Proposed integrated huanglongbing (HLB) management tools for citrus

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August 21, 2025

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Take home message

- No silver bullet for HLB
- **IPCs** are an excellent tool for protecting young trees
  - Effective for excluding ACP and other pests/pathogens!
- **Oxytetracycline** is the current hope for growers and is effective
- **Resistance to OTC** development should be delayed
- **Plant defense inducers**, including BRs and SAR inducers, can protect new flushes from reinfections
- New methods to deliver therapeutics (i.e., **ATIS**) are being developed
- **A regional IPM approach is the best path until HLB-resistant citrus varieties are developed!**

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How to control HLB?

- **Control 101**
  - Reduction of the Asian citrus psyllid (ACP) populations
  - Visual identification and prompt removal of infected trees
  - Production of propagation material in insect-proof facilities
- **HLB disease control ('tools'):**
  - Remove and destroy infected trees
  - Quarantine program
  - Chemotherapy and nutrition treatment
  - Thermotherapy (Heat/steam treatment)
  - Bactericides, antimicrobials, and 'snake oils.'
  - CRISPR, RNAi, and transgenic approaches?
- **Psyllid vector control:**
  - Chemical and biological control
  - Reflective mulch, Kaolin spray
  - Protective screens (CUPS and IPC)
  - Removal of preferred alternative hosts

There is NO single effective control strategy for HLB!

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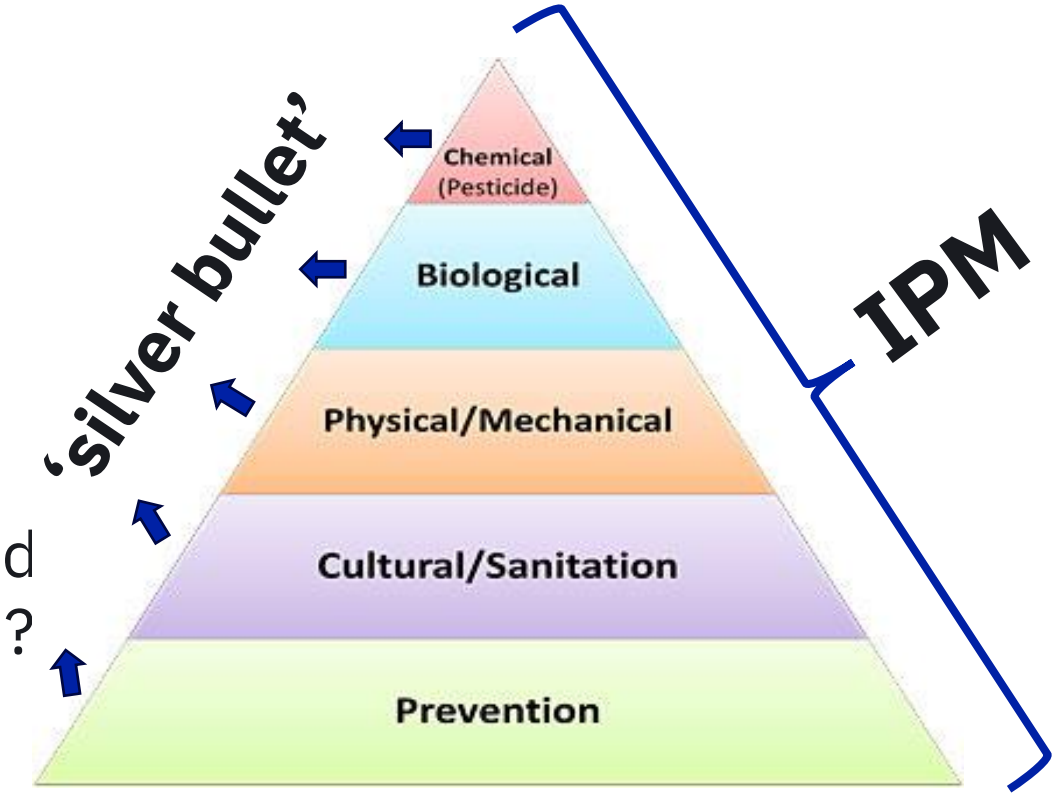
Developing an integrated pest management (IPM) for HLB control

- What treatment is working and what is not?
  - Nutrition (spoon-feeding)
  - Peptides
  - Bactericides (trunk injection)
  - ACP control

- At what frequency should treatments be applied
- What application method to use; how and when?
- Is there a ‘silver bullet’ to HLB? What is it?



