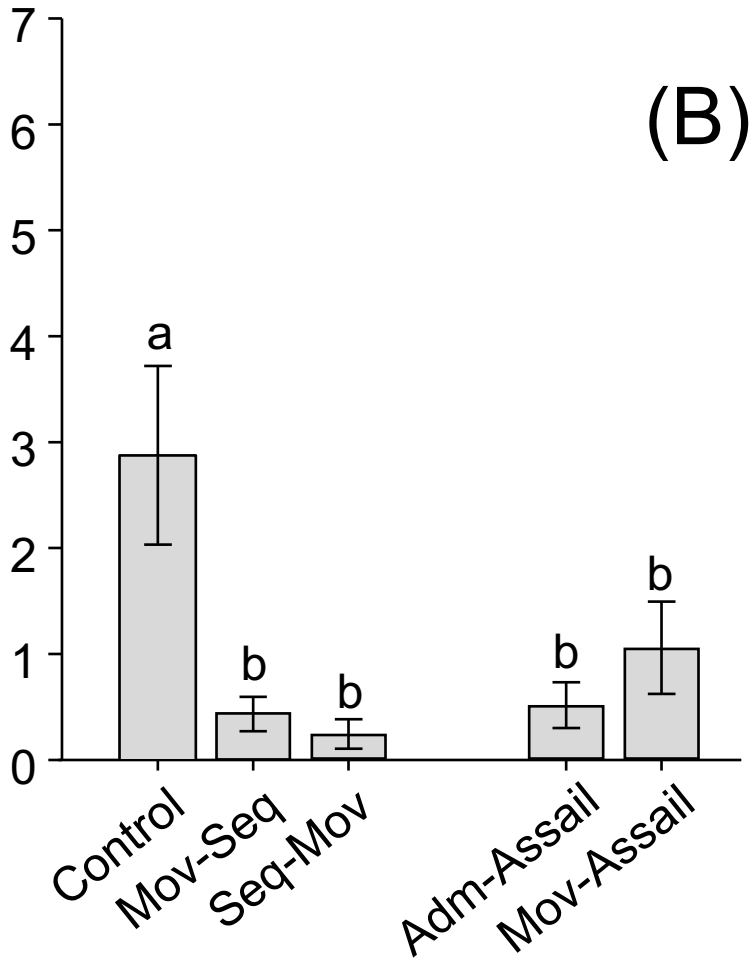


(A) 2021 – one application



Admire (14 oz) & Sivanto (28 oz) (Drip) - applied at shoot elongation (30 Apr)
Movento (8 oz) & Senstar (16 oz) - applied at bloom (12 May)
Sequoia (5.75 oz) & Sivanto (14 oz) Foliar – timed to crawlers (1 Jul)

(B) 2021 – two applications



Movento (17 Jun)-Sequoia (1 Jul) & Sequoia (17 Jun)-Movento (1 Jul)
Admire (12 May)- Assail (5.3 oz, 1 Jul)
Movento (17 Jun) – Assail (5.3 oz, 1 Jul)

neem

pyrethrin (botanical)

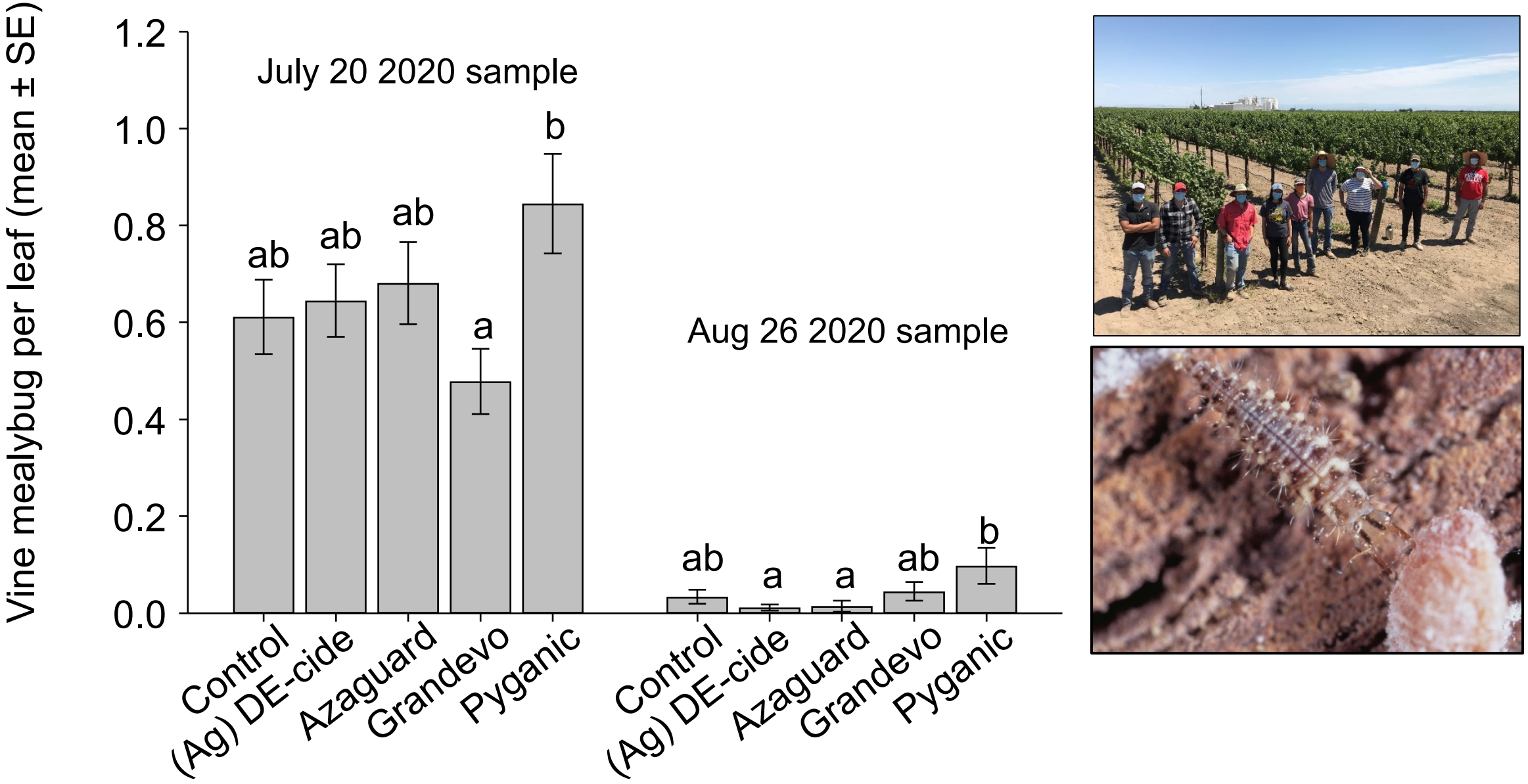
soaps

oils

Diatomaceous earth

2020 OMRI Materials (Brilliante/Mercer/Thomas/Daane) – leaf sample

Three applications of all materials



Areawide control programs

AREA-WIDE ERADICATION OF THE INVASIVE EUROPEAN GRAPEVINE MOTH *Lobesia botrana* IN CALIFORNIA, USA

G. S. SIMMONS[1], L. VARELA[2], M. DAUGHERTY[3], M. COOPER[4], D. LANCE[5], V. MASTRO[5], R. T. CARDE[3], A. LUCCHI[6], C. IORIATTI[7], B. BAGNOLI[8], R. STEINHAUER[9], R. BROADWAY[10], B. STONE SMITH[10], K. HOFFMAN[11], G. CLARK[12], D. WHITMER[13] AND R. JOHNSON[14]

