Root health of HLB-affected groves: What are the issues and how can we manage them?

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Current situation and questions about HLB expression in Florida

Situation

- HLB incidence is approaching 100%, especially in young groves
- Fruit drop statewide has led to a 13% reduction in the USDA crop estimate (unprecedented)
- Most of the Hamlin and Valencia drop appears to be due to HLB

Question

- Why is fruit drop greater than in past seasons?

Bacterial infection of the phloem causes carbohydrate disruption and fruit starvation

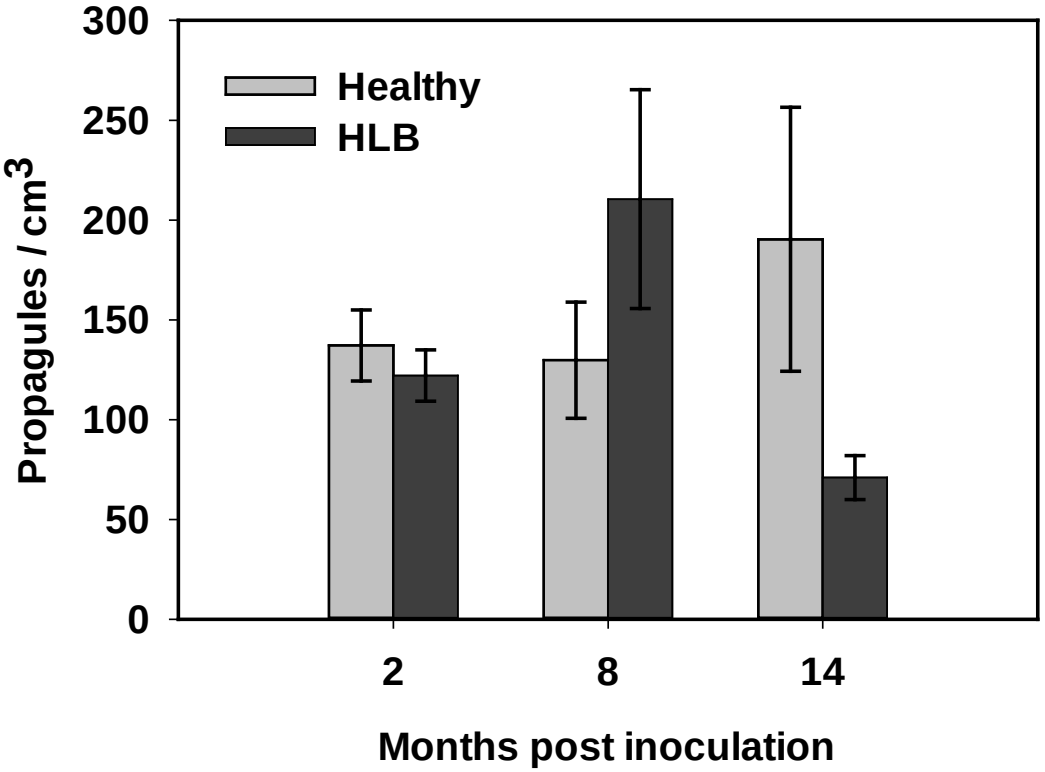
- About two months before harvest sugars move from the leaves into the fruit such that the Brix and the sugar:acid ratio increases
- In HLB trees starch accumulates in the leaf cells and disrupts the chloroplasts (leaf mottling)
- Movement of sucrose from the leaves to the fruit through the phloem is reduced (sugar:acid ratio may decrease!)
- Lack of carbohydrate supply causes fruit starvation and premature drop