There is no cure for HLB:

...best control would be relying on IPM of HLB disease and integrating resistant (or tolerant) citrus cultivars ASAP!

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My program in SWFREC:

- **Develops practical tools for growers to integrate into IPM for HLB!**
  - Collaborates with experts in academia and industry in ALL projects:
    - Screening for new therapeutics
    - Adopting new tools (IPC and Automated Trunk Injection Systems)
    - Using resistant interstocks
    - Testing HLB-resistant citrus cultivars
    - Developing RNAi and CRISPR/Cas strategies
    - Developing transgenic strategies
    - Characterizing insect-specific viruses
    - Searching for effective new IPM tools

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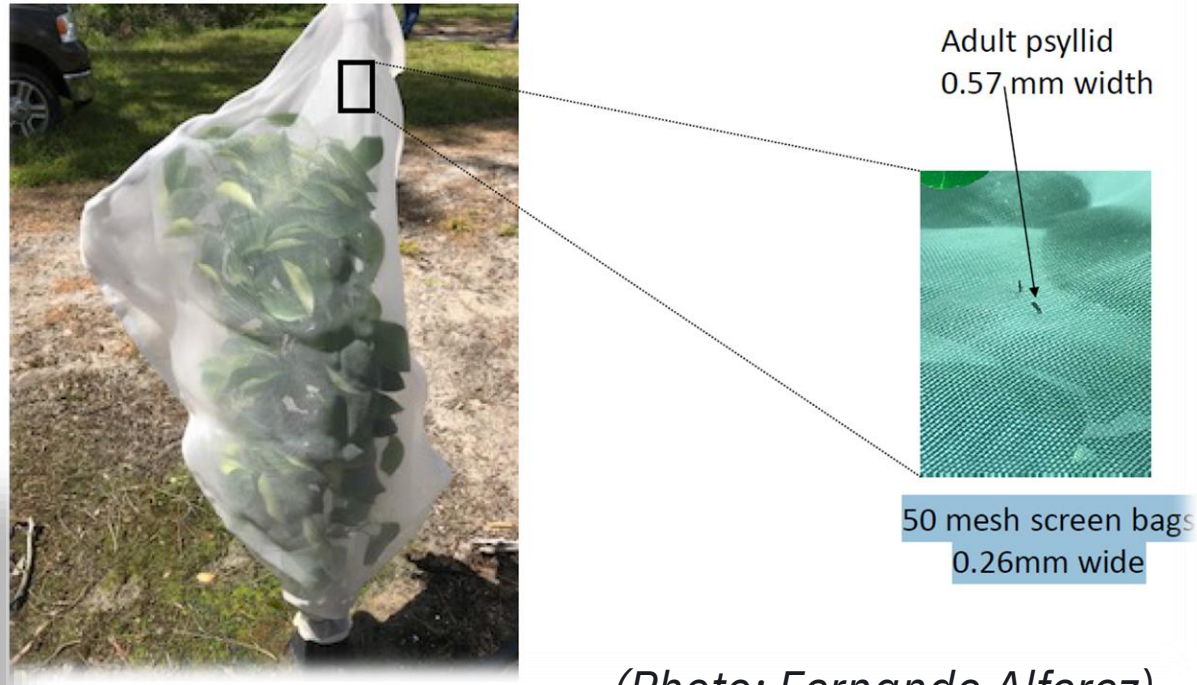
Use of individual protective covers (IPCs)

USDA-2022-70029-38481

- **Used in new planting and 'reset' situations**
- **Costly and laborious**
- **Can be used for 2-3 years, depending on cultivar**
- **Effective for excluding ACP and other pests/pathogens!**



(Photo: Fernando Alferez)