EGVM eradication campaign included:

1) State-wide-monitoring using a network of pheromone-baited traps;

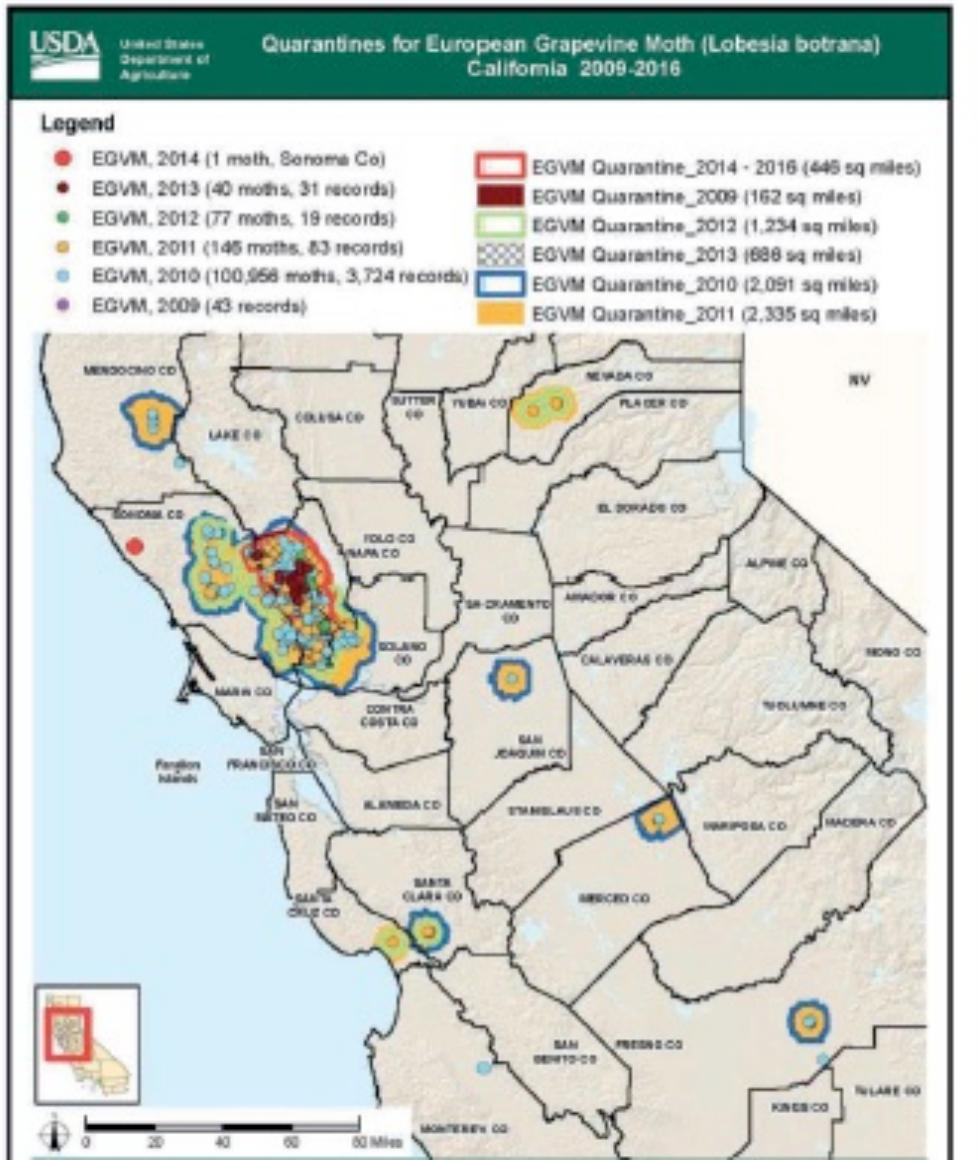
2) Area-wide application of mating disruption to infested vineyards and urban areas;

3) Implementation of area-wide insecticide treatments with application timing determined by degree-day modelling for each region;

4) a robust regulatory program that initiated and maintained a quarantine of infested areas;

5) an extensive outreach program;

6) formation of a technical working group that provided recommendations.

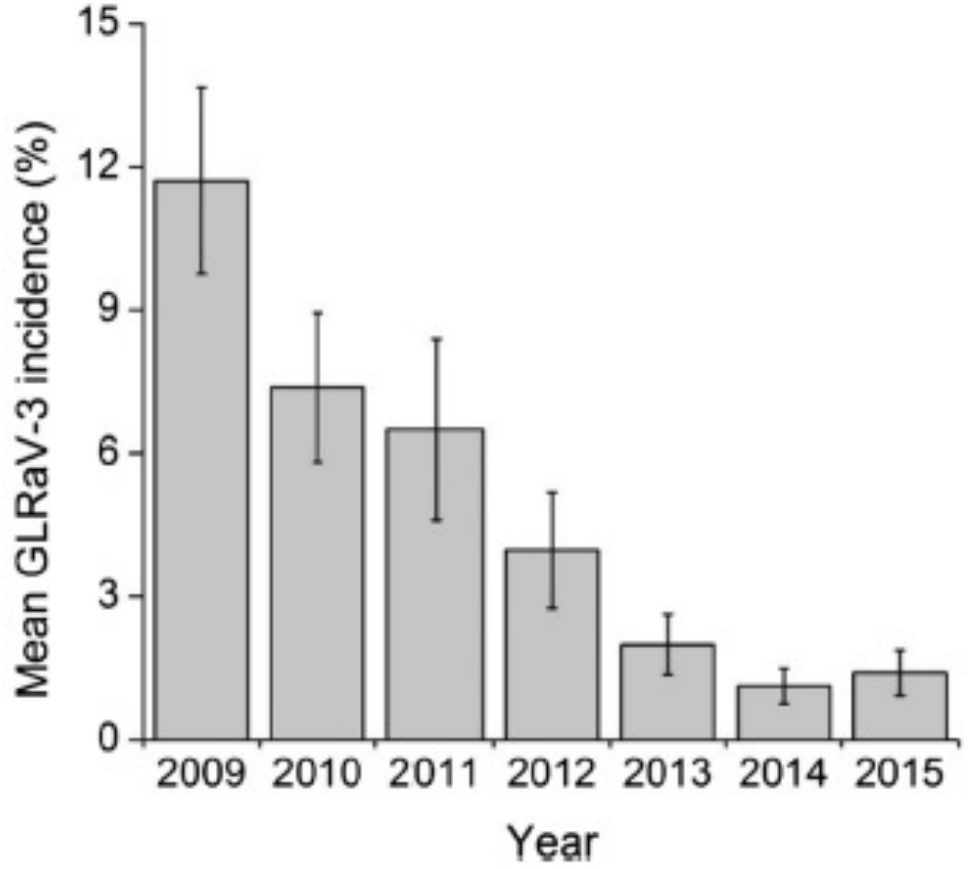


VMB & Leafroll Areawide control programs

1) Removal of GLRaV-infected vines
2) Using clean planting material (if possible)
3) Monitoring insect and pathogen
4) Controls – Chemical, Biological
5) Areawide Mating Disruption

