Reducing psyllids improves tree health even when trees have HLB: IPM approaches

Lukasz Stelinski

University of Florida, Entomology and Nematology Department, CREC, Lake Alfred, FL

Parameters of Damage to Crops:

Damage $\propto$ D x A x S x T

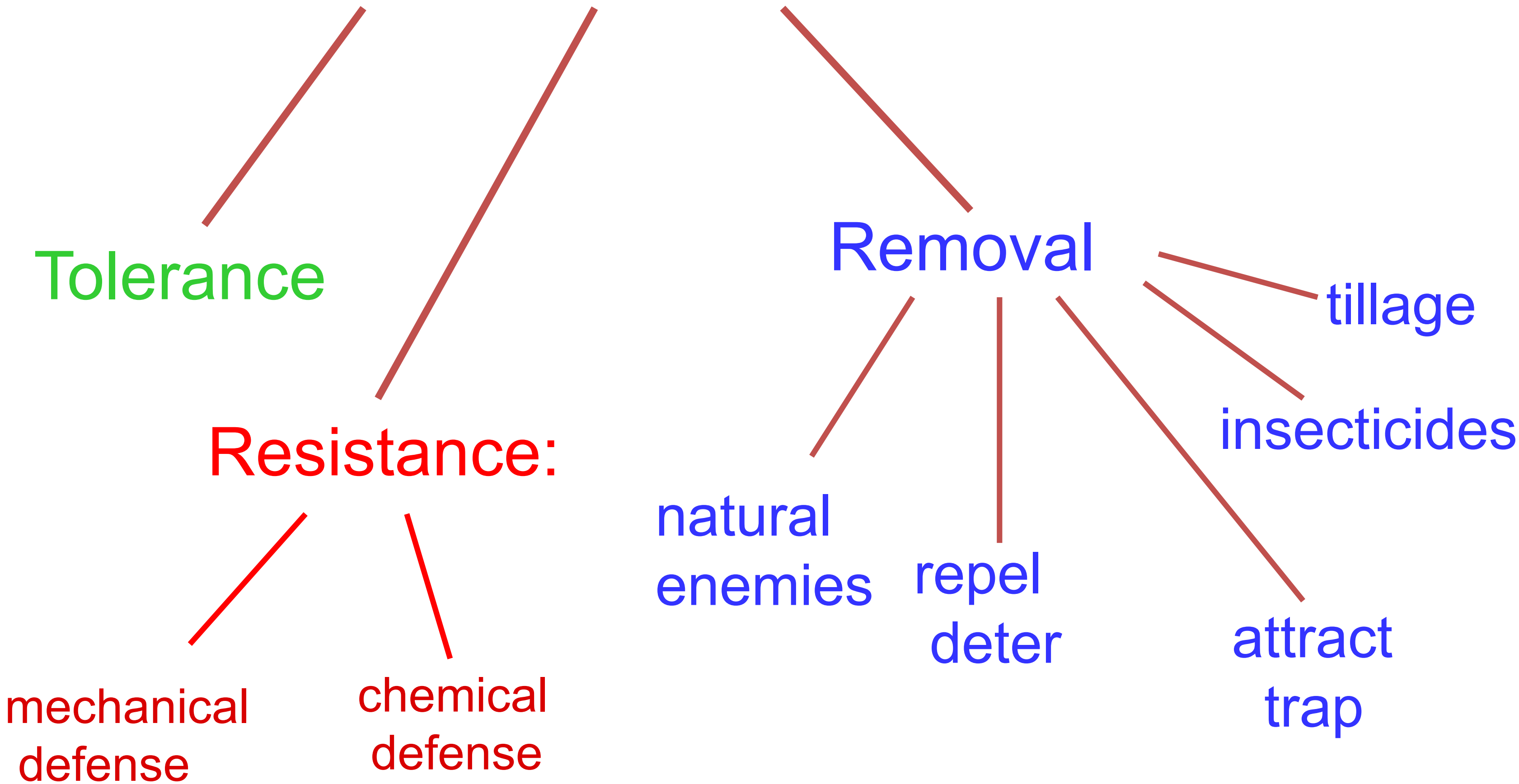
Density of pest

Acceptibility of crop

Suitability of crop

Time of interaction

Major tactics for managing pests:



Insecticides

$$Damage \propto D \times A \times S \times T$$

Density

Acceptibility

Suitability

Time of interaction

Resistant Varieties

$$\text{Damage} \propto D \times A \times S \times T$$

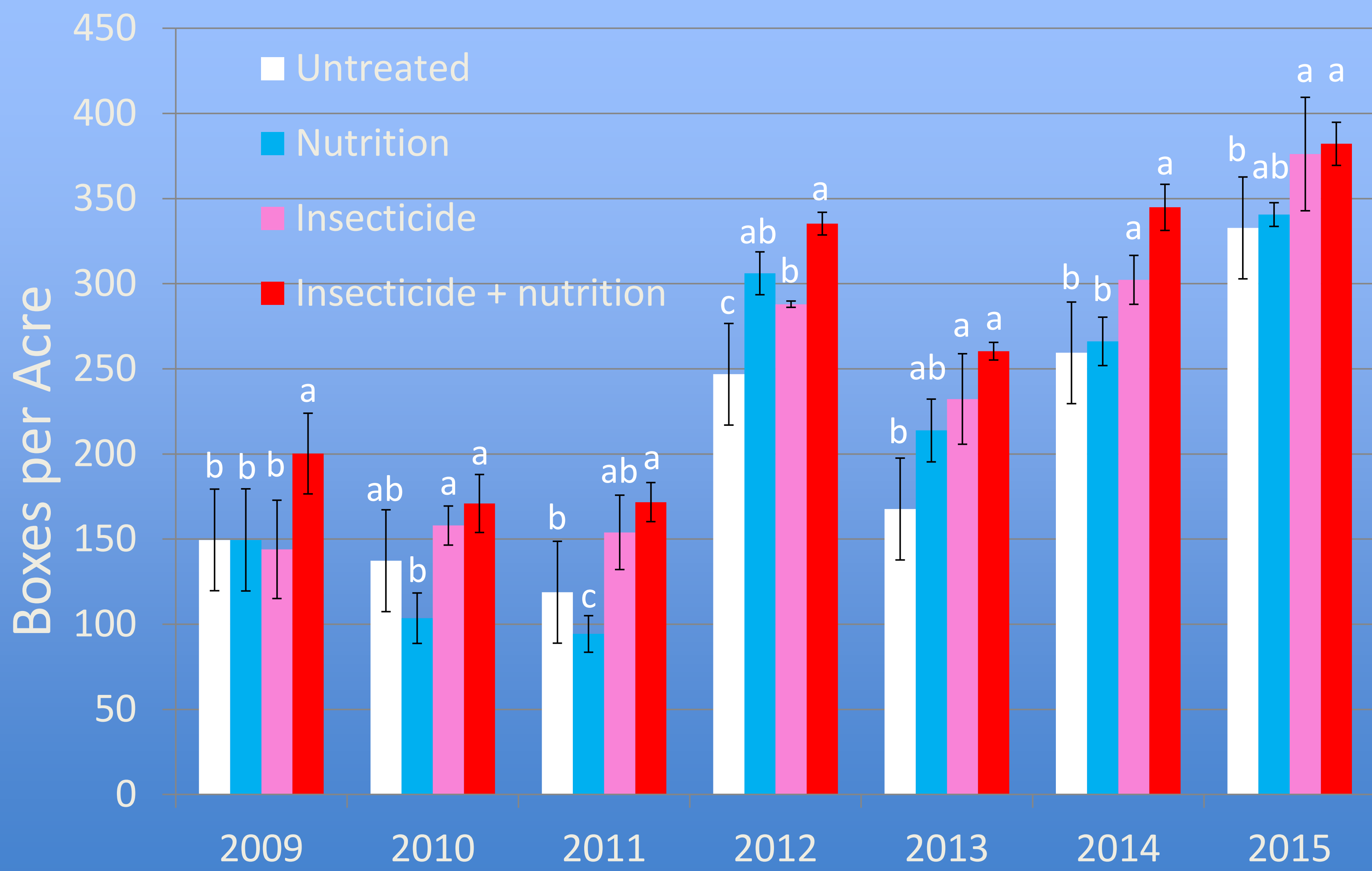
D ensity

A cceptibility

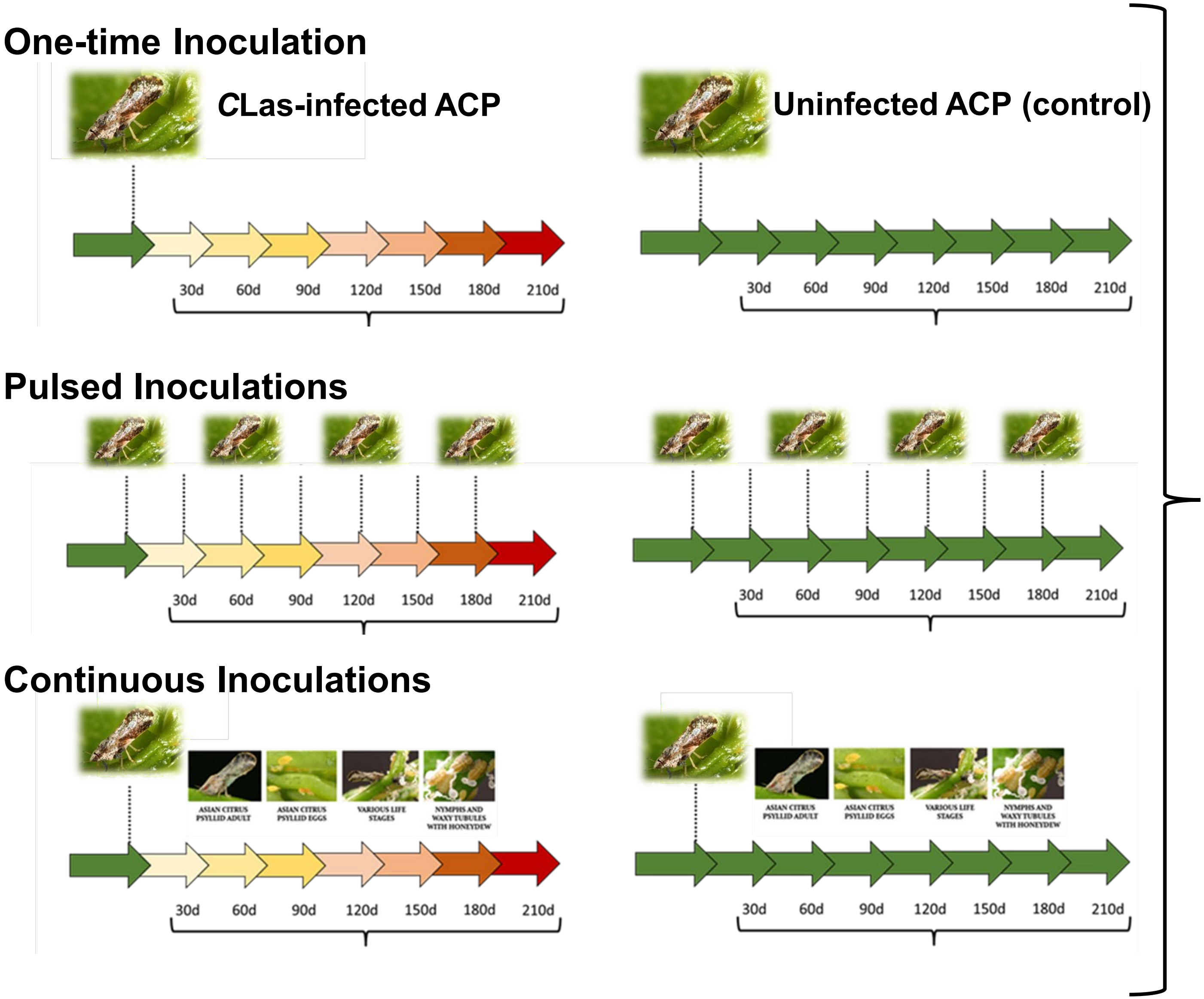
S uitability

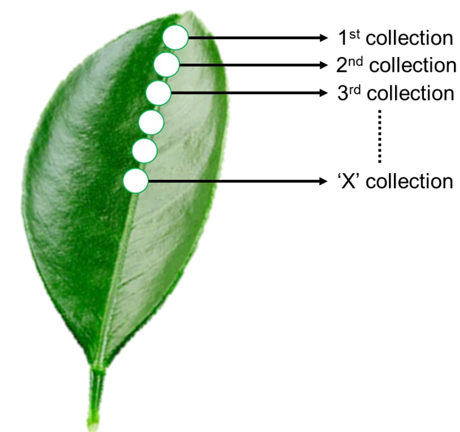
T ime of interaction

Keeping ACP down seems to help yield



Experimental design

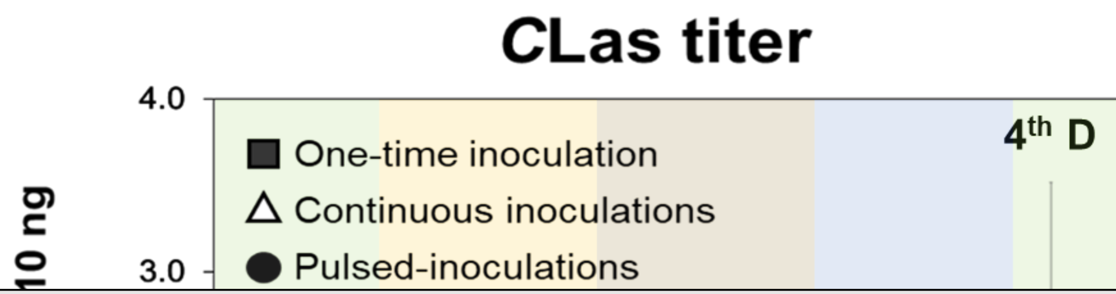


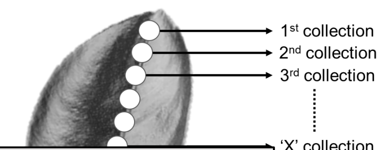


12 mature leaves were used to analyze:

- CLas titer
- Gene expression
- SA and its analytes

Pathogen titer not related to inoculation frequency