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IPCs: Do’s and Don'ts

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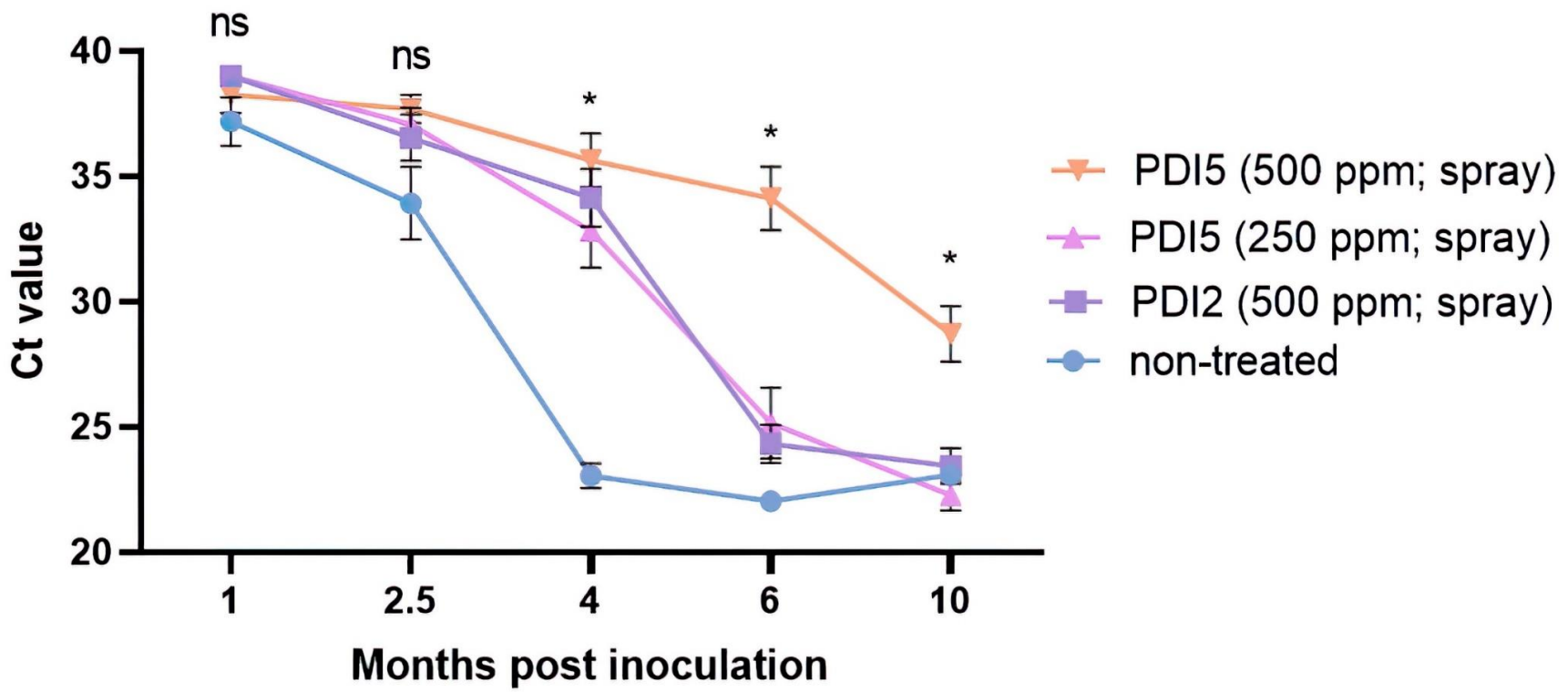
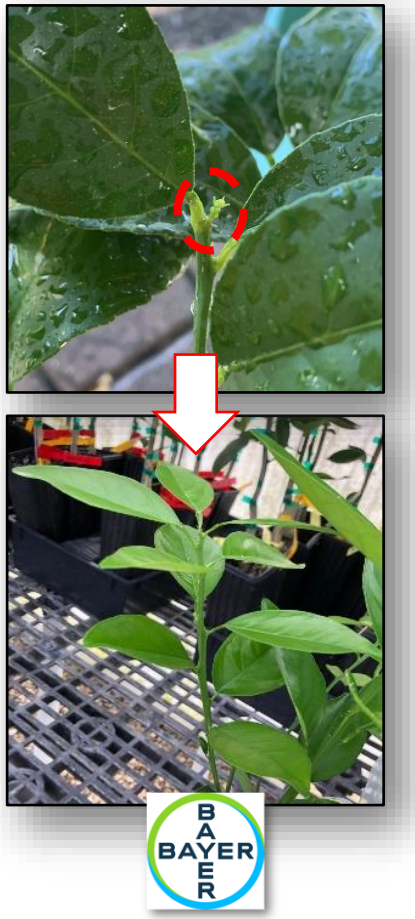
Use of Plant Defense Inducers to protect new flushes

- Used by monthly spraying of Plant Defense Inducers (PDIs) on new shoots
- Some of the PDIs protected young shoots from getting infected by CLas up to 10 months





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BAYER

How about ‘OTC injection + PDI’ treatments?

