Citrus disease trends we should heed: Phytophthora, HLB and Leprosis

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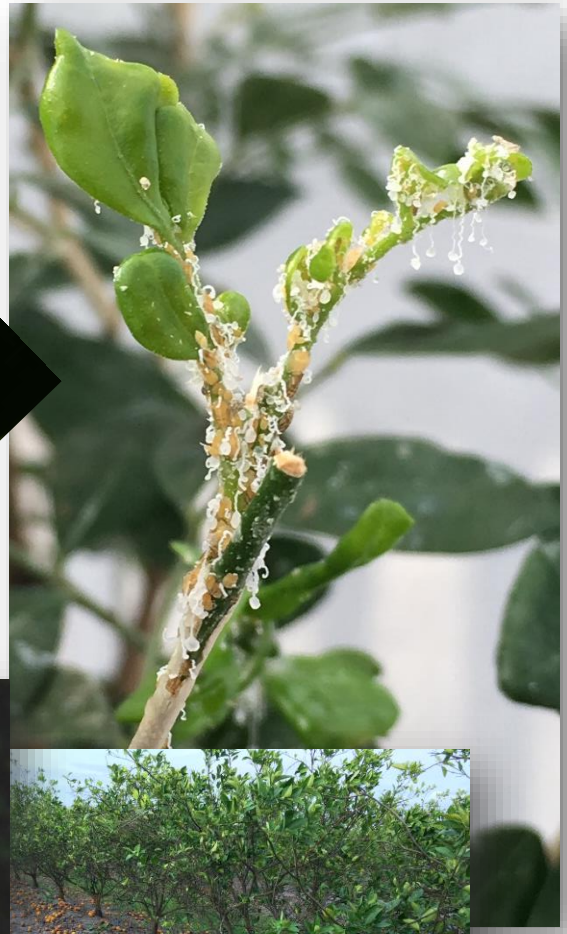
HLB Disease Intro.

- Background
- Epidemiology
- Importance
- Damage
- Biology
- Spread
- Life Cycle
- Scouting
- Symptoms
- Management
- New Approaches



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New and old approaches to control HLB

- Control
  - 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:
  - Remove and destroy infected trees
  - Quarantine program
  - Chemotherapy and nutrition treatment
  - Thermotherapy (Heat/steam treatment)
  - Bactericides, antimicrobials and 'snake oils'
  - Peptides, 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 –*M. paniculata*

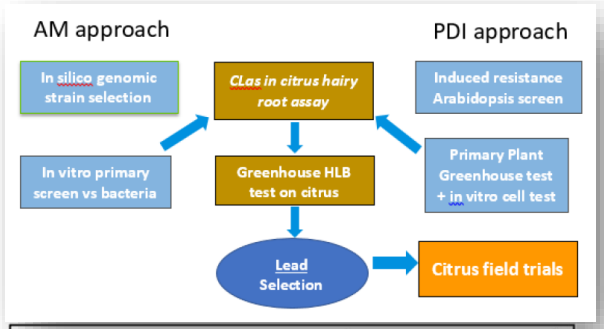
There is NO single effective control strategy for HLB!

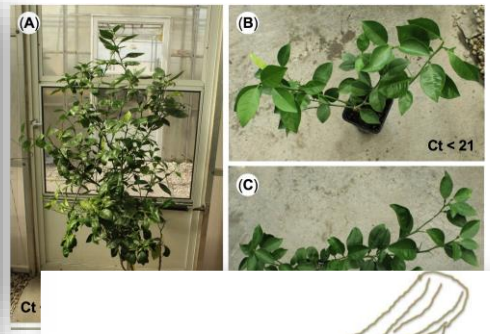
Anything new on the horizon?

USDA-NIFA Project CRDF-Bayer:

Collaborative approach to discover, develop and commercialize therapies for HLB

USDA-2020-70029-33196

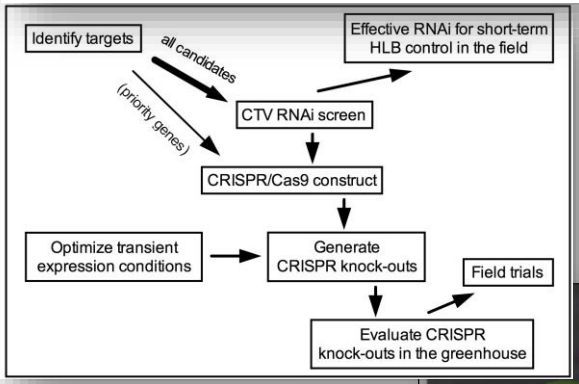


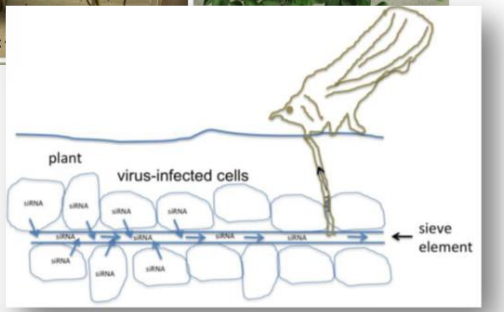


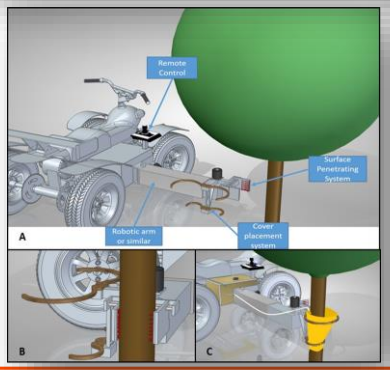
USDA-NIFA Project Mou et al:

- **HLB disease resistance / tolerance in citrus by gene editing** USDA-2018-70016-27392
- **A novel therapeutic strategy for HLB-infected trees**

USDA-2020-70029-33195







USDA-NIFA Project Batuman et al:

Development of an automated delivery system for therapeutic materials to treat HLB infected citrus