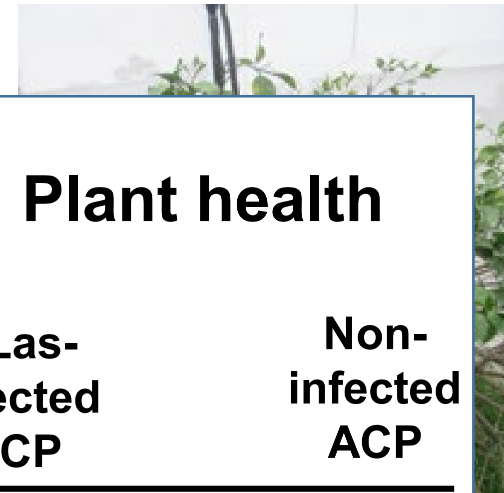
- **No differences in *C*Las titer** between plants exposed to infected vectors once (7 day inoculation access period) as compared with plants exposed to continuously to breeding *C*Las-infected insects
- Are insecticide applications needed if *C*Las titer does not appear to be impacted (no super-infection)?

Larger cage experiment in Texas (Mamoudou Setamou, Texas A&M)-same results

HLB +; No ACP

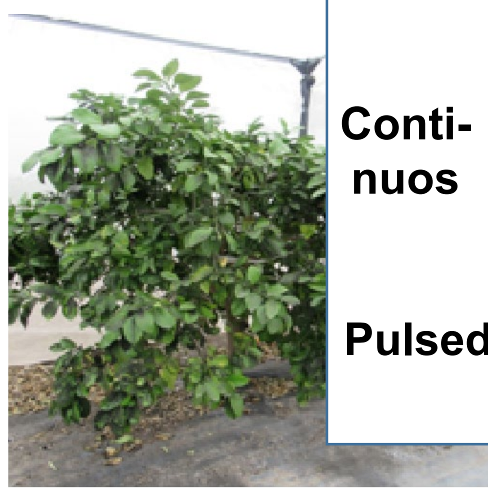
HLB +; Pulsed (monthly) ACP

HLB +; Continuous ACP



HLB -; No ACP

HLB -; Pulsed (mo



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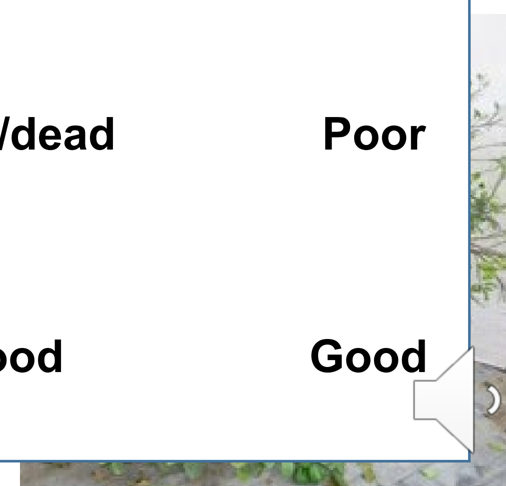