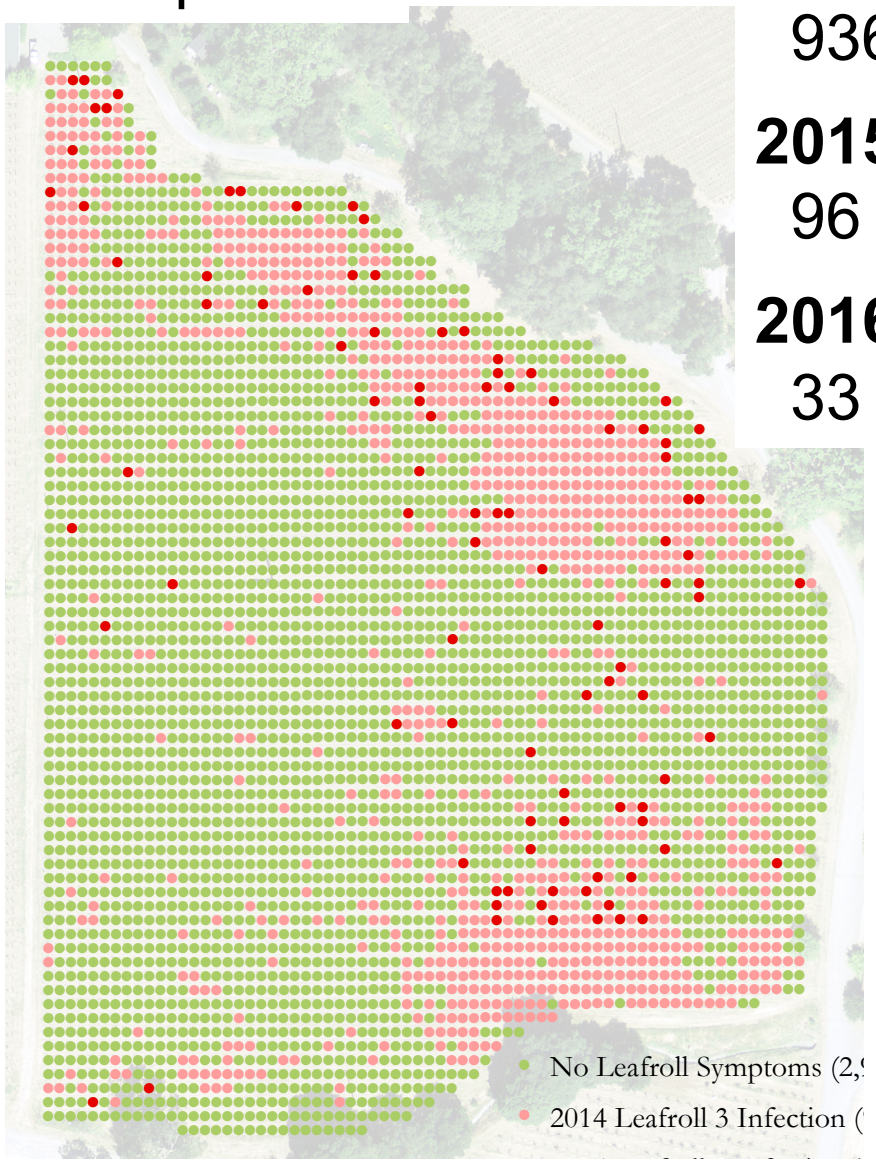
Roguing: A multi-year strategy

I. New Zealand



Bell et al. 2018. *J. Plant Path.* 100: 399-408.

II. Napa



2014-15
936 vines

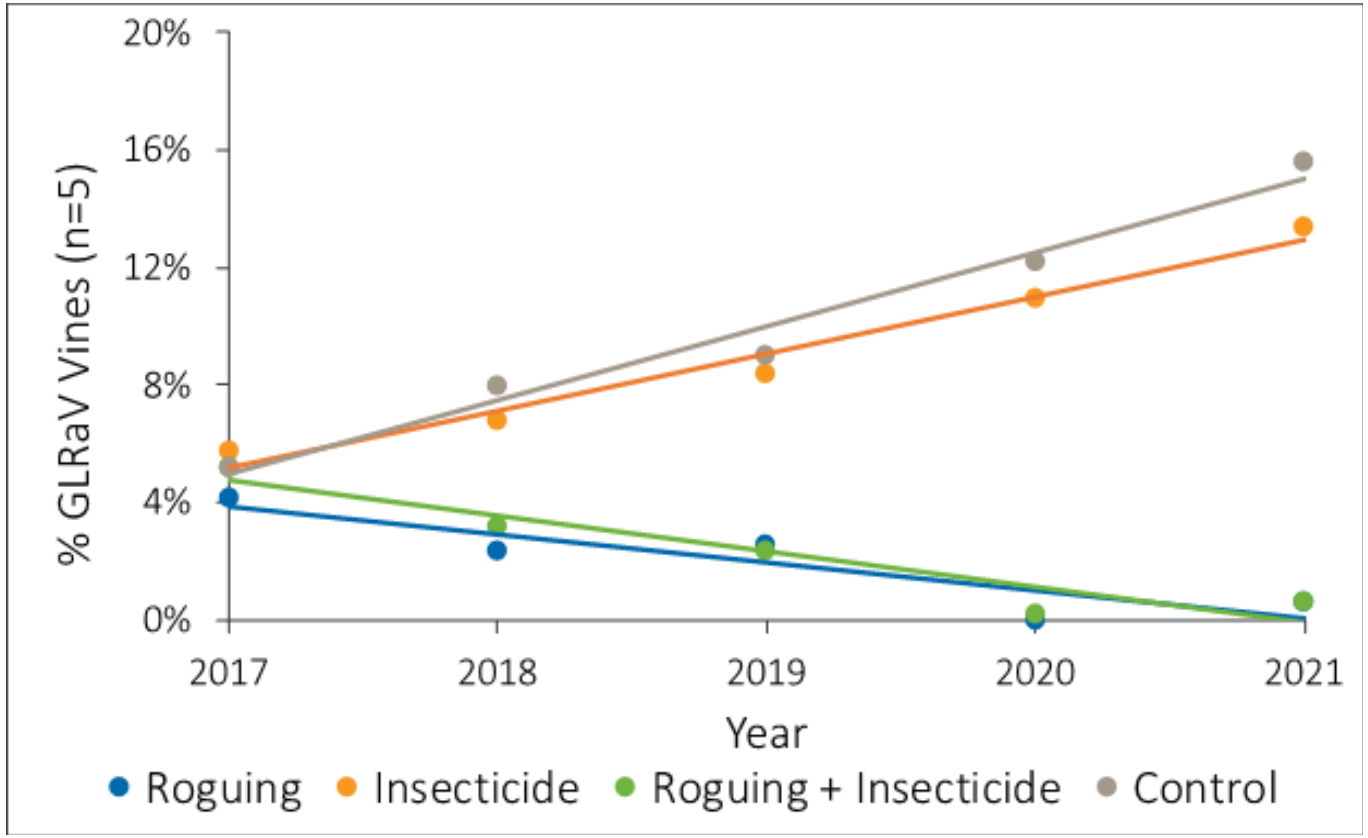
2015-16
96 vines

2016-17
33 vines

Research Focus

Vineyard Trial Demonstrates Effectiveness of Roguing and Replanting to Curtail the Spread of Grapevine Leafroll Disease