USDA-2019-70016-29096

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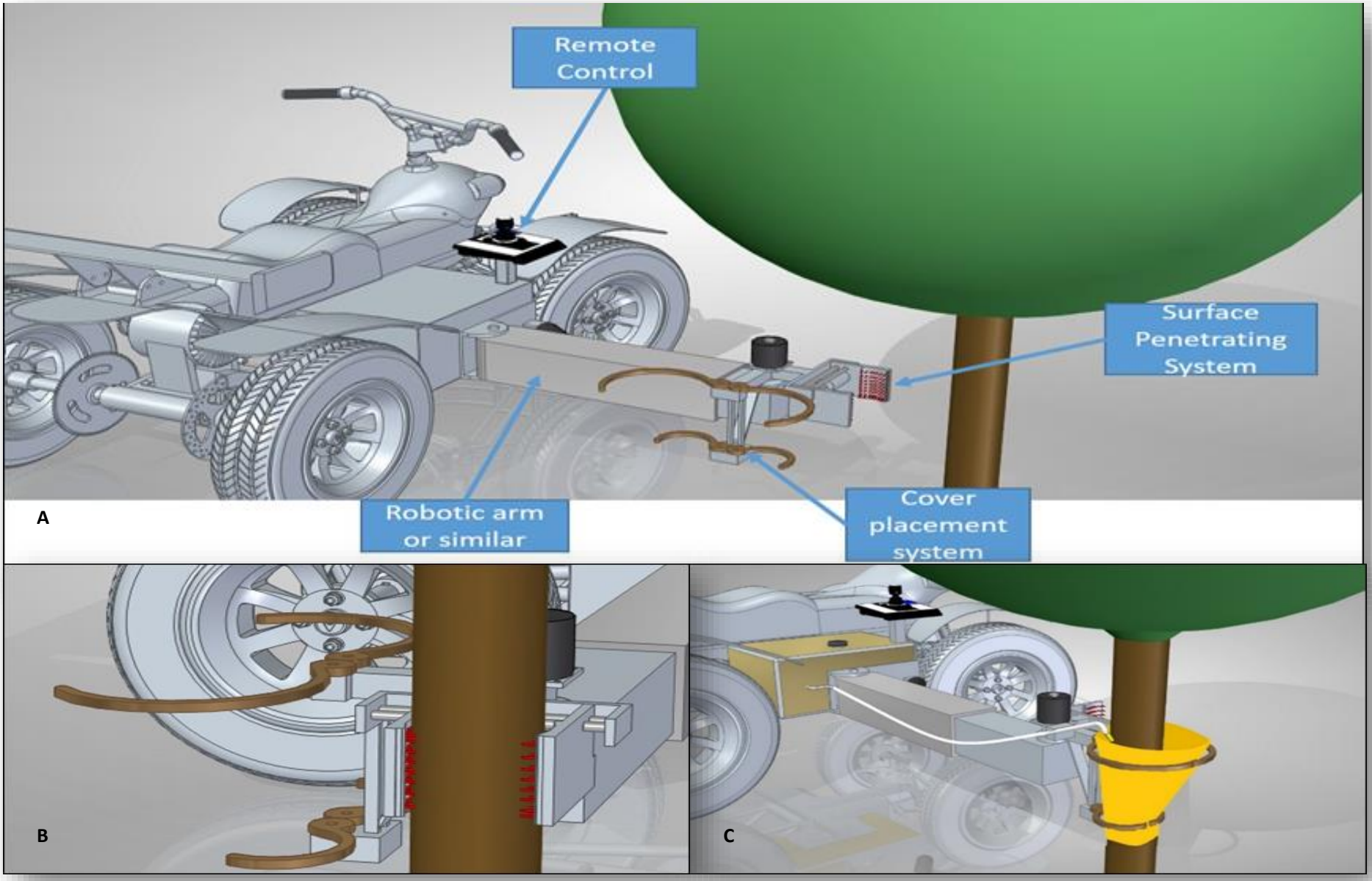
Needle assisted trunk infusion (NATI) of therapeutic material for controlling HLB and its psyllid vector

Goal of our project: Automated Delivery System



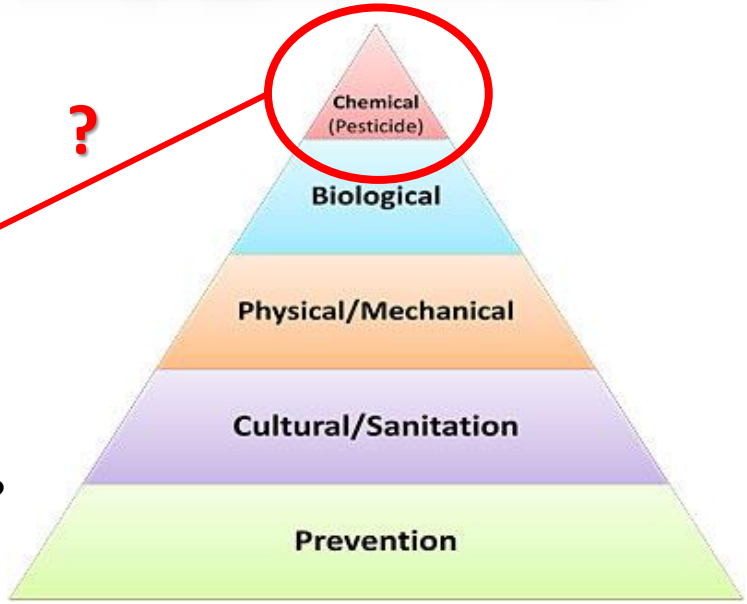
How to manage HLB?

- No ‘silver bullet’ yet; IPM is your best option!
- You can maintain your production if you:
  - Monitor for all pests and diseases (and take action!)
  - Reduce inoculum sources as much as possible
  - Remove infected trees and establish clean resets
  - Implement measures to reduce psyllid populations
  - Improve plant nutrition and irrigation programs (pay attention to root health)

HLB control in citrus (many questions!)

- **What treatment is working and what is not?**
  - **Nutrition (spoon-feeding)**
  - **Thermotherapy**
  - **Bactericides (spray application)**
  - **ACP control**

- **In what frequency to apply treatments?**
- **What application method to use; how and when?**
- **Is there a 'silver bullet' to HLB? What is it?**



…best control would be relaying on integrated pest management (IPM) of ACP and HLB; and having resistant (or tolerant) citrus cultivars in near future!

Phytophthora Management

Topics:

- **Citrus diseases caused by Phytophthora**
- **Cultural control and management**
- **Interaction with HLB**

Phytophthora Diseases

- **Foot rot of trunk and limbs**
- **Root Rot**
- **Brown Rot**
- **Yield reduction estimate:** 3-6% per year or approx. $20M in crop loss ***(pre HLB)***

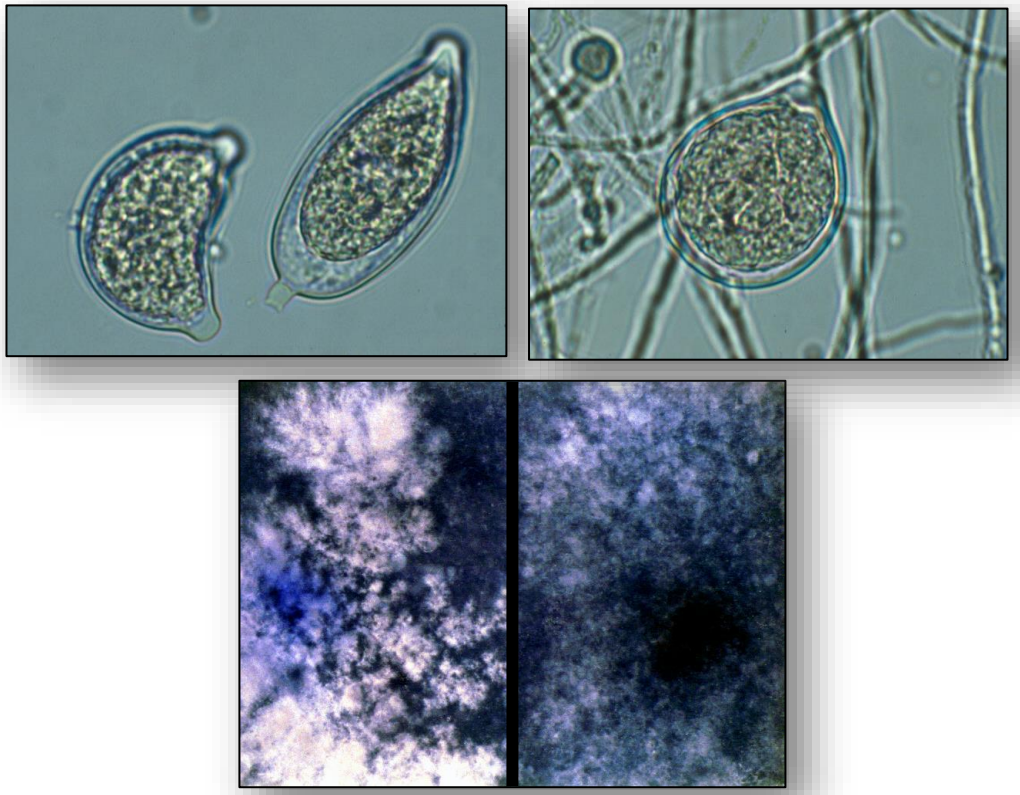
The Phytophthora species causing diseases in Florida citrus