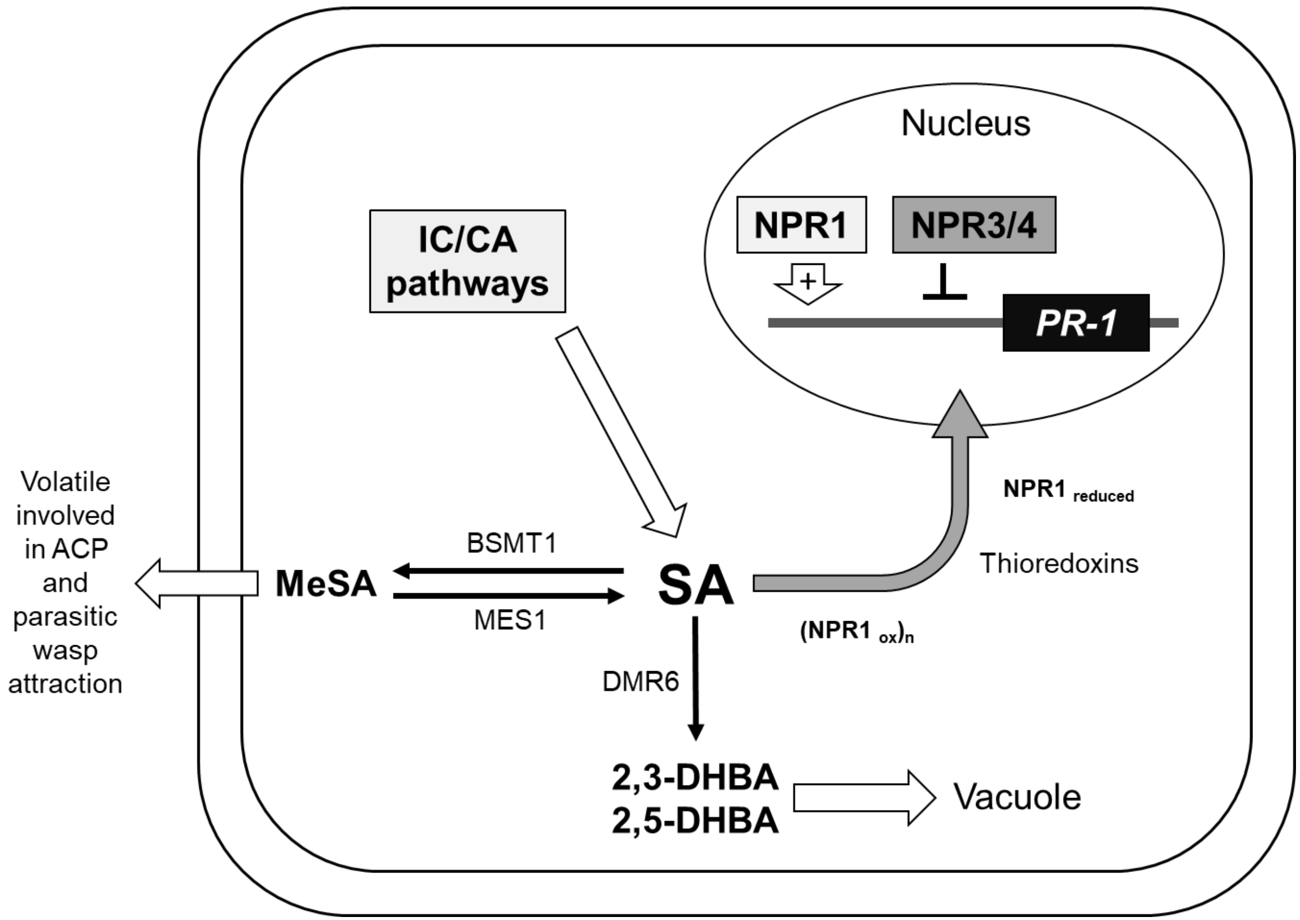
Plant health

	CLas-infected ACP	Non-infected ACP
One-time	**Intermediate**	**Good**
Conti-nuos	**Poor/dead**	**Poor**
Pulsed	**Good**	**Good**

Do *C*Las and ACP affect SA defenses?

We have described salicylic acid-induced plant defense response at varying *C*Las inoculation frequencies

Model of SA metabolism and signaling

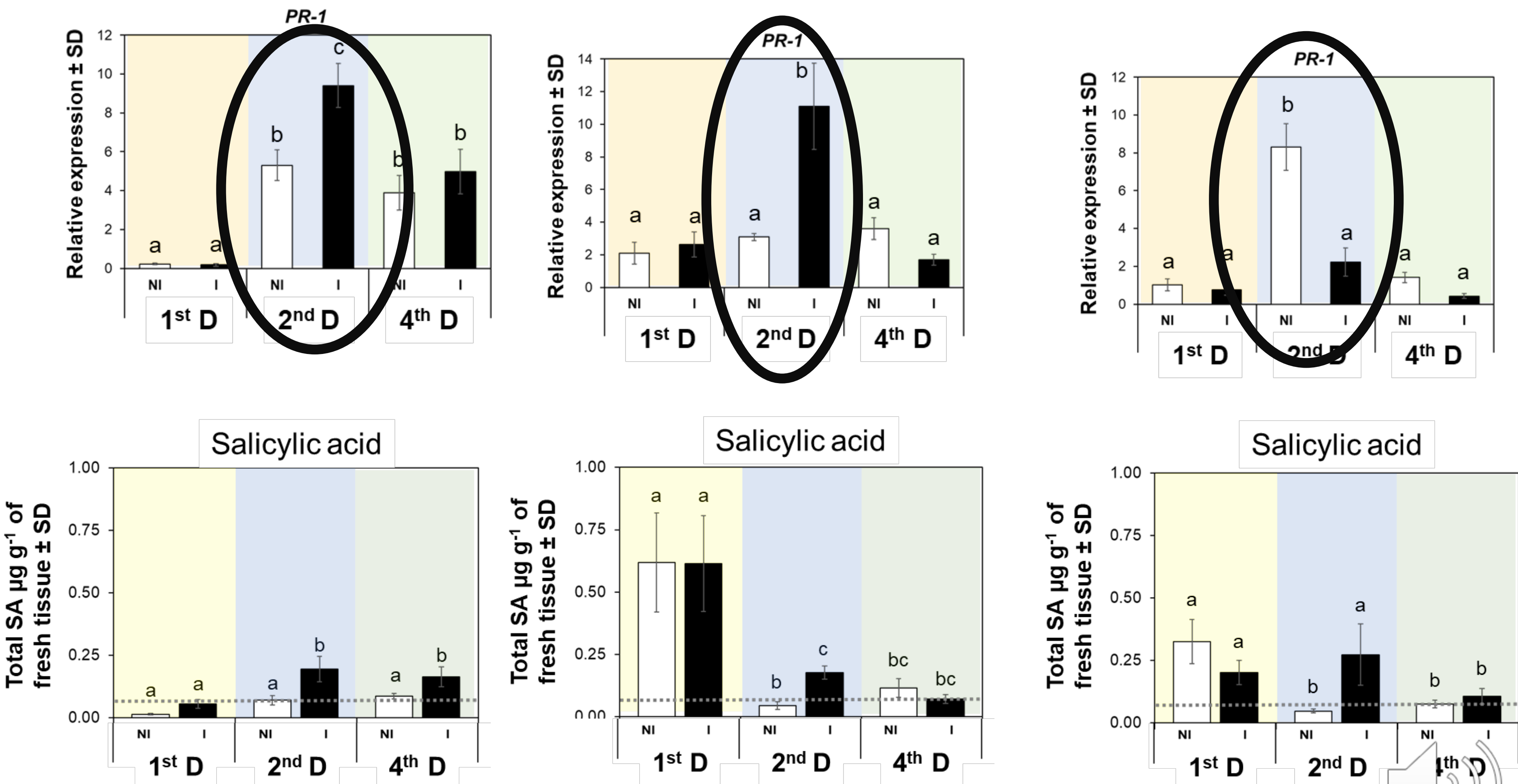


ACP damage interacts with CLas to affect plant defense:

White bars = Uninfected
Black bars = CLas-infected

Inoculation frequency:

One time | Pulsed | Continuous



Take home

- Pulses of psyllid feeding stimulate immunity [increase salicylic acid (SA)], but long-term feeding turns it off [decreases SA and increases the genes (*BMST* and *DMR6)* that metabolize SA].
- After one-time inoculation, *C*Las-infected samples exhibit upregulation of *PR1* genes; these turn on defense response after a long period of infection (270 and 330 days).
- CLas-infected trees without other stressors (psyllid damage) can induce an immune response against CLas infection by activating SA-dependent defense responses.