Aborted fruit that drop have stem-end break-down

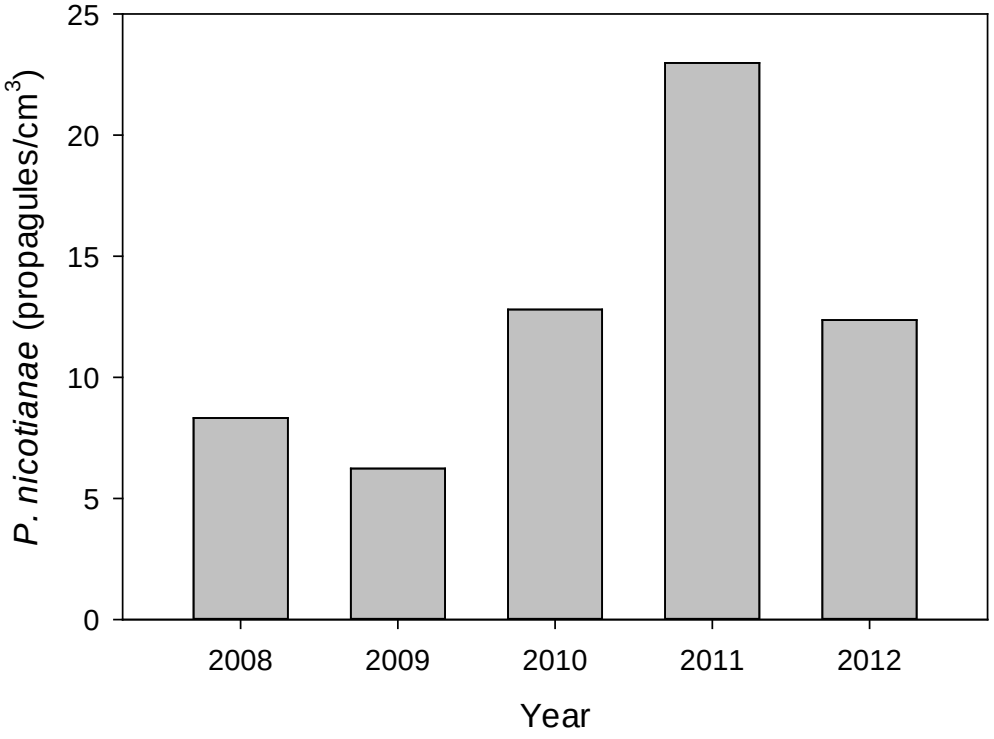
Findings from our recent greenhouse and field studies on root health of HLB-affected trees

- The bacterium moves to the roots after initial infection /transmission in the shoots
- The HLB pathogen, *Candidatus* Liberibacter asiaticus (*Las*) infects structural and fibrous roots
- *Las* colonizes the roots before the shoots
- This infection causes a rapid of fibrous root loss of 27-40% before symptoms in the canopy
- Phytophthora interacts to further reduce root health but the majority of the root loss is due to HLB
- Phytophthora populations of HLB trees initially increase then as roots are lost due to *Las* infection, the populations decline rapidly

Phytophthora population in potting soil at 2, 8 and 14 mpi for bud-inoc trees HLB+ and mock-inoc trees HLB-



Statewide drop in Phytophthora counts may reflect the HLB-induced root loss which accelerated fruit drop in 2012-13



2012 count based on **2961** samples

Data courtesy of John Taylor, Syngenta Crop Protection

Crop loss for HLB symptomatic trees compared to matched healthy Valencia orange trees on two rootstocks in Hardee Co. from 2009 to 2011*

Rootstock	Health	2009 Fruit no. per tree	2009 Difference	2010 Fruit no. per tree	2010 Difference	2011 Fruit no. per tree	2011 Difference
Swingle	Healthy	849		896		777	
	HLB	519	-39%	561	-37%	532	-31%
Carrizo	Healthy	1043		803		873	
	HLB	673	-35%	621	-23%	613	-30%

*In 2011 measured a 45% reduction in fibrous roots for HLB+ trees compared to HLB-