- ***Phytophthora nicotianae*** **(*parasitica*) common cause of foot rot and root rot**

- ***Phytophthora palmivora*** **causes brown rot of fruit, root rot in poorly drained soils with high water tables**

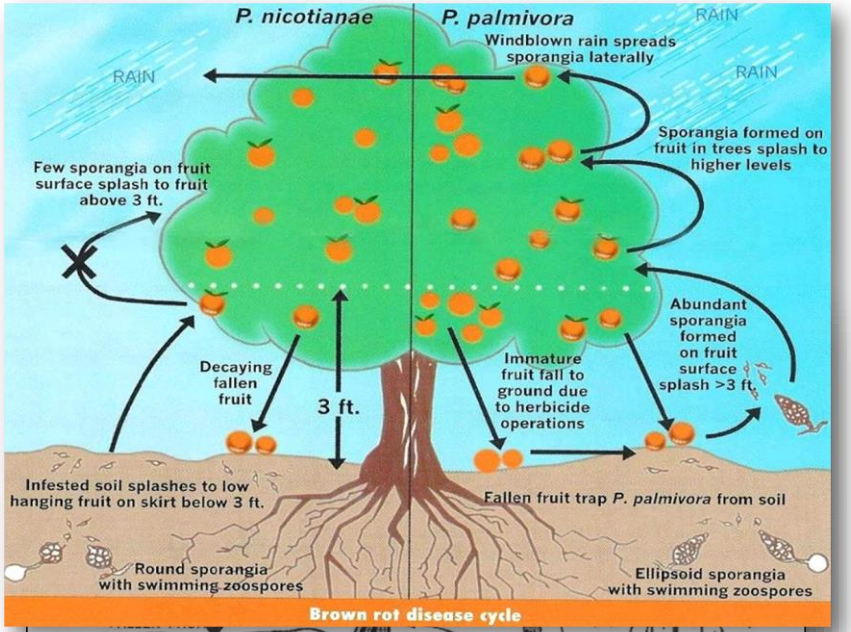
P. palmivora
Sporangia elongated

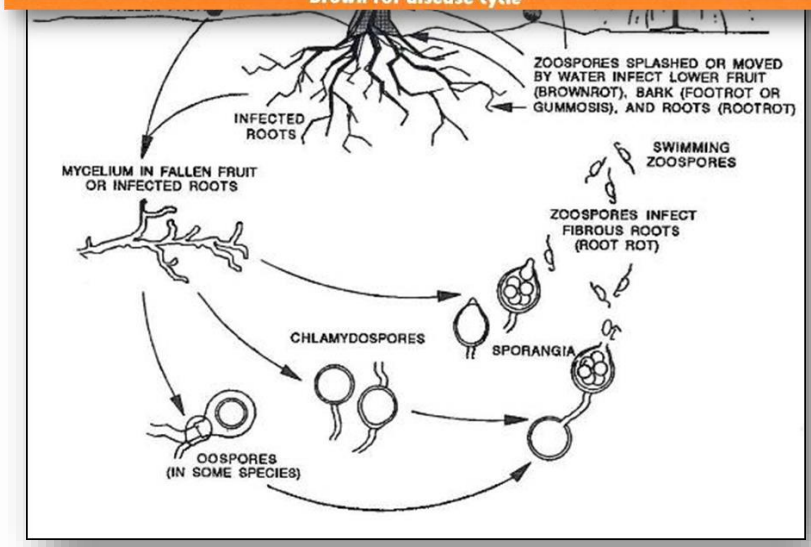
P. nicotianae
Sporangia round



Wet conditions favor root infection cycles

- **Susceptibility of roots highest during very wet to very dry cycles**
- **Wetting and drying increases root exudation attracts zoospores**
- **HLB infected roots also produce more exudates that promotes infection**





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Phytophthora Foot Rot

- **Kills bark**
  - **Blocks water and carbohydrate transport**
- **Can girdle tree**
- **Controlled with rootstock**
  - **see rootstock guide for 'resets'**
- **Avoid wounding and soil exposure of scion**
- **Graft union >6 inches above soil**

Phytophthora Root Rot

- **Impairs water and nutrient uptake**
- **Reduces CHOs allocated for next crop season**
- **If severe at planting, stunts tree**

Phytophthora Root Rot Control

- **Good drainage and irrigation**
- **Clean nursery material**
- **Monitor disease pressure (propagule count; Syngenta)**

Chemical Management of Phytophthora

- **Based on history of Phytophthora in the grove; protect growing roots**

  – details in FCPMG https://crec.ifas.ufl.edu/resources/production-guide/#diseases

- **Phytophthora count >10-20 propagules/cm^3 recommend rotation of fungicides:**
  - **Fosetyl-Al /phosphite after spring shoot flush**
- **If severe problem -Mefenoxam after spring-early summer rains begin**
- **Fosetyl-Al /phosphite after midsummer shoot flush**
- **Mefenoxam after fall shoot flushes**

Remember root flushes follow shoot flushes!

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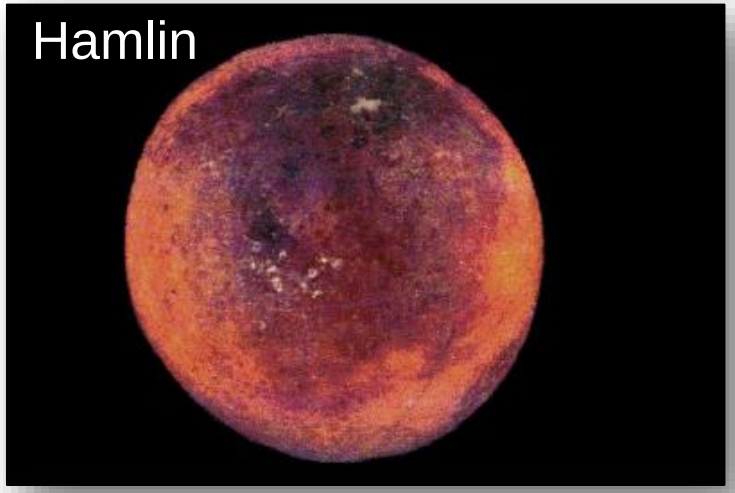
Phytophthora Brown Rot