Can we inject OTC first (to reduce CLas titer) and then spray PDIs (to prevent reinfection by ACPs) during ‘major flushes’ in the grove?

- **Trees were injected with OTC on February 7, 2023**
- **Subgroup of trees sprayed with PDI 31 (or other PDIs, or BRs) on May 9, 2023**

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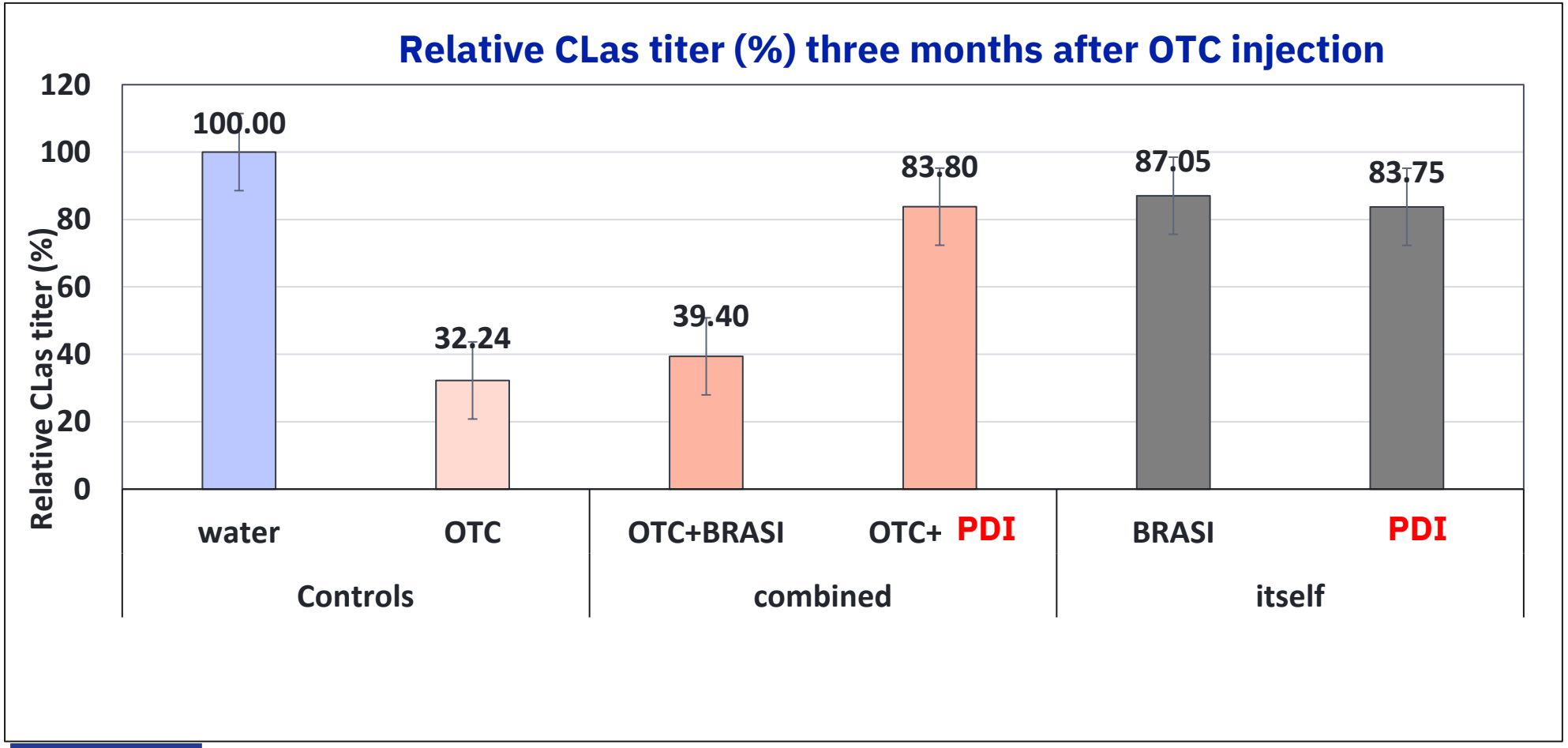
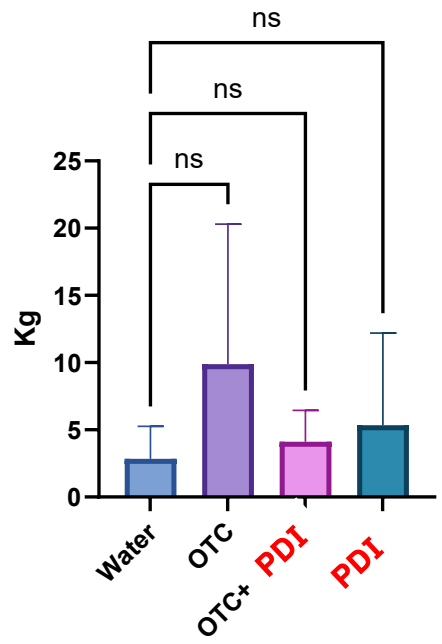
How about ‘OTC injection + PDI’ treatments?