Stephen Hesler[1], Rosemary Cox[2], Greg Loeb[3] and Marc Fuchs[4]
[1]Research Support Specialist, Department of Entomology, [2]Research Support Specialist, Plant Pathology and Plant-Microbe Biology,
[3]Professor, Department of Entomology, [4]Professor, Plant Pathology and Plant-Microbe Biology, Cornell AgriTech, Geneva, NY

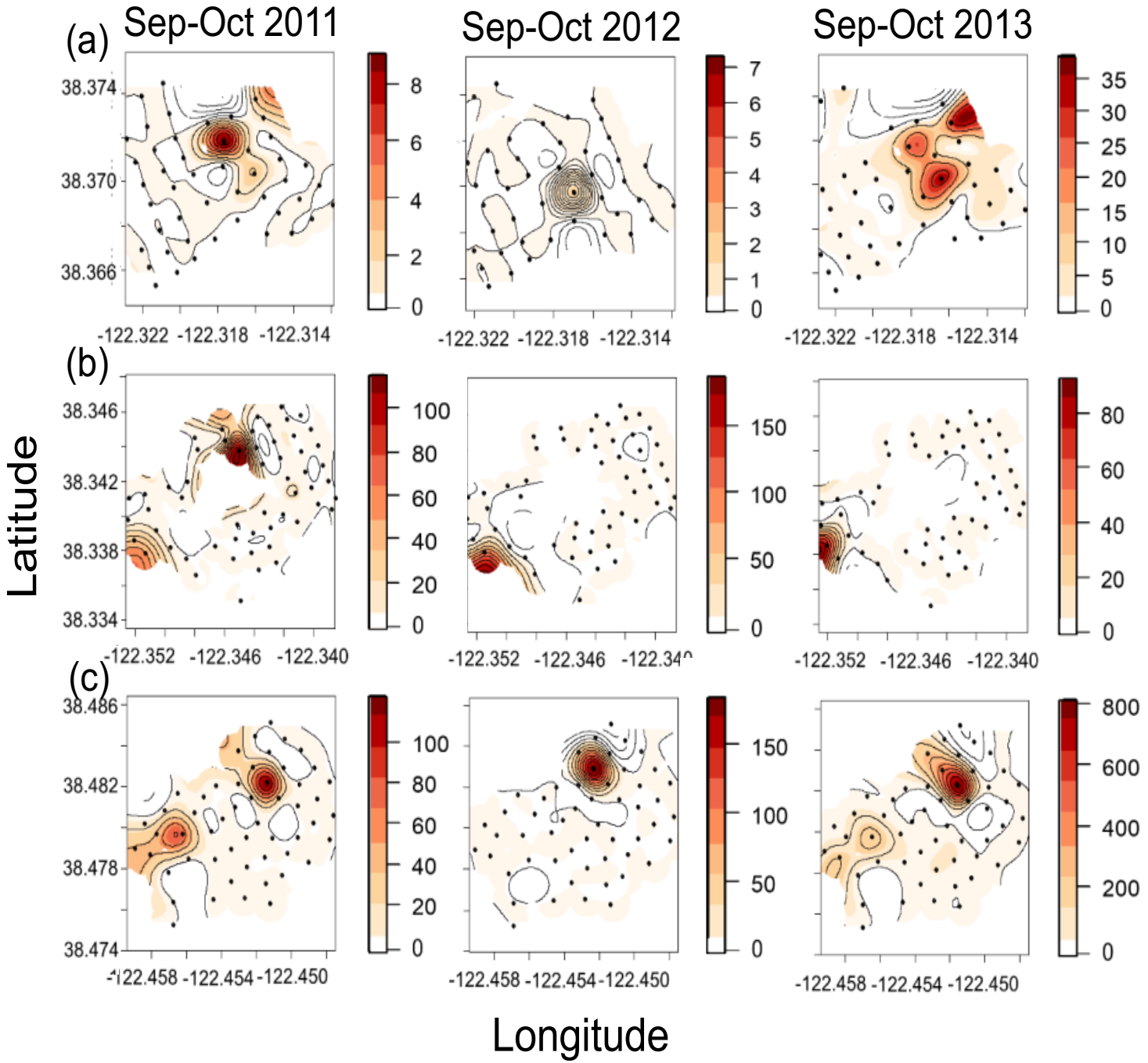


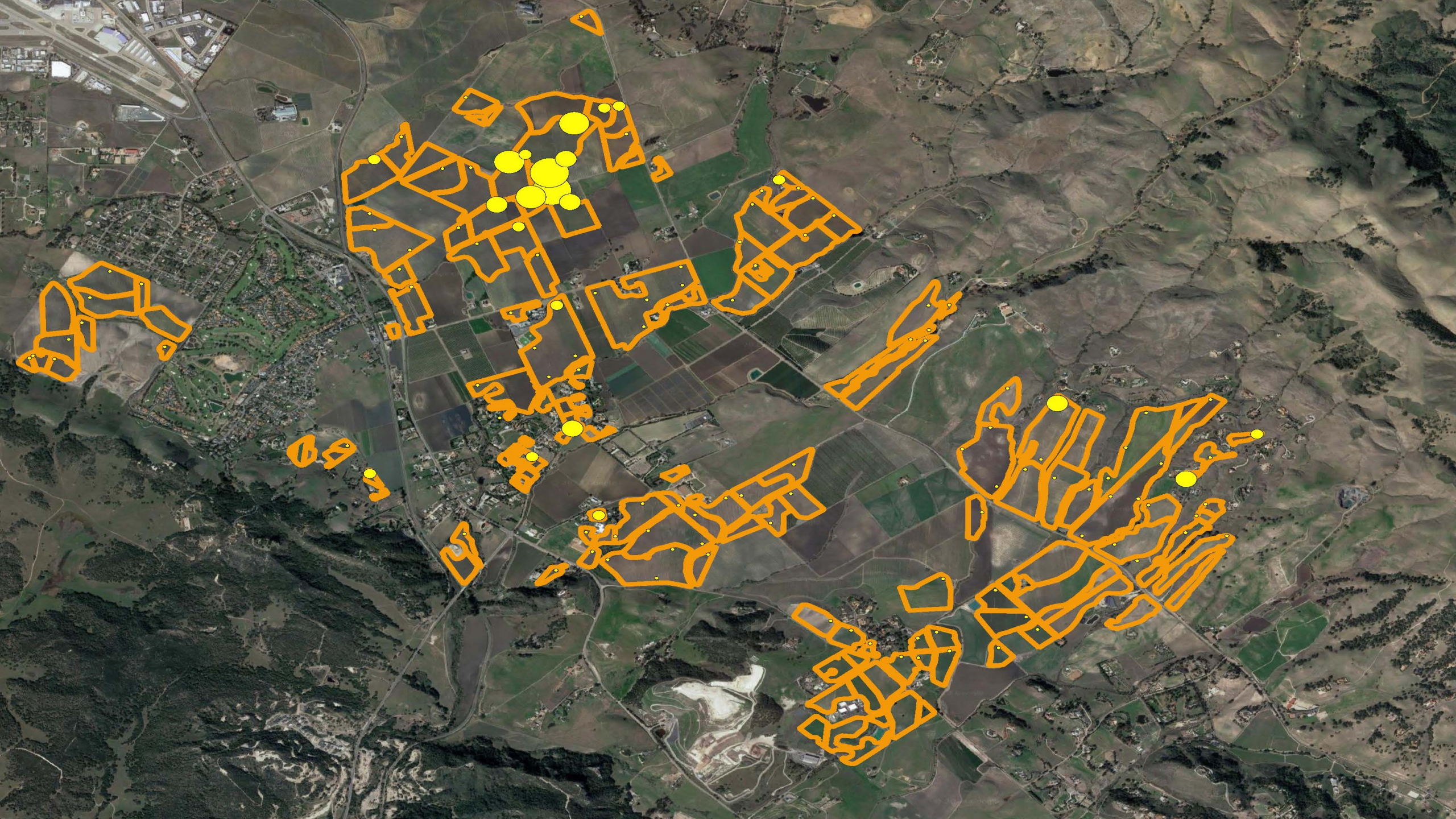
III. New York

Detection of leafroll viruses from 2017 to 2021 in a Cabernet franc vineyard study site affected with leafroll disease.

Contour maps showing numbers of VMB in traps Sept- Oct of each year, in MD site 1 (a), MD site 2 (b) and MD site 3 (c).

Results show decrease from MD yr1 to MD yr2 and then a sharp rise after areawide program stops





Obstacles to mapping and removal

Distinguish visual symptoms

Leafroll

Visual symptom mapping

Invest in staff training: symptom recognition
Retain proficient staff to provide consistency
Develop mapping, vine removal & replant strategy

Economic studies:

25% disease incidence threshold
Below threshold: rogue + replant
Above threshold: redevelop block

Roguing vector density dependent

Field studies & modeling

Grape mealybug + GLRaV-3
Napa (2009-2016)

Disease incidence category

less than 1% GLD incidence

Pathogen originating outside the block
Regional monitoring + communication among neighbors
Rogue to reduce build-up of inoculum in the block
No clear role for insecticides (GMB)

1 to 20% GLD incidence

Roguing & Insecticides
Alone or in combination reduced GLD spread

greater than 20% GLD incidence

Roguing effective (reduces inoculum)
Insecticide did not reduce spread (in the target block)

Cooper et al. 2018. J. Econ. Entomol. 10.1093/jee/toy124
MacDonald et al. 2021. J Econ Entomol. 10.1093/jee/toab091

Areawide Mealybug & GLRaV:

1) Monitoring using a network of pheromone-baited traps;

2) Area-wide application of mating disruption to infested vineyards and urban areas;

3) Implementation of area-wide insecticide treatments with application timing determined by degree-day modelling for each region;

4) a robust regulatory program that initiated and maintained a quarantine of infested areas;

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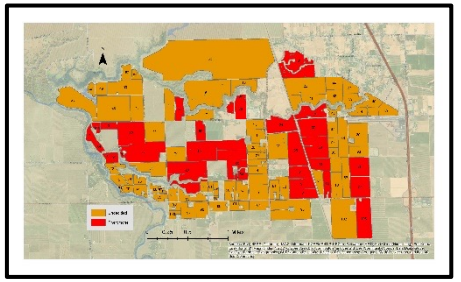

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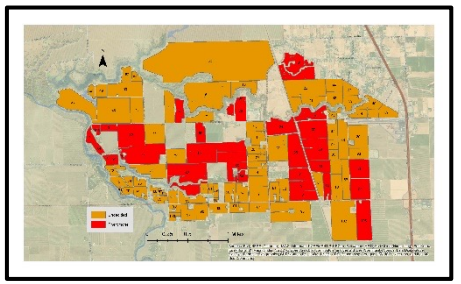


Summary

1) Mating disruption can be a part of VMB management; a good insecticide program is important as MD works best at low pest densities, and with multiple years of application and larger areas under MD (areawide controls).
2) As mealybug control/suppression is achieved, applications of insecticides and rate of MD deployment can be lowered.
3) Cons – high VMB densities, small plots, windy conditions, half season exposure (remember adult longevity), deployment rates too low compared with VMB density, neighboring vineyards that serve as refuge for more male VMB.
4) No single pesticide application provides 100% control. Trial results can vary (David has mentioned 'consistency'). OMRI material have not worked as well as conventional materials, in my trials.
5) Natural enemies play a role, even with insecticides and even without manipulation.