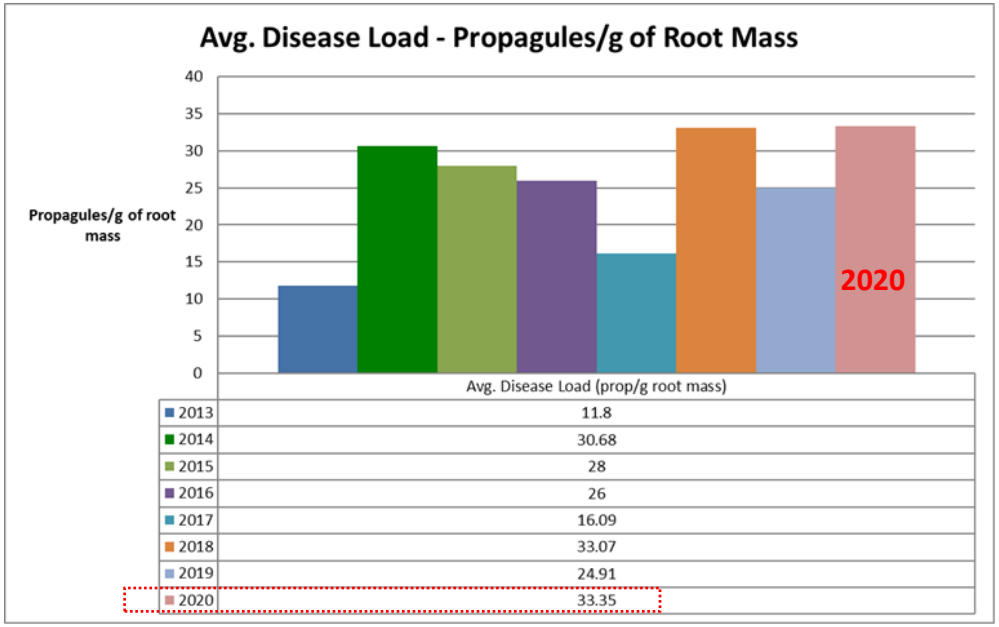
- **Mainly damages early varieties**
- **Light brown leathery decay**
- **White fungal growth on surface under humid conditions**
- **Infected fruit have sharp, pungent odor**
- **Infection spreads in post harvest**



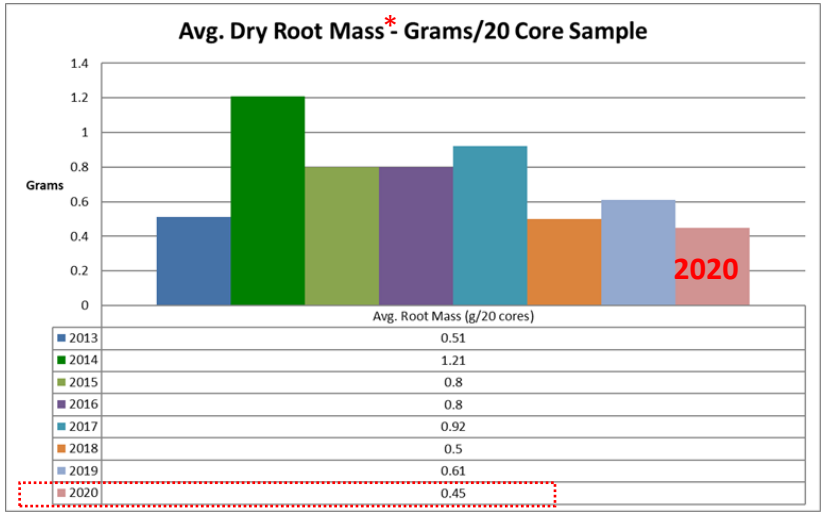
Brown Rot Management

- **Avoid fruit under tree to reduce inoculum (may not be feasible due HLB)**
- **Raise tree skirts to increase air movement and promote drying of foliage**
- **Apply preventative sprays of phosphites or copper**
- **Time phosphite sprays in July (and October if fall rainy season is prolonged)**

HLB-Phytophthora interaction



	Avg. Disease Load (prop/g root mass)
2013	11.8
2014	30.68
2015	28
2016	26
2017	16.09
2018	33.07
2019	24.91
2020	33.35

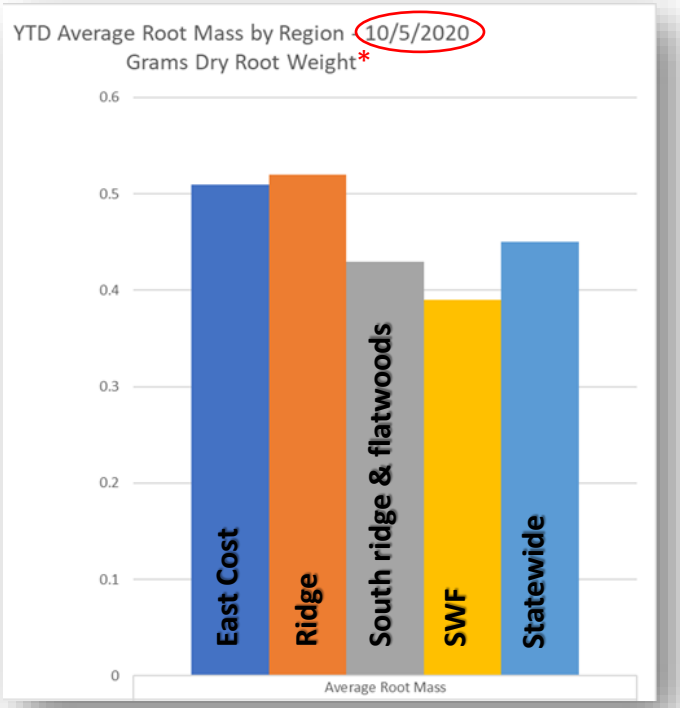


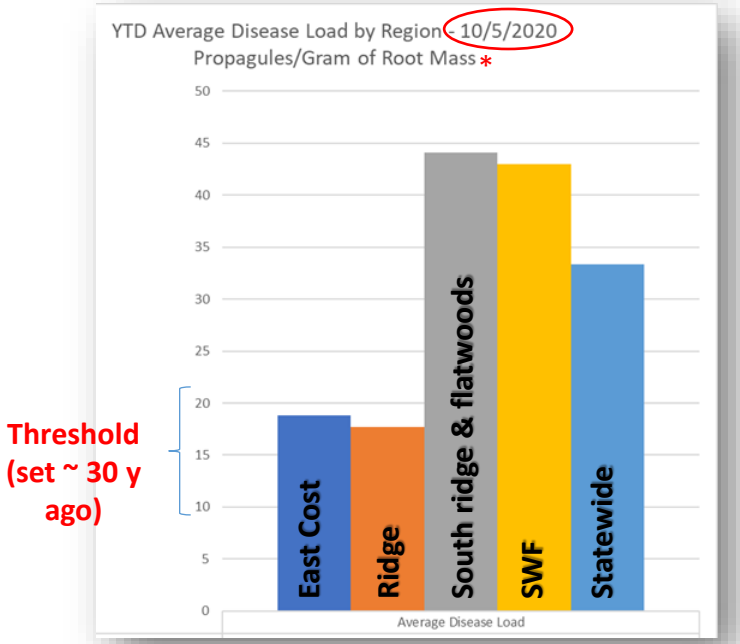
	Avg. Root Mass (g/20 cores)
2013	0.51
2014	1.21
2015	0.8
2016	0.8
2017	0.92
2018	0.5
2019	0.61
2020	0.45

Based on >3.5K samples statewide; representing >137K acre in 2020.