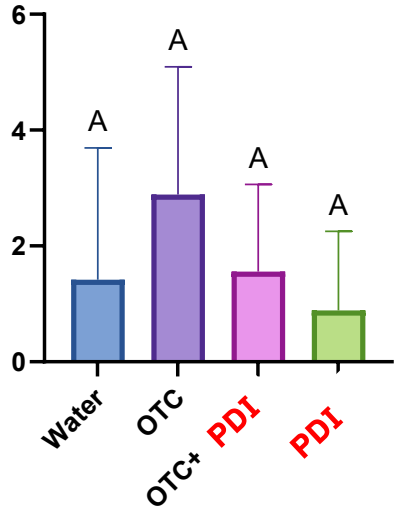
- Trees were injected with OTC+ PDIs (or BRs) second time in 2024
- BRs are being sprayed monthly from time zero, but PDI was only sprayed once.



Yield: Kg per treatment



Total fruit drop per treatment



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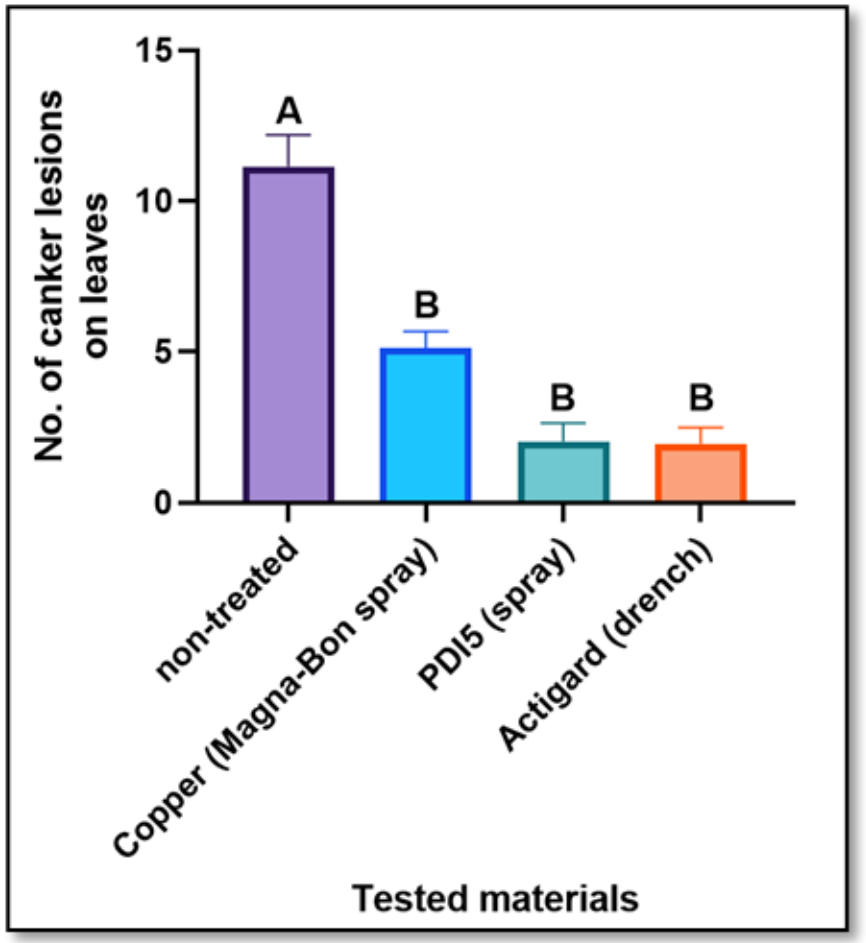
Use of PDIs to protect new flushes

- Most of the PDIs tested protected citrus leaves from citrus canker

Actigard
(acibenzolar-s-methyl; (drench)

Non-treated

PDI5
(spray)