Extra slides for questions

Vector Epidemiology – or how efficient are mealybugs at moving the pathogen

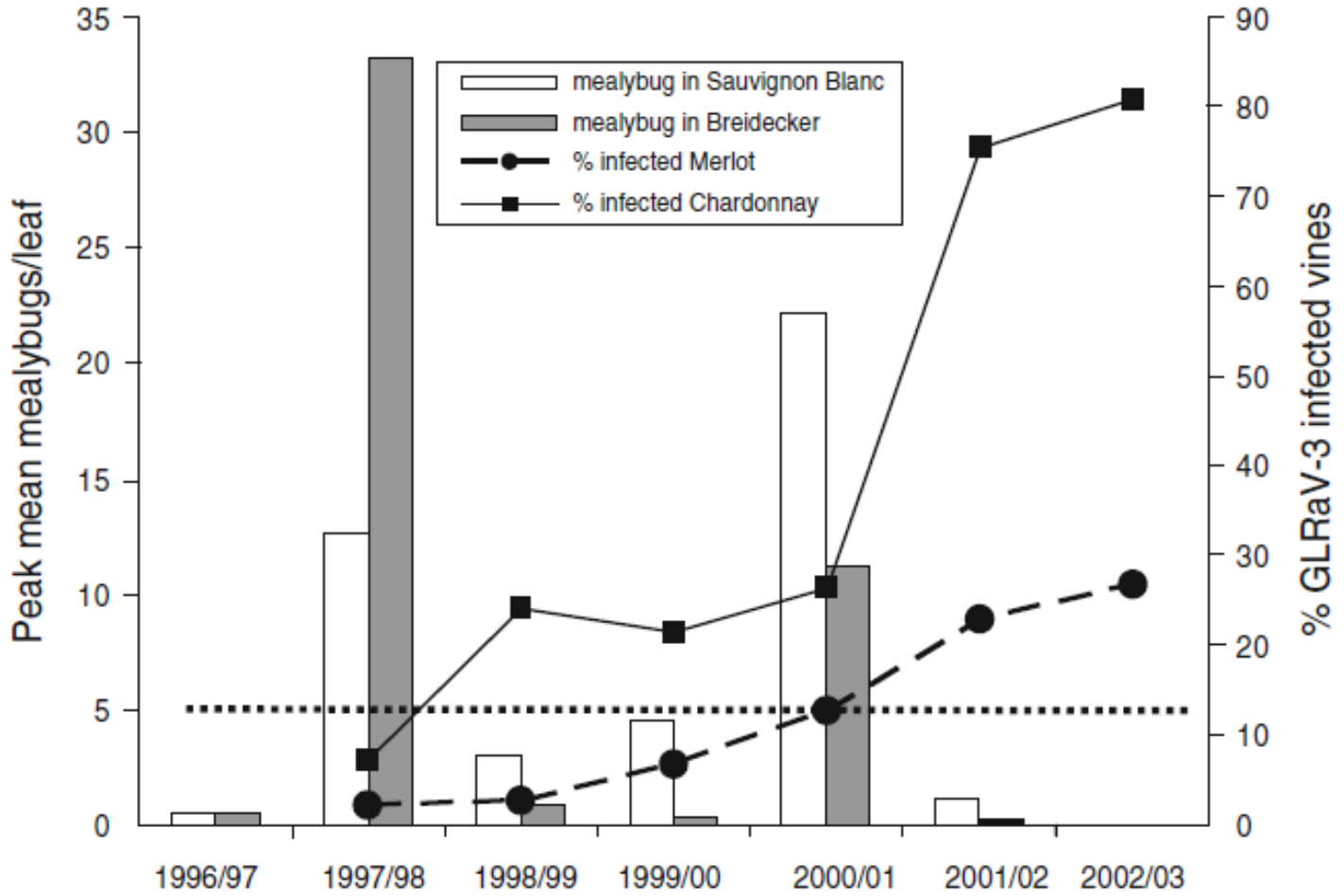
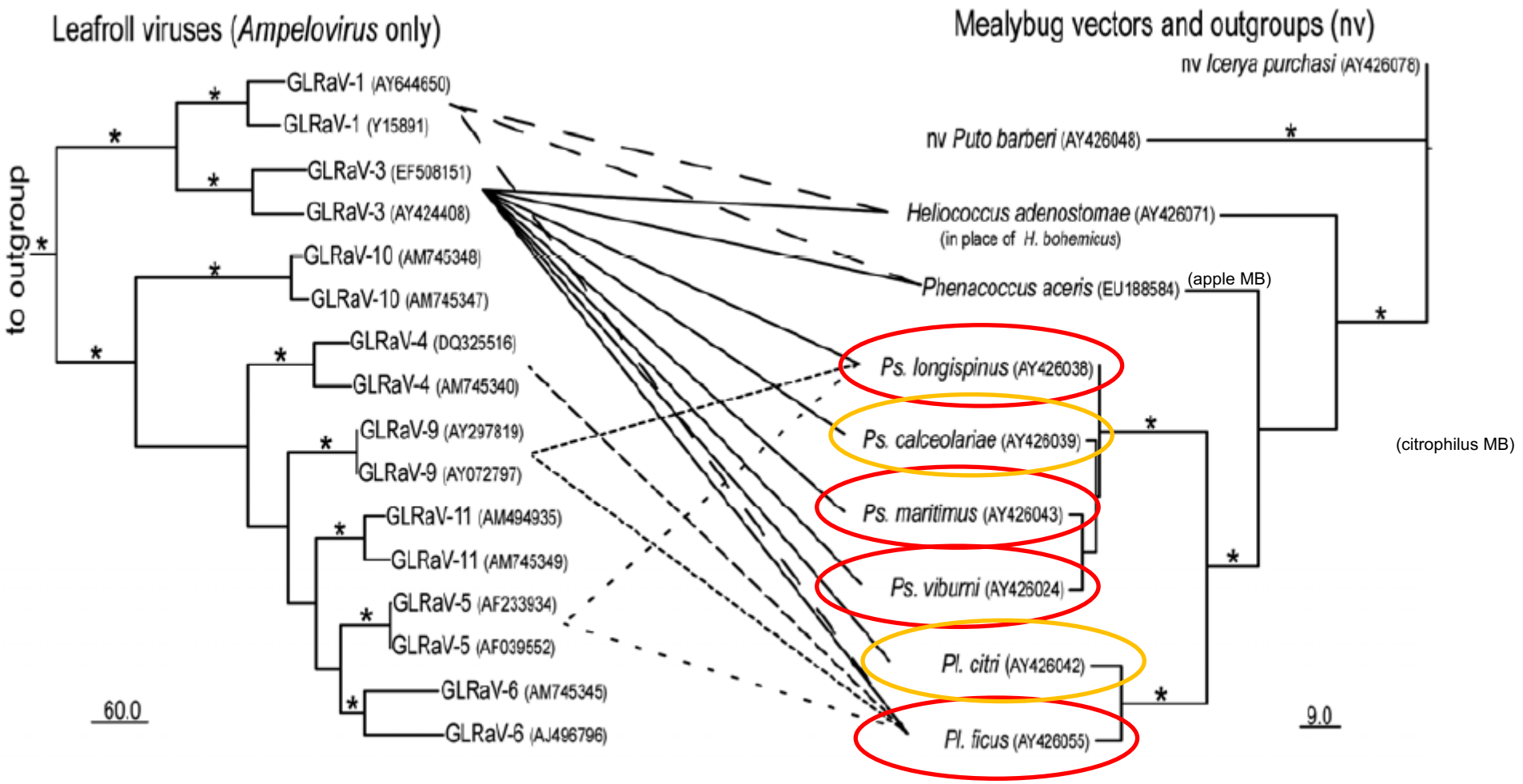
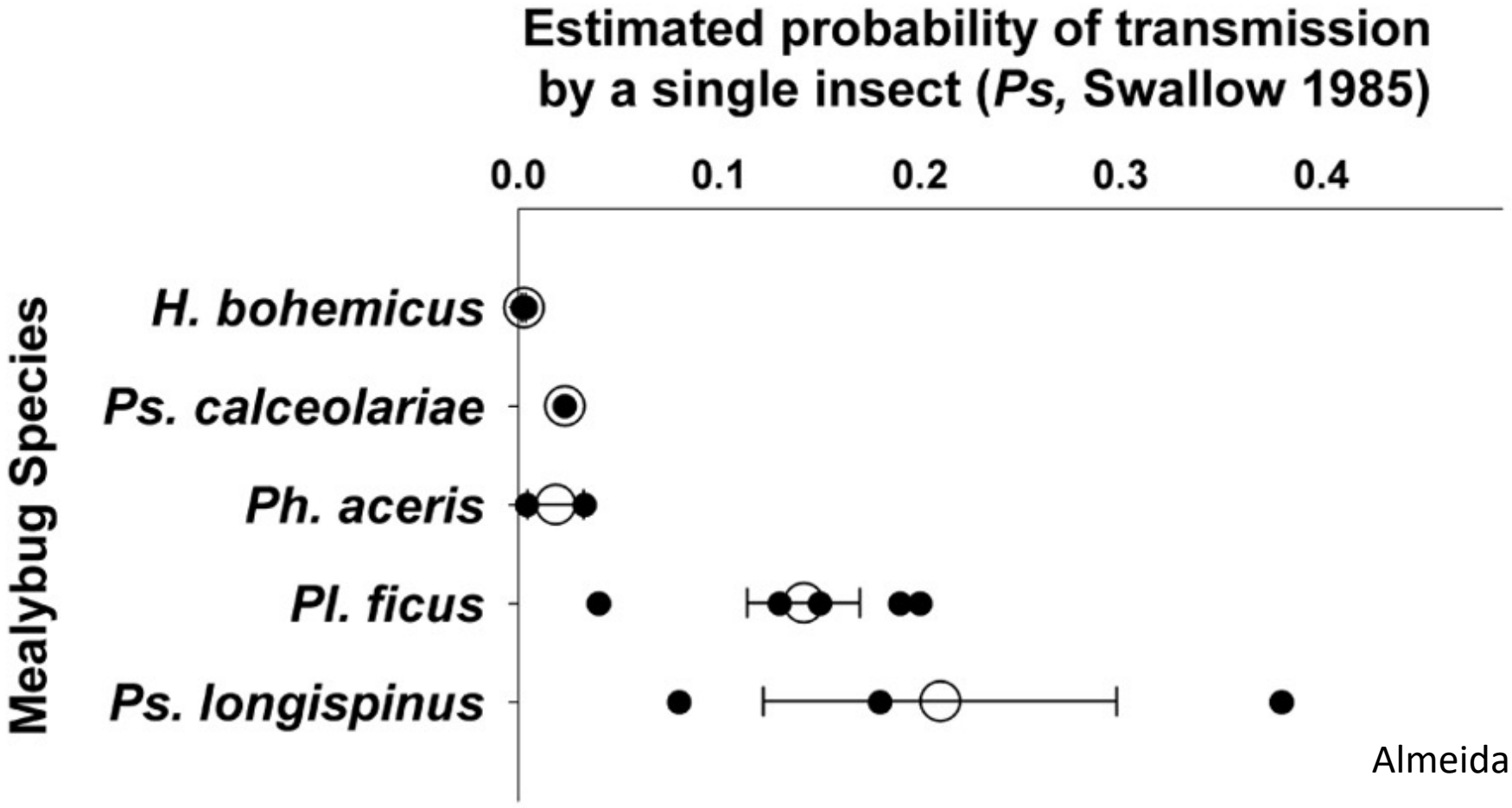