Take home

- Psyllid feeding also increases *NPR3/4* gene expression.

- *NPR3/4* reduces expression of genes involved in plant defenses (*PR1*) when SA concentrations are low.

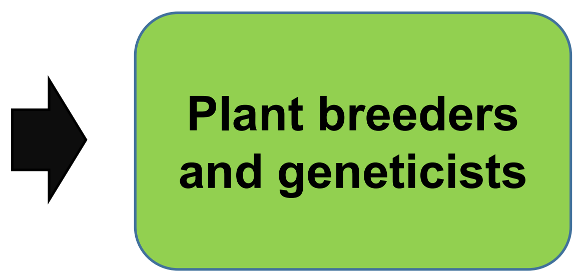
- CLas infection with ACP damage causes a situation where defense response is compromised.

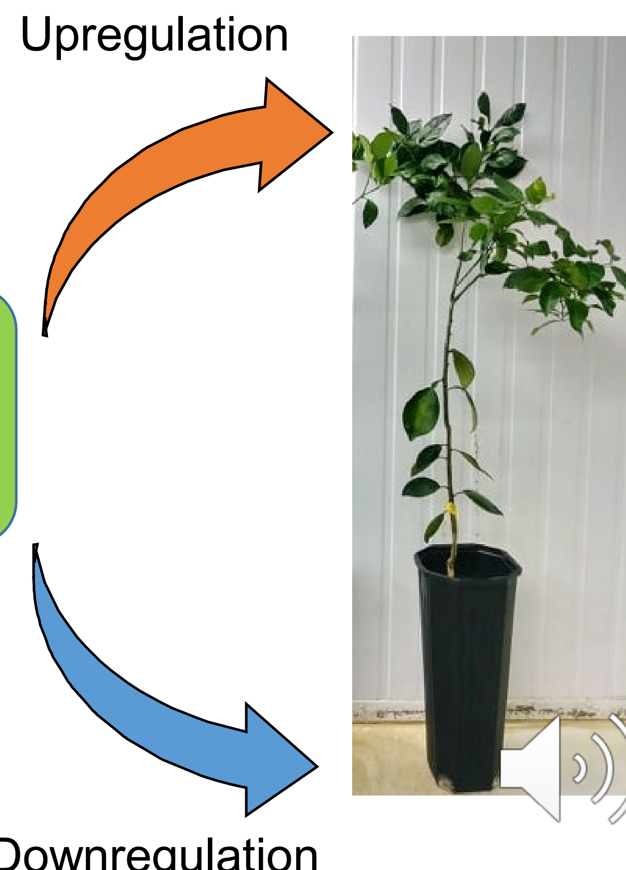
- The elimination of ACP from the tritrophic interaction allows the citrus plant to better handle CLas infection.

Future directions

- We hypothesize that enhanced resistance to *C*Las will be observed in transgenic plants with low expression of *NPR3/NPR4*

- We propose to determine the biological functions on NPR3/NPR4 in HLB disease progression and describe their role in SA signaling. To accomplish this goal, *C*Las-susceptible 'Hamlin', and *C*Las-tolerant 'Bearss' lemon will be transformed for overexpression/knockdown expression of NPR3/NPR4





General observations

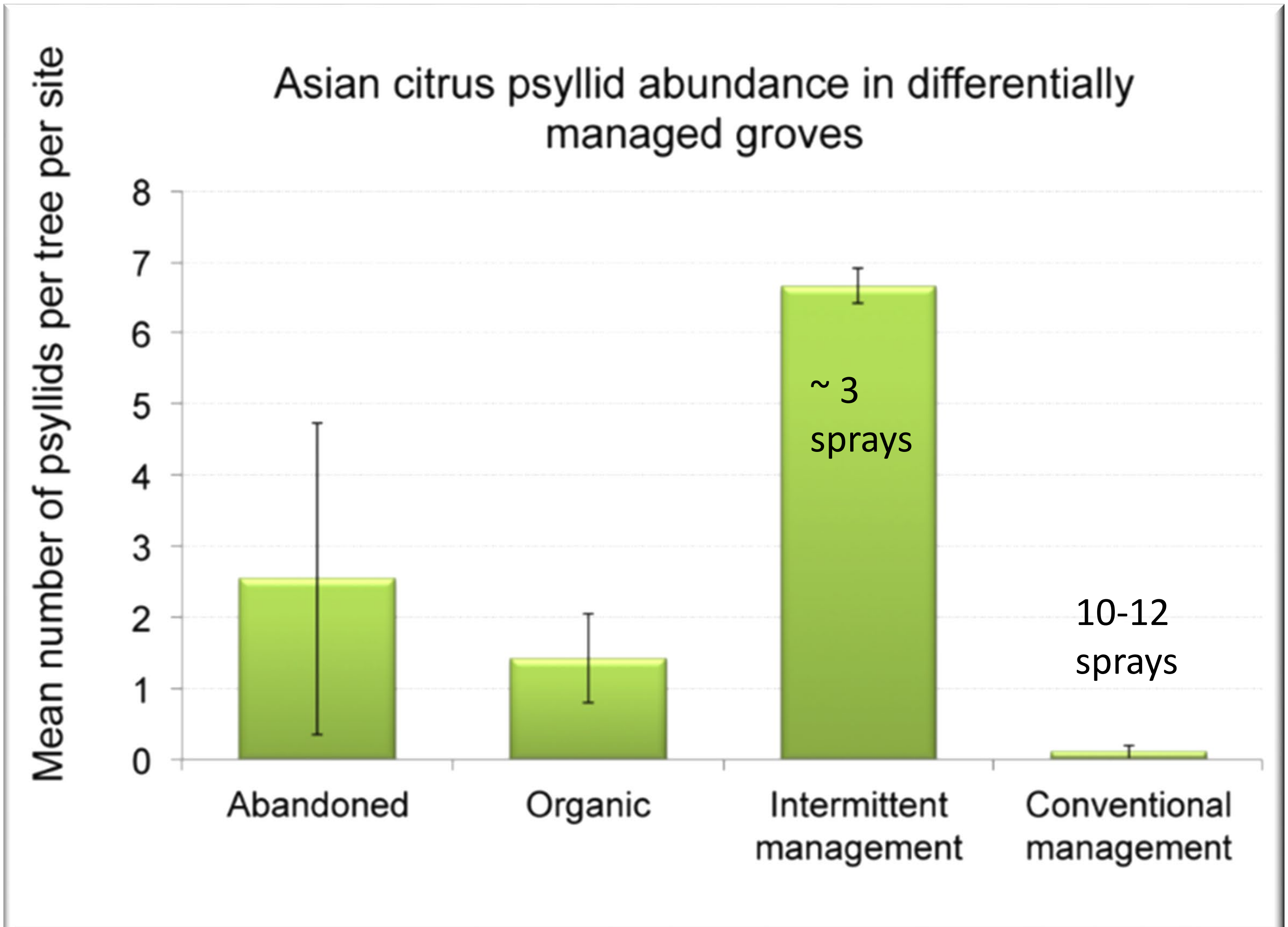
- CLas titer in leaf tissues is not affected by inoculum load imparted by the vector