Use of PDIs to protect new flushes

Water (Negative) Control

PDI 31

PDI 26

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USDA-2019-70016-29096

ATIS: Automated trunk injection system

- Developed a novel method to deliver chemicals through the trunk of trees
- Studied citrus vasculature and fluid dynamics
- Determined the best conditions for trunk injection of trees
- Developed ATIS to reduce labor and time required to complete the injection

2-year-old Valencia

1-year-old macrophylla

USDA-2019-70016-29096

ATIS: Automated trunk injection system

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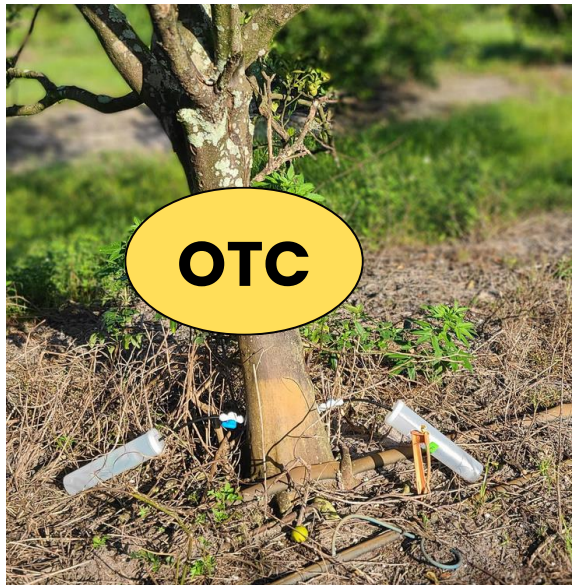
Screening for OTC alternatives

"Our goal is to maintain OTC efficacy while reducing selection pressure on CLas."



Antibiotic rotations

Kasugamycin
Oxolinic acid
Streptomycin
Validamycin A
Nalidixic acid
Gentamicin

- Approved for use in trees or other crops in the US
- Approved for use in plant agriculture in other countries
- Easily soluble and injectable

Combination synergies

PDIs
- Actigard
- Regalia
- PDI7 & PDI31 (Bayer)

Insecticide
- Xytect

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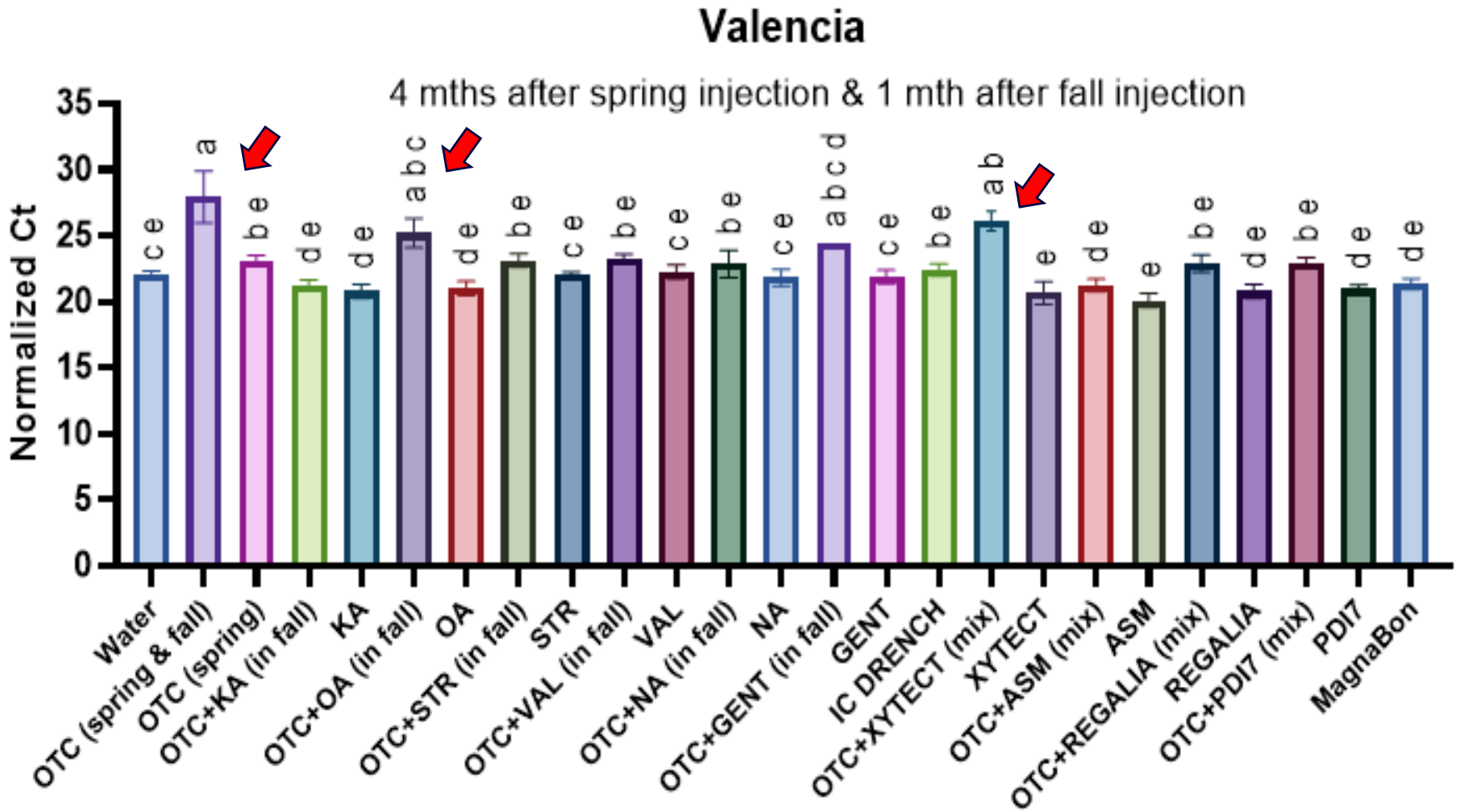
Screening for OTC alternatives