Data courtesy of John Taylor, Syngenta Crop Protection

HLB-Phytophthora interaction





*Now trees have the ¼ of the root

Based on >3.5K samples statewide; representing >137K acre in 2020.

Data courtesy of John Taylor, Syngenta Crop Protection

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HLB reduces efficacy of Phytophthora management

And possible reasons for this are:

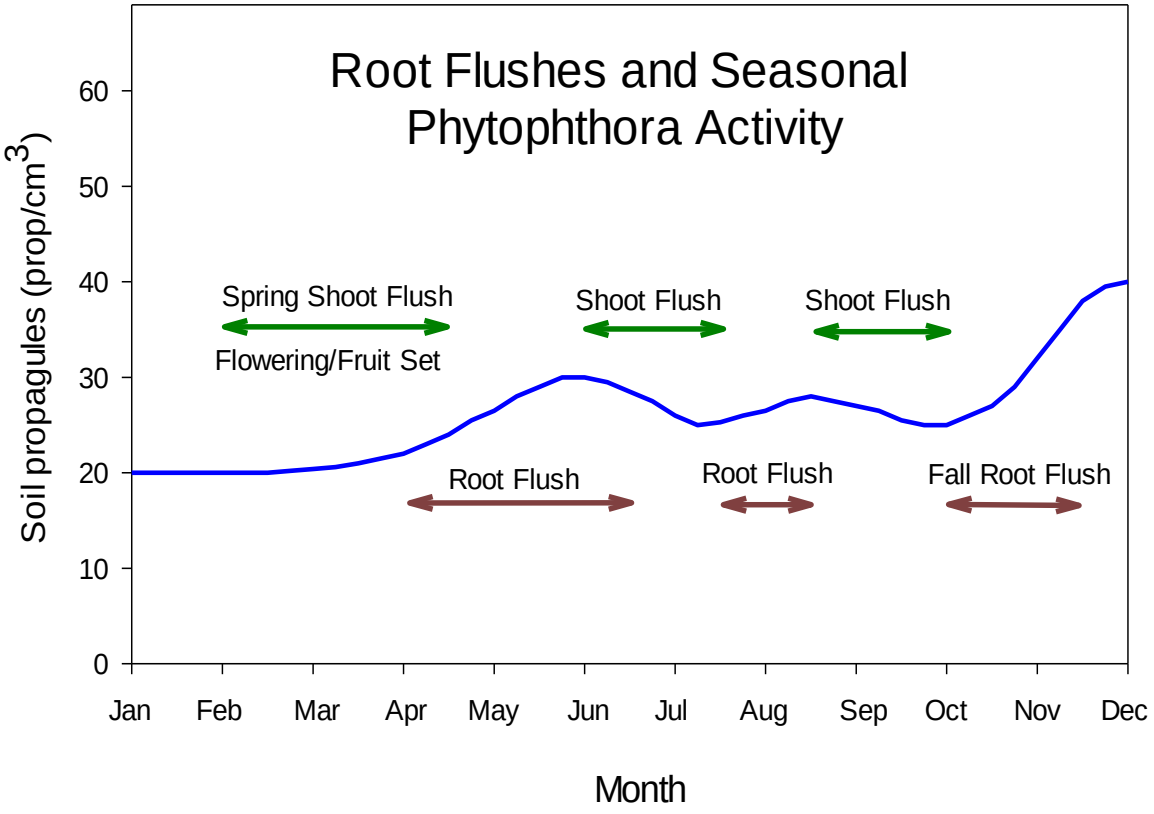
- **Trees' response to therapies has changed**
  - **fundamentally impaired by HLB, tree response to all manner of stress events and therapies (including response to fertilizers) are affected.**

- **Pressure of the phytopthora (propagule count/gr of root etc.) has been magnified, and average root mass of trees is reduced.**

- **The cycles of root production and disease are disrupted, atypical and fluctuate widely so proper timing of fungicide applications becomes more complicated.**

Improving fungicide timing, number of applications and rates are needed to achieve better control.

Phytophthora control with HLB



- **Start with root stresses that give the best return**
- **Monitor groves to look for a developing problem**
- **Decide which root flushes to protect**

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Phytophthora control with HLB

- **Treat based on propagule count**

  >20 propagules per cm^3 of soil

- **Time application for maximum effect**
  - **Management tools are less effective**
  - **Phytophthora damages root flushes**
  - **Treatments are protective – apply at/just before root flush**

Citrus Leprosis Disease

(An exotic disease of quarantine concern)

Topics:

- **Intro. to disease (caused by viruses)**
- **Symptoms on leaves, fruits and stems**
- **Vector and transmission (and control)**

(With Photos and Slides from Hilda Gomez, USDA, PPQ FL-CHRP Pathology Group)

Citrus leprosis virus

- **First reported from Florida in the 1860s and last reported in the State in 1968.**

- **Disappeared since then probably due to the reduction of vector population and citrus hosts caused by freezing weather and intensive sulfur applications.**

- **Since 1960s, citrus leprosis has not been found in the United States.**


Photo: H. Gomez

Today, leprosis is considered one of the most important emerging citrus diseases.

Current Distribution

In recent years, the disease has quickly spread northward from South America through Central America and is now established in Southern Mexico; threatening all the Caribbean islands as well as the citrus growing areas within the United States.


Photo: H. Gomez

South America: Paraguay, Brazil, Argentina, Uruguay, Venezuela, Bolivia, Colombia.

Central America: Panama, Costa Rica, Guatemala, Nicaragua, El Salvador, Honduras, Belize.

North America: Mexico, Hawaii.

An approaching threat to FL citrus; we need to be on the lookout.

Citrus leprosis virus

- **Citrus leprosis is a non systemic viral disease, which causes chlorotic lesions on citrus leaves, fruit, twigs, and branches.**
- **The causal virus agents of citrus leprosis consist of a number of viruses with remarkably similar biology.**
- **These viruses (12 viruses in three genera) are grouped together by their similar disease symptoms, genomic characteristics and the cellular location of the virus (i.e., cytoplasmic (C) type or nuclear (N) type)**
- **These viruses are transmitted by species of Brevipalpus mites (also known as flat mites or false spider mites)**

Photo: H. Gomez

Host Range of Leprosis Disease

- ***Citrus* species, Rutaceae,**
- ***C. aurantiifolia* (Key/Mexican lime)**
- ***C. aurantium* (sour orange)**
- ***C. jambhiri* (rough lemon)**
- ***C. latifolia* (Persian lime)**
- ***C. limettioides* (Palestine sweet lime)**
- ***C. limon* (lemon)**
- ***C. medica* (citron)**
- ***C. paradisi* (grapefruit)**
- ***C. reshni* (Cleopatra mandarin)**
- ***C. reticulata* (mandarin)**
- ***C. sinensis* (sweet orange)**
- ***C. sinensis* x *Poncirus trifoliata* (citrange)**

Sweet orange and mandarins are mainly affected

(The virus has also been found naturally infecting non-citrus species (e.g. species of Hibiscus and Dieffenbachia), and can be transmitted to a wide range of experimental plant species.)