- Plants respond to pulses of ACP feeding with boost to plant defense

- Long-term ACP feeding suppresses plant immunity and inhibits growth, which explains the importance of vector suppression as part of HLB management

- ACP management is beneficial, but we need to make it more sustainable.

Psyllids can be pushed down with intense use of insecticides, but this is not sustainable for many (2016-17) – Average from 4-13 groves



Typical recent model for ACP sprays:

- After harvest, a dormant spray has been usually timed before major spring flush using pyrethroid or organophosphate.
- Sprays made on a schedule with intervals somewhat determined by length of efficacy of a particular insecticide.

Possible better alternative:

- Spray for adults at bud break at the beginning of each new flush before there is feather flush on which adults can lay eggs.
- Apply second spray on the flush as ACP begin to reappear. This seems to achieve more than 60 days of low ACP populations
- Hold off spraying until ACP reach threshold (0.2—0.7 per tap)

Objectives

- Evaluate conventional grower practices versus sprays coordinated with bud break to suppress ACP populations

Specific Objectives

a) Quantify impact of management protocols on ACP populations and *C*Las titer.

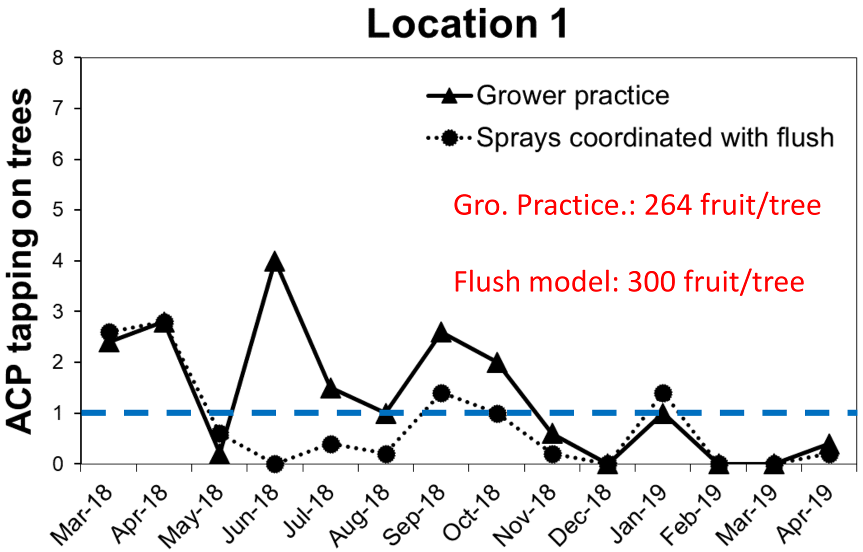
b) Examine association between insecticide applications, ACP populations and *C*Las titer.

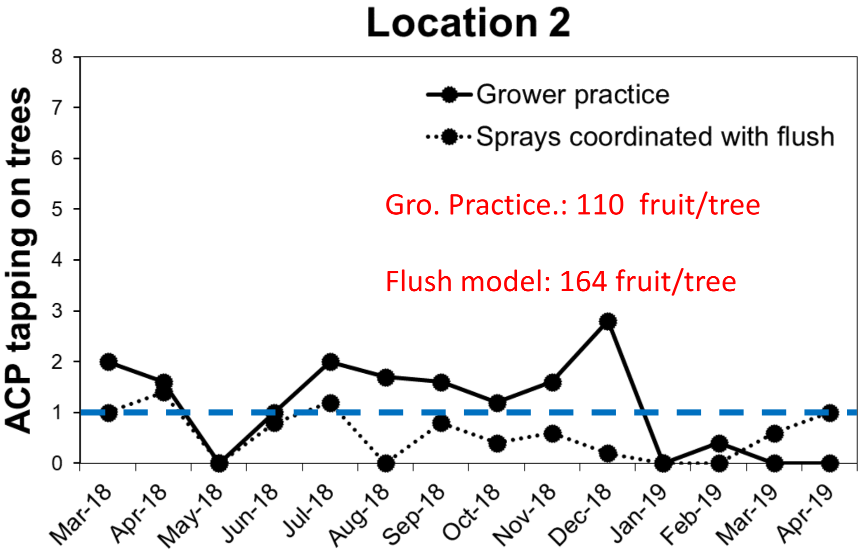
Take Home

- Timing insecticide applications with bud break caused better ACP suppression.
- Maintaining ACP populations below a threshold of 1 ACP / tap was associated with better yield.

-Solid lines indicate applications near flushing periods-grower practice (higher ACP)

-Dashed lines indicate use of bud break model to predict flushes (lower ACP)