- OTC is the best performer
- OTC + (rotated with) oxolinic acid or xytec are promising
- Needs more testing



Field trials are ongoing!

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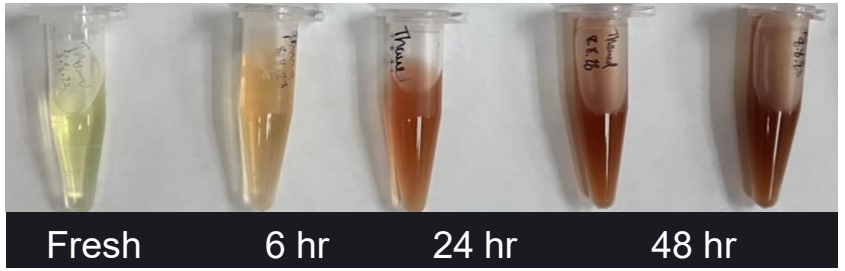
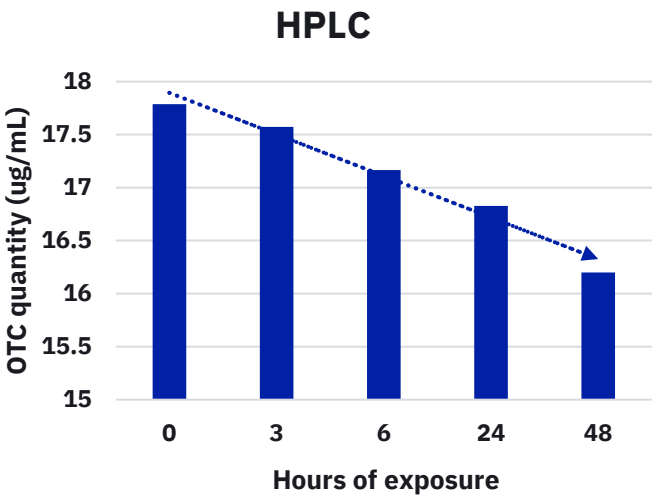
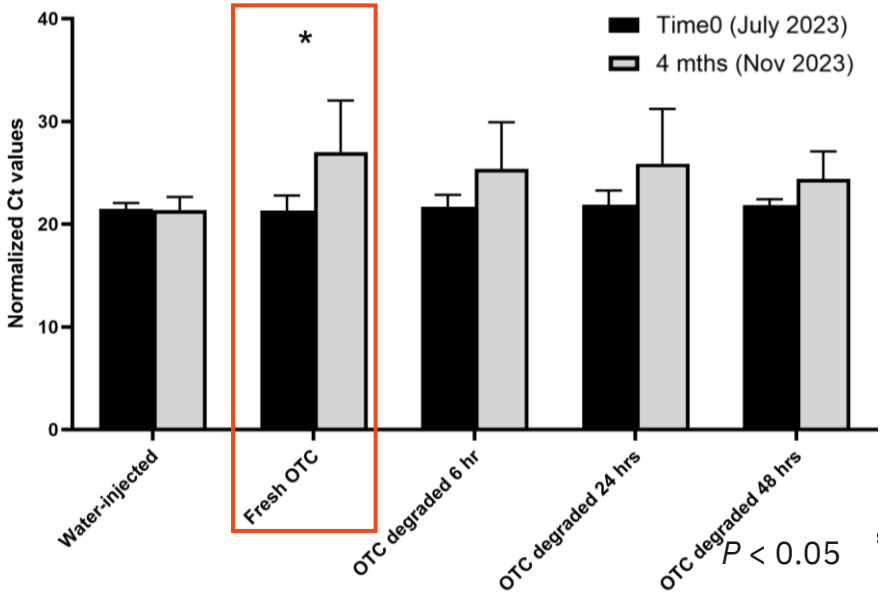
OTC Degradation