Photo: Roy et al. 2018

Dispersal of Leprosis Disease

- **Leprosis is not transmitted by seeds.**
- **It does not move systemically in the host plant but can move short distances from a graft to the adjacent tissue.**
- **The main means of movement and dispersal is via the vector Brevipalpus mites, which colonize most species of citrus and many other plant species.**

Vector of Leprosis Disease

Vectored only by flat mites *(Brevipalpus spp.);* they exist in major US citrus growing areas.

All active stages of the mite (larvae, nymph, and adult) can acquire and transmit the virus (for their lifetime).

Brevipalpus yothersi
USDA Electron and Confocal Microscopy Unit

https://agresearchmag.ars.usda.gov/2016/oct/mites/

Symptoms of Leprosis Disease

Symptoms include:

- **Localized lesions on leaves, fruit, and stems**
- **Lower fruit quality, fruit drop (lesions only affect the external part of the fruit)**
- **Premature leaf drop**
- **Decreased foliar area**
- **Branch death**
- **Untreated trees eventually die**

The disease in Florida was called 'scaly bark' due to the damage produced on the bark.

Symptoms of Leprosis Disease

Each lesion observed is caused by an individual mite feeding injury.

Dark central spot
from feeding wound

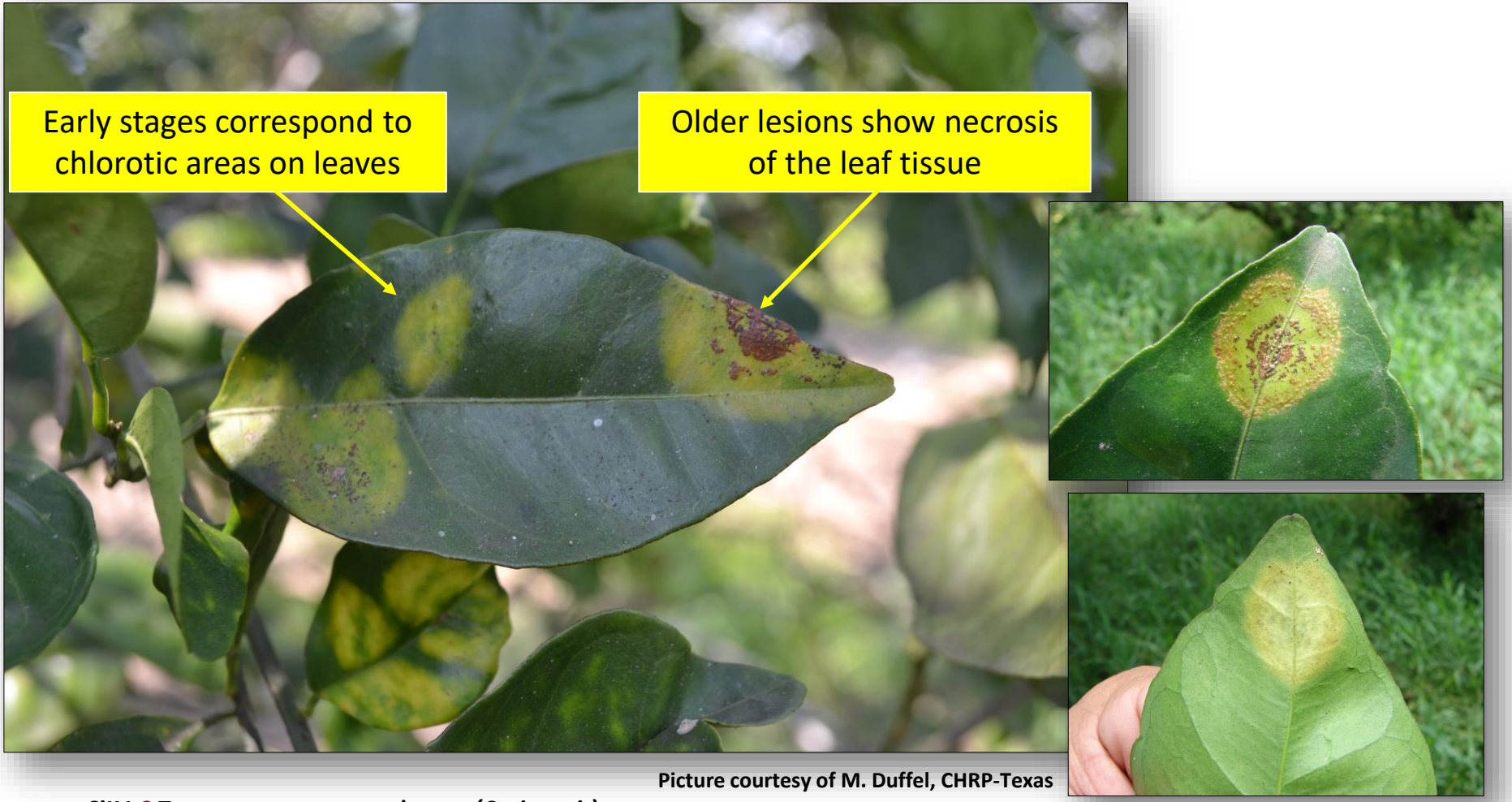
CiLV-C Type on sweet orange leaves *(C. sinensis)*

Symptoms of Leprosis Disease

Leaf lesions caused by the 'C type' virus tend to be larger, with a pale green color and commonly having one or more concentric rings of gummy nature.

CiLV-C Type on sweet orange leaves (*C. sinensis*)

Symptoms of Leprosis Disease



Picture courtesy of M. Duffel, CHRP-Texas

CiLV-C Type on sweet orange leaves *(C. sinensis)*

Symptoms of Leprosis Disease

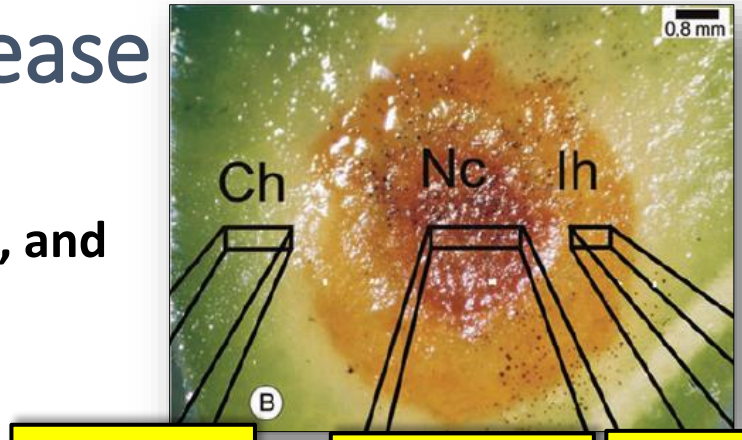
CiLV-C Type

Symptoms of Leprosis Disease

'N Type' virus causes smaller lesions with a necrotic center, an intermediate orange halo, and a bright yellow halo.

CiLV-N Type

Dark spot / yellow halo
Intermediate orange halo



CiLV-N Type on a sweet orange leaf *(C. sinensis)*

An Acad Bras (2010) 82 (2)

CiLV-N Type on mandarin leaves *(C. reticulata)*

Pictures courtesy of I. Alanis

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Symptoms of Leprosis Disease

On stems, young lesions are flat or slightly raised, necrotic, and rusty in color.

Older lesions may coalesce causing the bark to slough off.