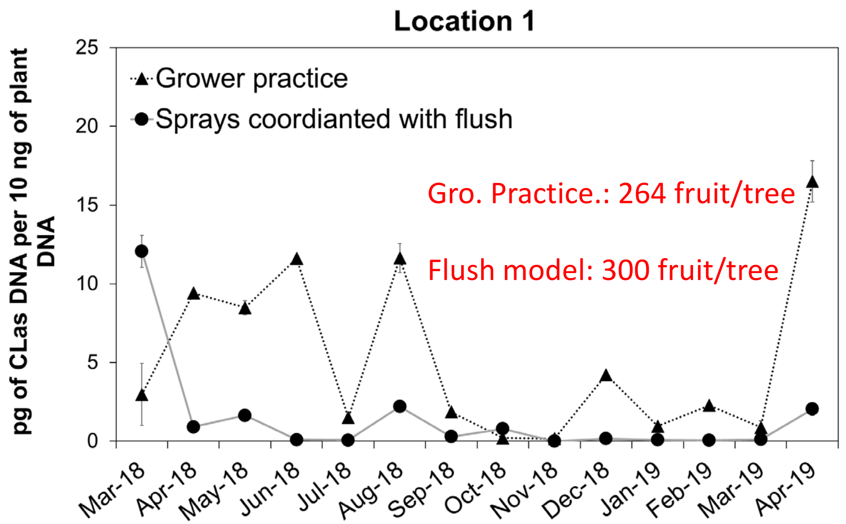


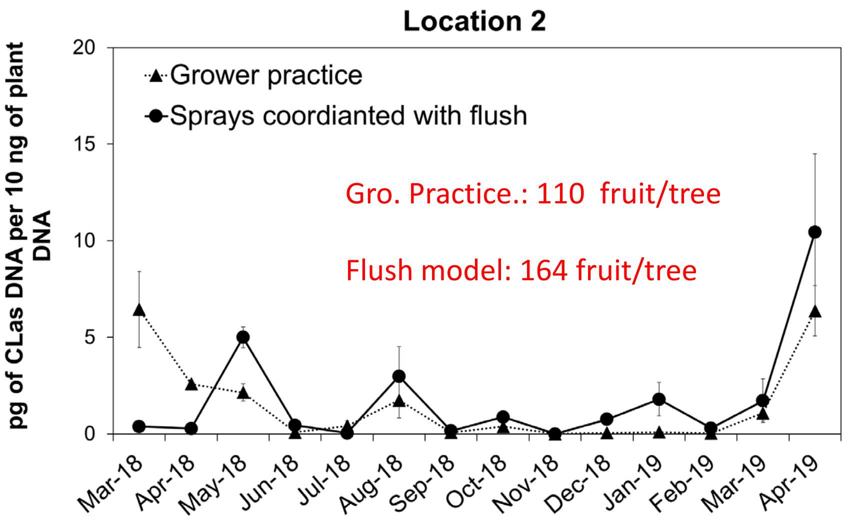
Take Home

CLas titer over time.

Higher fruit-yields were associated with lower ACP populations when sprays were coordinated with flushing cycles using bud break phenology model

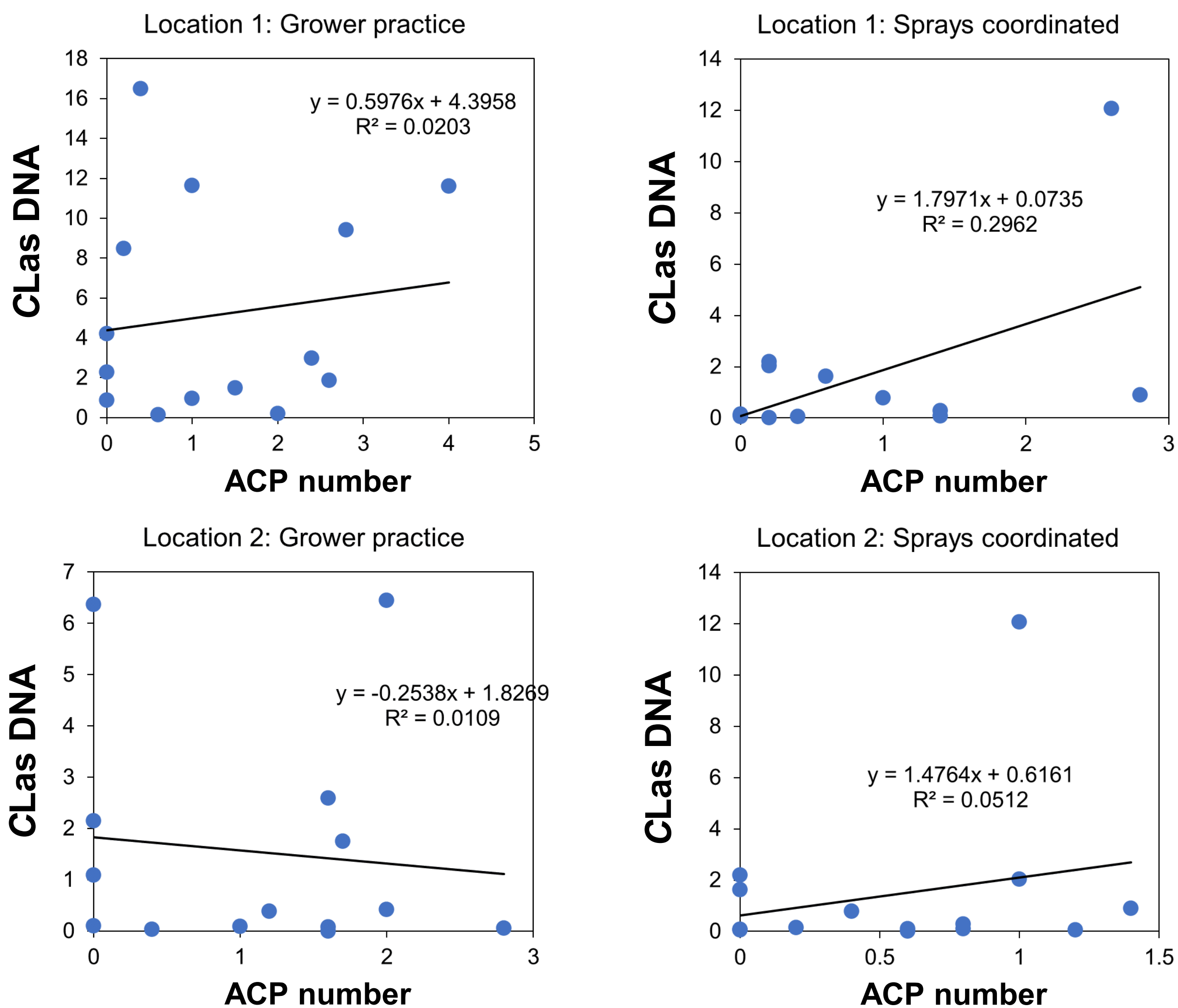
- 8 Leaves per tree
- 10 trees per location