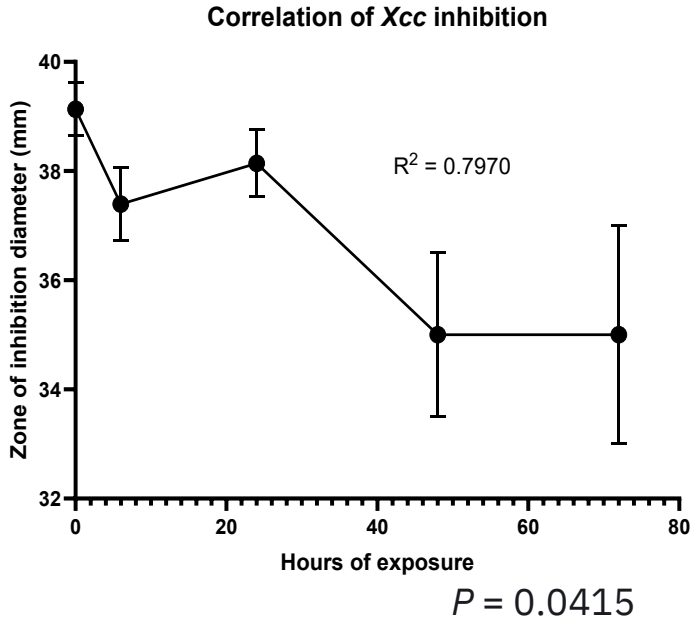
- The rate of degradation of OTC increases under intense UV radiation and high temperatures – conditions inherent to Florida citrus groves
- Our research has demonstrated that both OTC quantity and bacterial inhibition decrease with increased exposure to field conditions



Color change in OTC solutions after exposure to field conditions.







Injecting freshly prepared OTC ensures the product maintains its full antimicrobial properties

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Tools might be integrated into the IPM of HLB

- Always manage Asian citrus psyllids and other pathogens
- Use proper nutrient and irrigation practices

Proposed IPM Tools

IPCs

PDIs or BRs

Trunk Injection

Year 0 | Year 3 | Year 5 | Year 8 | Future Years

- New therapeutics
- Resistant Interstocks
- HLB-resistant citrus cultivars
- RNAi and CRISPR/Cas
- Transgenic
- Insect-specific viruses
- Effective new IPM tools

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Conclusion

- **Will be NO Silver Bullet for HLB!**

- With the proposed IPM tools, we can stay productive.
- Producing citrus juice in Florida will not be easy or cheap
- We need HLB-tolerant and resistant varieties

- **Regionally implemented HLB-IPM is a better option than fighting alone.**

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Thank You!

Acknowledgments

- Florida citrus growers
- Stakeholder Advisory Board Members
- Grower and Industry Collaborators
- USDA NIFA (Award No's: 2018-70016-27392; 2019-70016-29096; 2020-70029-33195; 2020-70029-33196; 2021-70029-3605; 2021-70029-36055; 2022-70029-38481; 2022-70029-38470; 2025-70029-44035; 2025-70029-44032)
- CRDF and Citrus Initiative
- Bayer CA-U.S. & Lyon-France

Ana Redondo, Sanju Kunwar, Kellee Britt-Ugartemendia, Salih Yilmaz, Lauren Fesler Mathews, Selin Boga, Egem Ozbudak, Fetchina Gereus, Juan Balderas, Nico Tezna, Alec Pika and many more…

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CRDF Citrus Research and Development Foundation

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United States Department of Agriculture
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