EARLY

ADVANCED

CiLV-C Type on sweet orange stems *(C. sinensis)*

Tabasco, Mexico- 2008

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Symptoms of Leprosis Disease

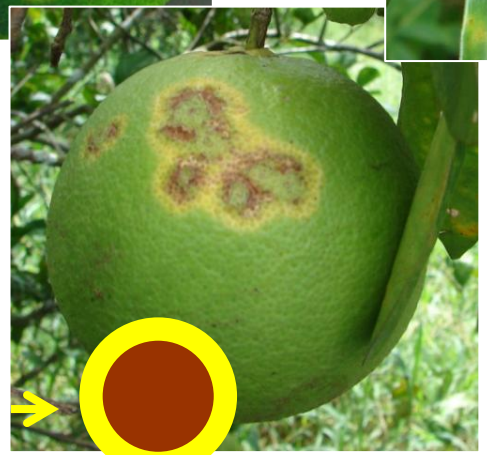
CiLV-C Type on sweet orange stems *(C. sinensis*)

Santa Cruz de la Sierra, Bolivia-2016

Symptoms of Leprosis Disease

On fruit, lesions are usually flat, but as they enlarge become sunken, and necrotic.

EARLY



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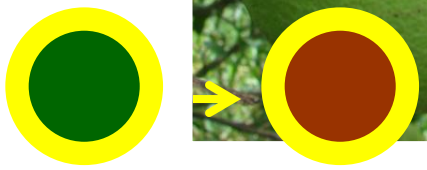

CiLV-C Type on sweet orange fruit *(C. sinensis)*

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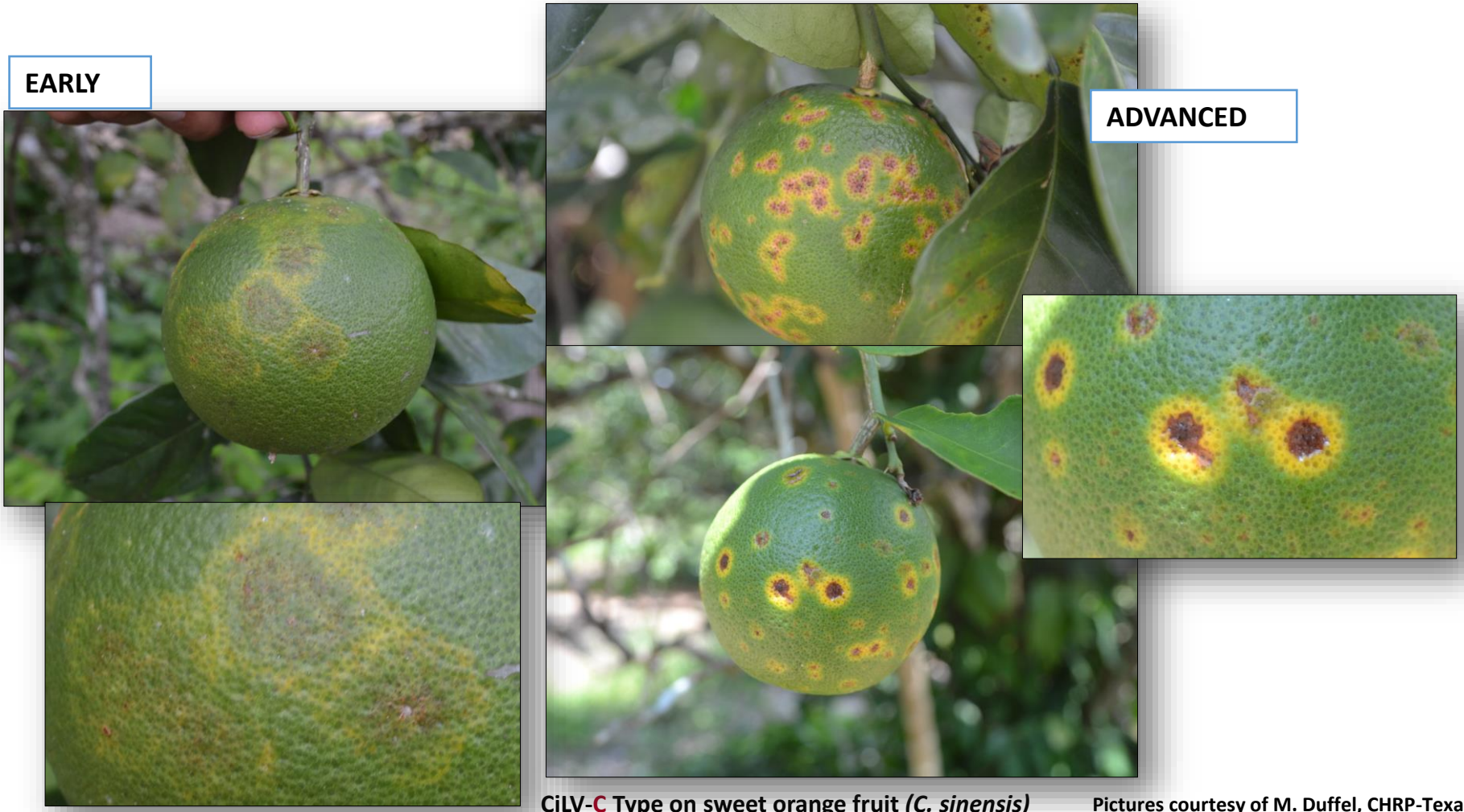
Symptoms of Leprosis Disease

EARLY

ADVANCED



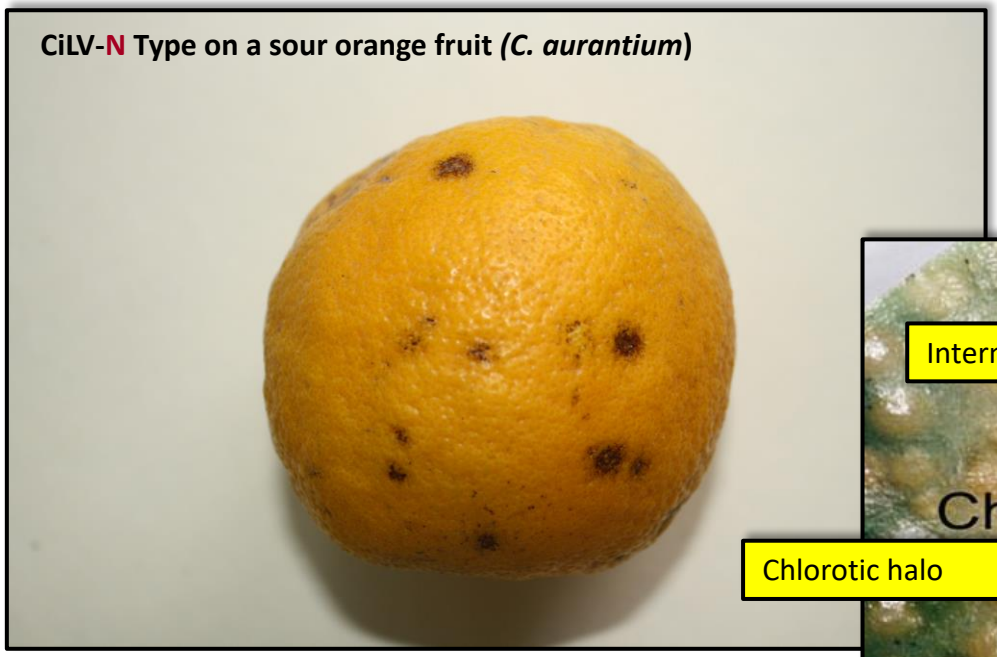
CiLV-C Type on sweet orange fruit *(C. sinensis)*