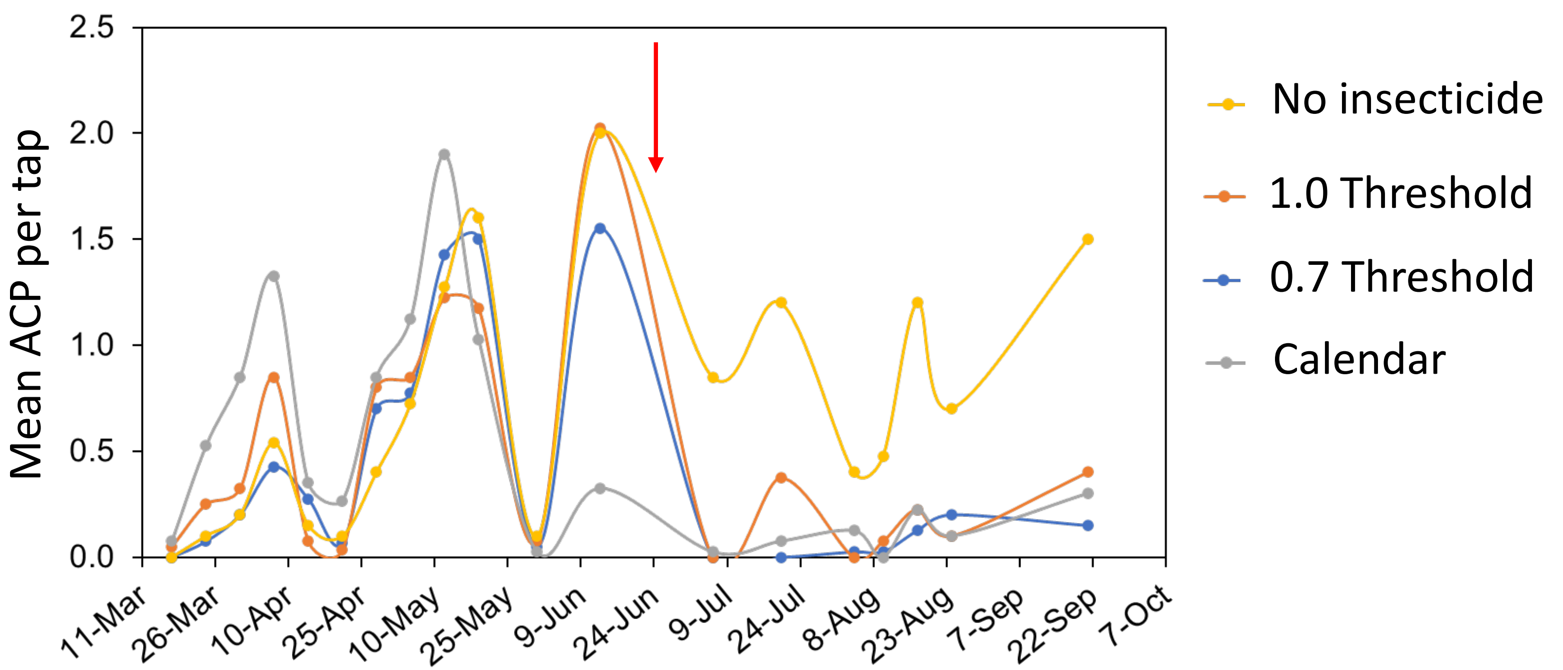


Take home

No correlation between ACP density and CLas titer—*This field result is congruent with our growth chamber investigations.* The difference in yield was more likely caused by difference in ACP damage

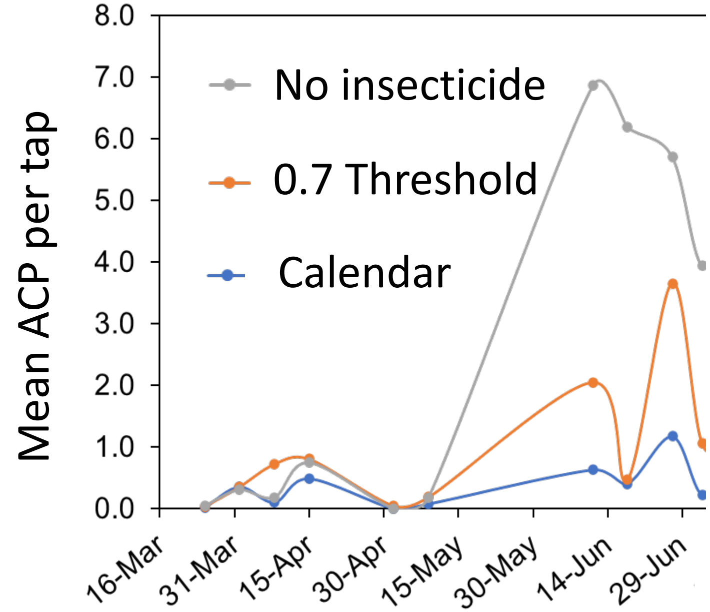


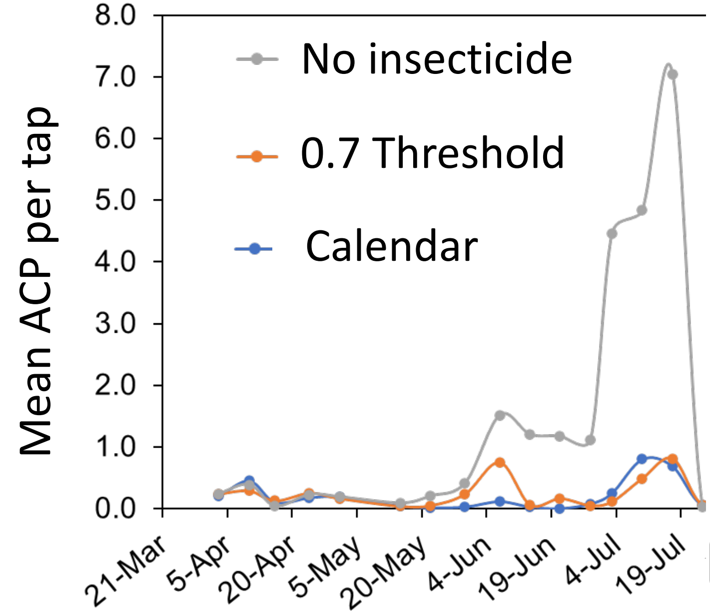
Psyllid densities when using thresholds were slightly higher than with calendar sprays



Key Feature of IPM:

- Deciding whether treatment is necessary after assessing the pest populations
- This decisions based on regular monitoring
- You determine whether to spray using a threshold that tells you that you reached a point where there are “too many psyllids” present rather than spraying on a calendar basis
- In our case, it’s the point where cumulative annual damage reduces yield
- 0.7 ACP/tap looks like a pretty good ballpark threshold





Take home

- CLas titer in trees does not appear related to psyllid population density
- Psyllid density is related to tree stress—more psyllids--> higher damage (stress), which compromises tree health
- If the pest population (and the resulting damage) is low enough, it does not pay to take control measures
- As the pest population continues to rise, it reaches a point where the resulting damage would justify taking control measures
- 0.7 ACP / tap is a “working ballpark” threshold