Fig. 5. The relationship between *Pseudococcus longispinus* mealybug populations on Sauvignon Blanc and Breidecker vines (primary *y*-axis) and cumulative grapevine leafroll-associated virus type 3 (GLRaV-3) infection on Merlot and Chardonnay (secondary *y*-axis).

There is no vector-pathogen specificity or fidelity



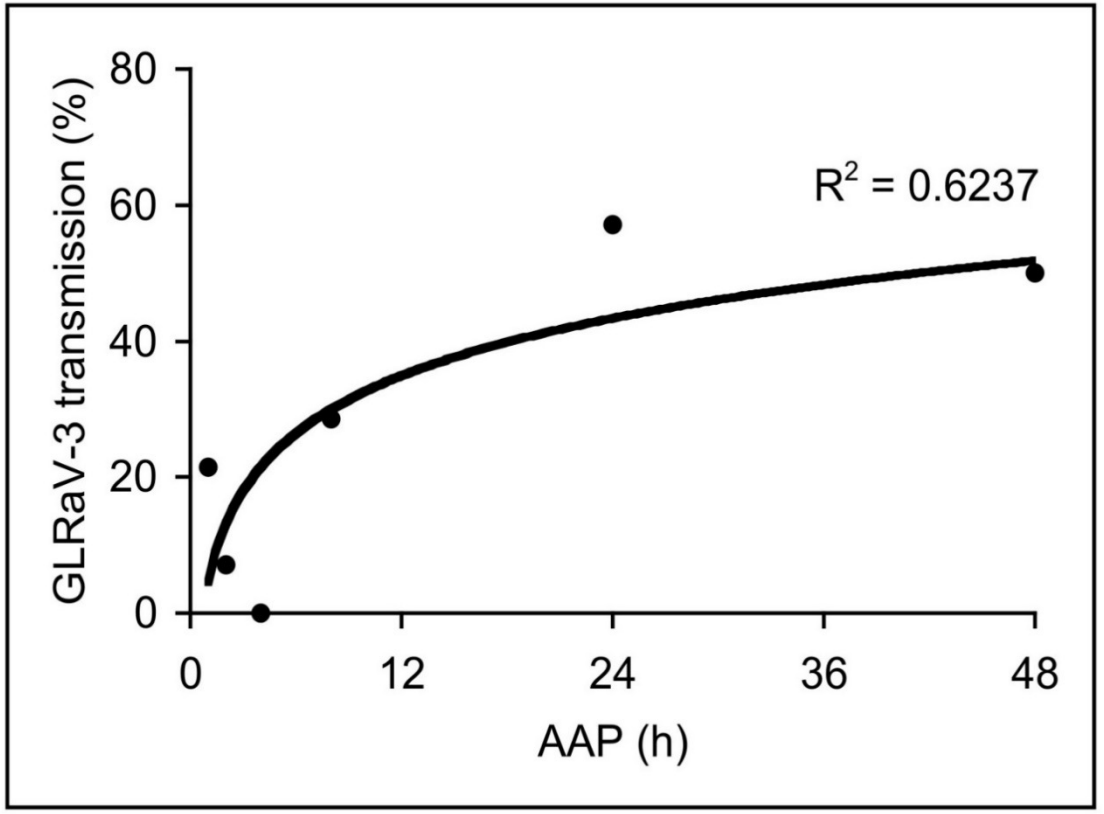
Vectors of Leafroll 3: mealybug spp. efficiency may vary