Pictures courtesy of M. Duffel, CHRP-Texas

Symptoms of Leprosis Disease

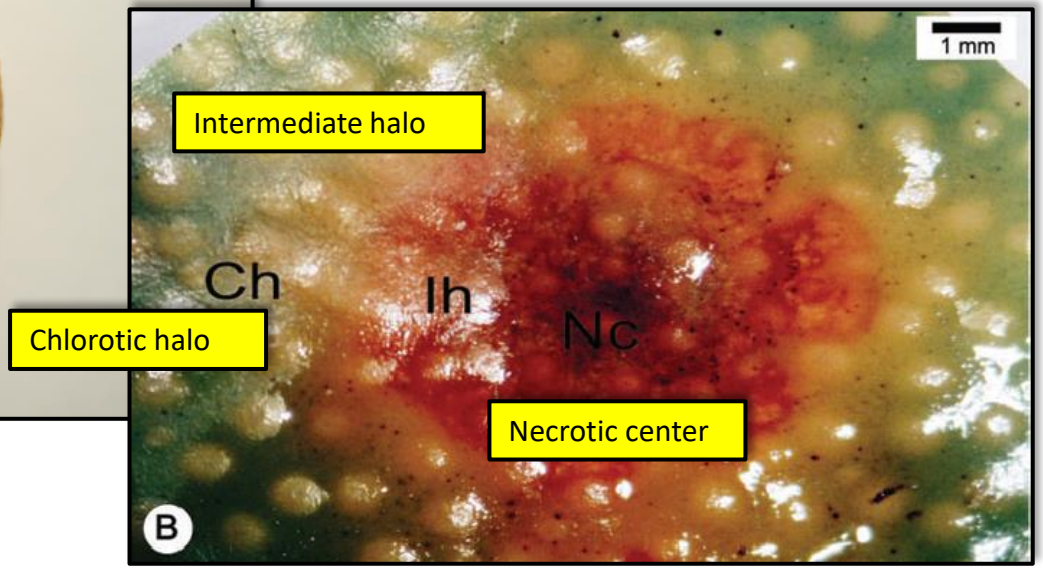
Lesions caused by 'N type' tend to be smaller with a necrotic center and a chlorotic halo.

CiLV-N Type on a sour orange fruit *(C. aurantium)*



Picture courtesy of G. Otero-Colina, Mexico

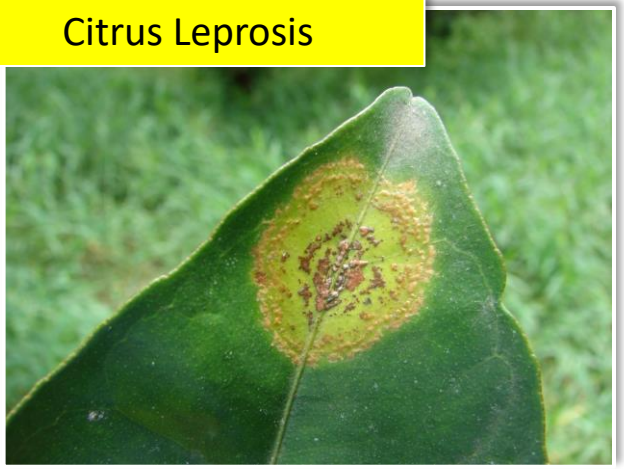
CiLV-N Type on a sweet orange fruit *(C. sinensis)*

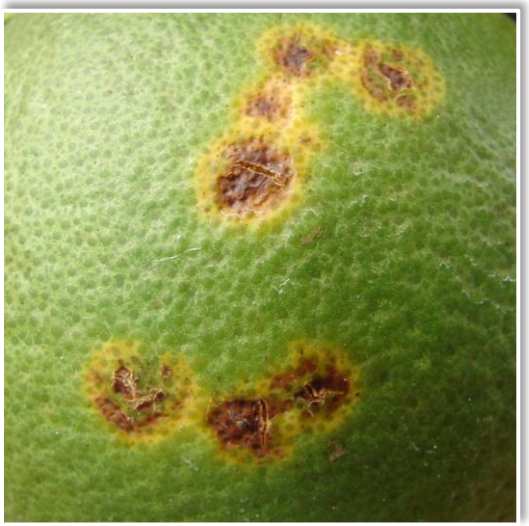


An Acad Bras (2010) 82 (2)

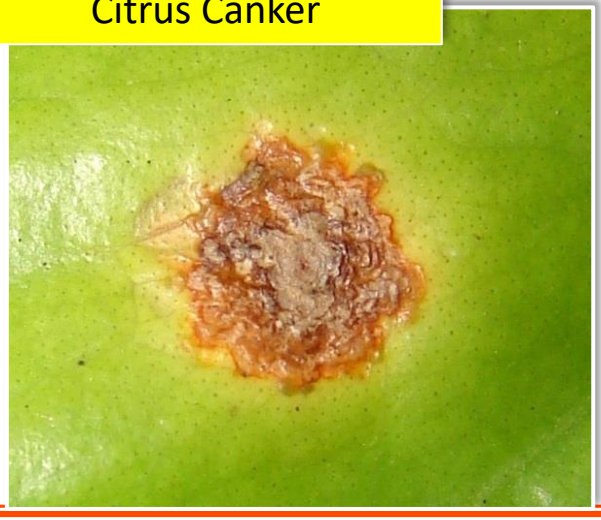
Leprosis vs. Citrus Canker Symptoms

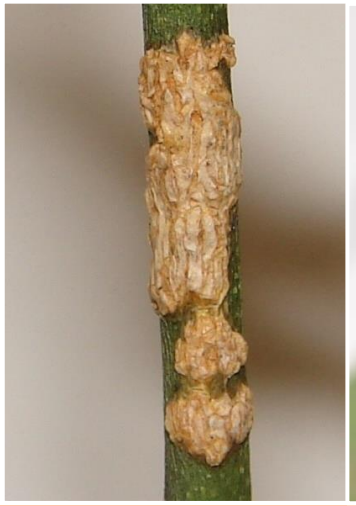
Citrus Leprosis





Citrus Canker





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Leprosis Control

(Heads up)

- **Given that Florida's climatic conditions are highly suited for establishment of citrus leprosis and is predicted to have an economic impact on citrus production in Florida, if found again.**

- **Preventing citrus leprosis from re-entering Florida is much easier than trying to eradicate or control it.**

- **It is important to avoid bringing propagation materials from areas infected with citrus leprosis into Florida.**

- **Citrus leprosis is basically controlled by controlling the mite vectors.**

If you suspect leprosis in your grove, PLEASE contact FDACS or your extension specialist ASAP for diagnosis; I can help.

Acknowledgements

Thank You!

- Cit. Path. and NATI Team Members
- Advisory Board Members
- Grower and Industry Collaborators
- USDA NIFA (Award No's: 2018-70016-27392; 2019-70016-29096; 2020-70029-33195; 2020-70029-33196)
- Citrus Initiative Grant of University of Florida
- Bayer U.S. LLC Crop Science, Biologics

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

BAYER

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Thank You!
Any question?

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