Almeida et al. 2013

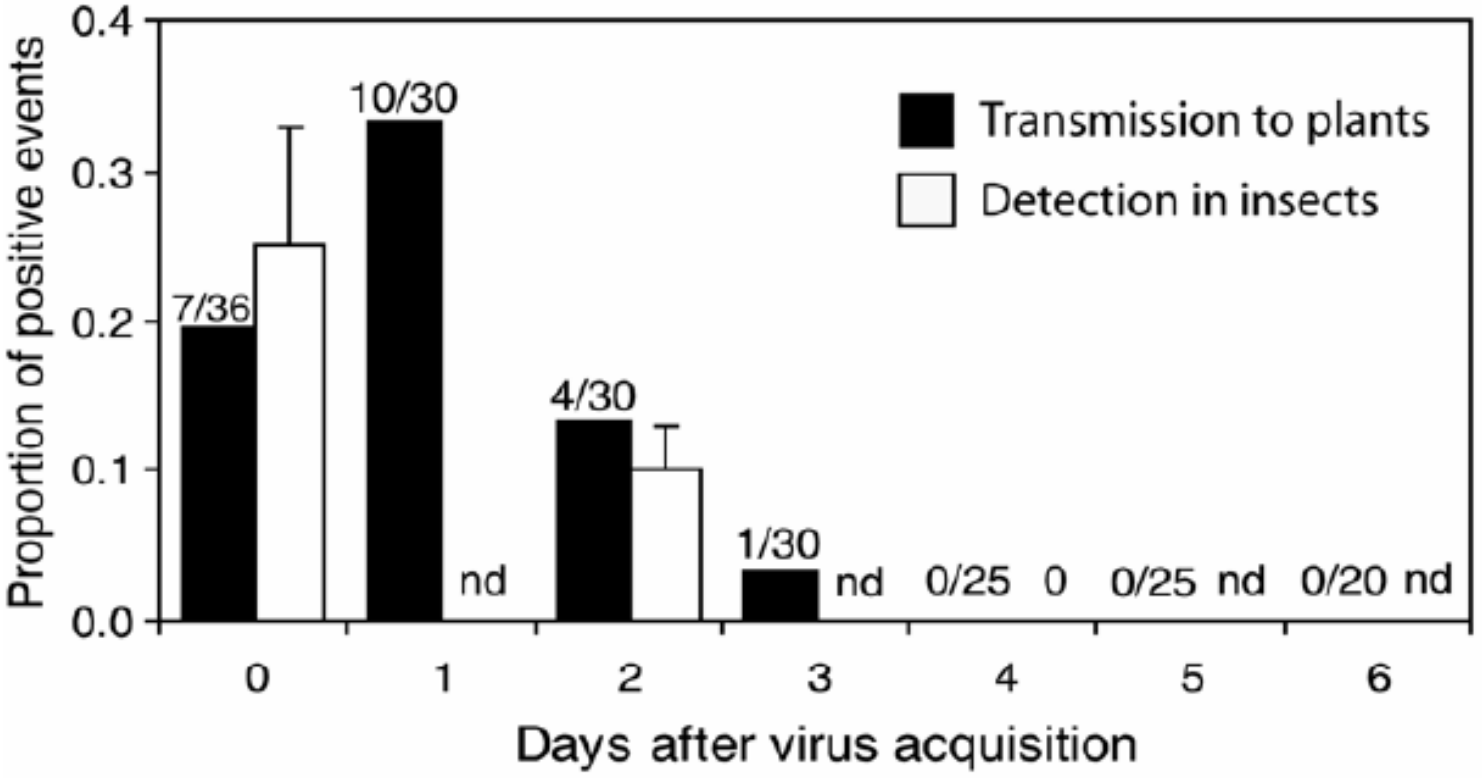
Key Transmission Facts – Acquisition & Transmission

- Crawlers **acquired** virus w/in 1 hr, and could **transmit** the virus w/in 1 hr
- Peak at 24 hr, all stages could acquire and transmit the pathogen for GLRaV



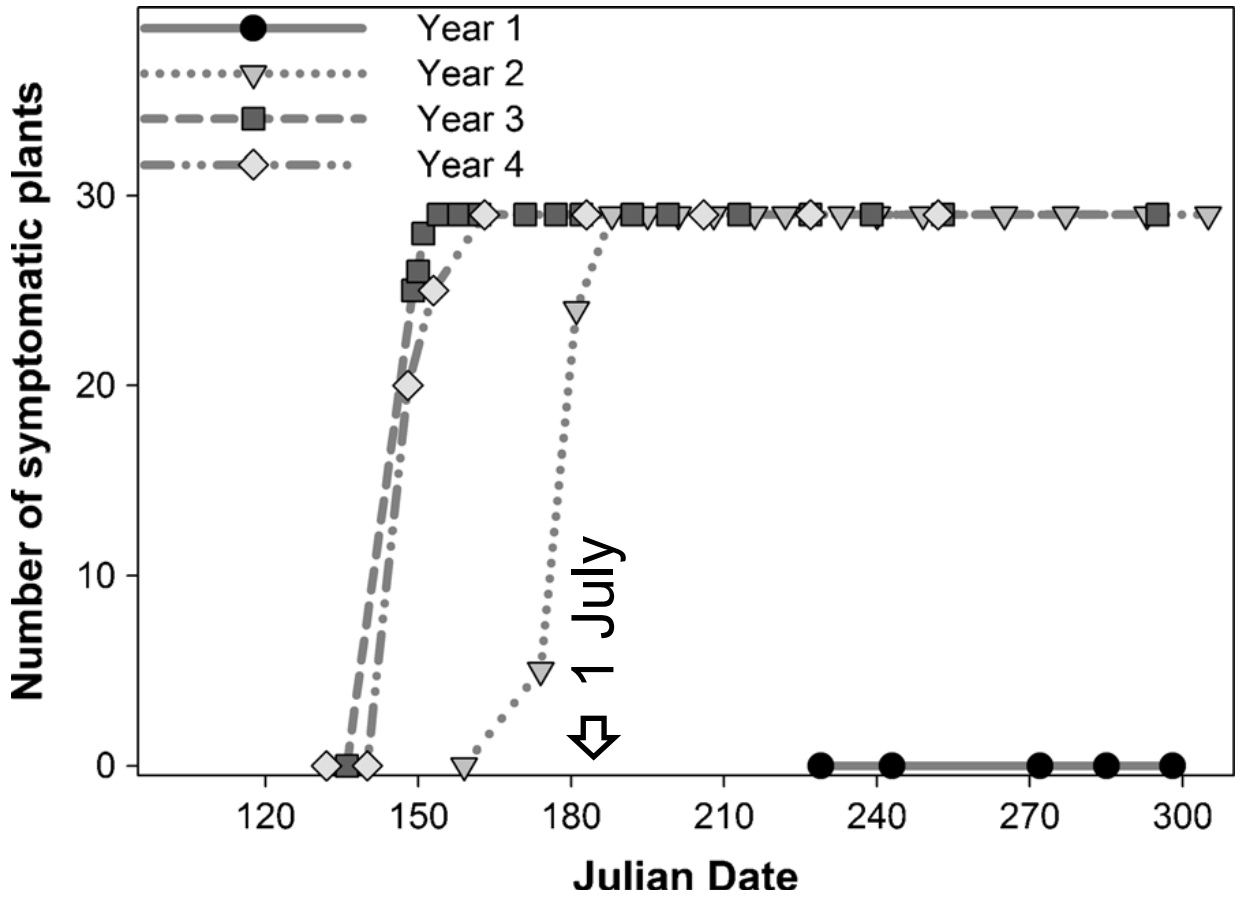
Tsai et al. 2008 *Phytopath*.

Semi-persistent transmission (lost after four days, or each molt)



Tsai et al 2008 *Phytopathology*

How long before GLRaV Symptoms occur?



10 grape MB per plant (on a single leaf);
48 h acquisition (in lab), 48 h inoculation (in field 19 July, Movento)

Blaisdell et al. 2016 *European J Plant Pathology*