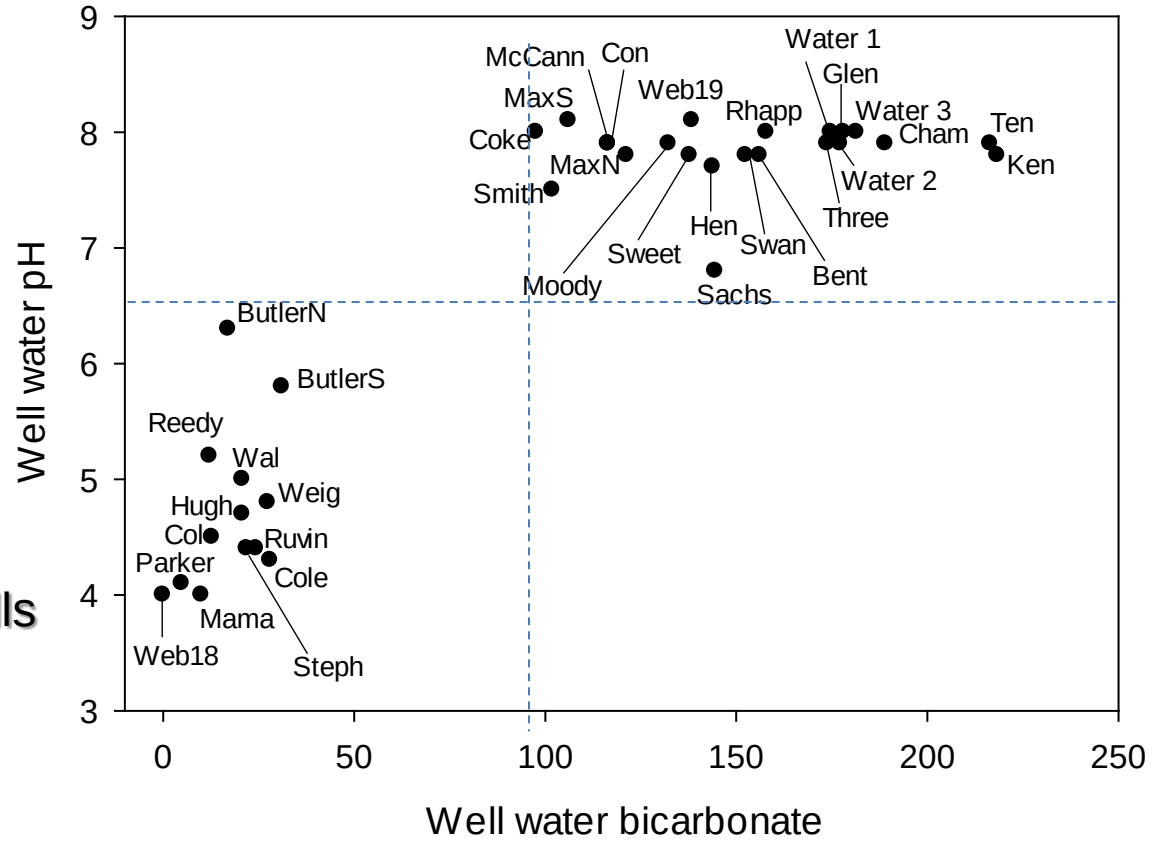
Data kindly provided by Davis Citrus Management, Inc. and Magnolia Consulting, Inc.

Soil pH and well water quality may affect root health and HLB disease expression

- Citrus groves often have history of dolomite liming for control of copper toxicity and microjet irrigation that concentrates fibrous roots in the wetted zone
- Soil pH >6.5 and/or well water with bicarbonate (>100 ppm) are associated with >HLB expression
- Groves with soil pH <6.5 and/or low bicarbonate water may be experiencing less deterioration in root health
- Rootstock sensitivity: Swingle > Carrizo > Volk > Cleopatra
- Compared 41 grove locations in Highlands and Desoto Counties with varying liming history and deep vs. shallow wells mostly on Swingle and Carrizo

Survey of well water in central FL citrus groves
Deep wells - pH >7.0 and bicarbonates >100 ppm

Data from Davis Citrus Management

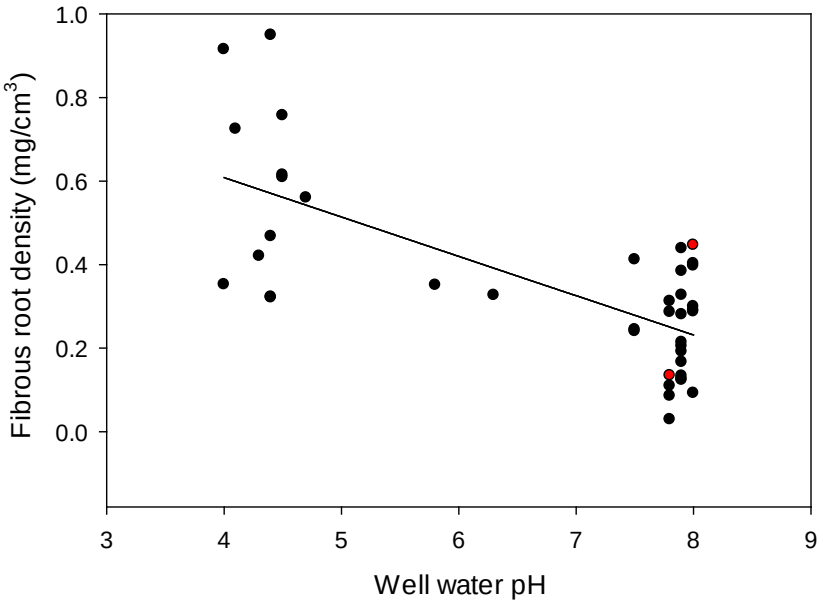


Deep wells

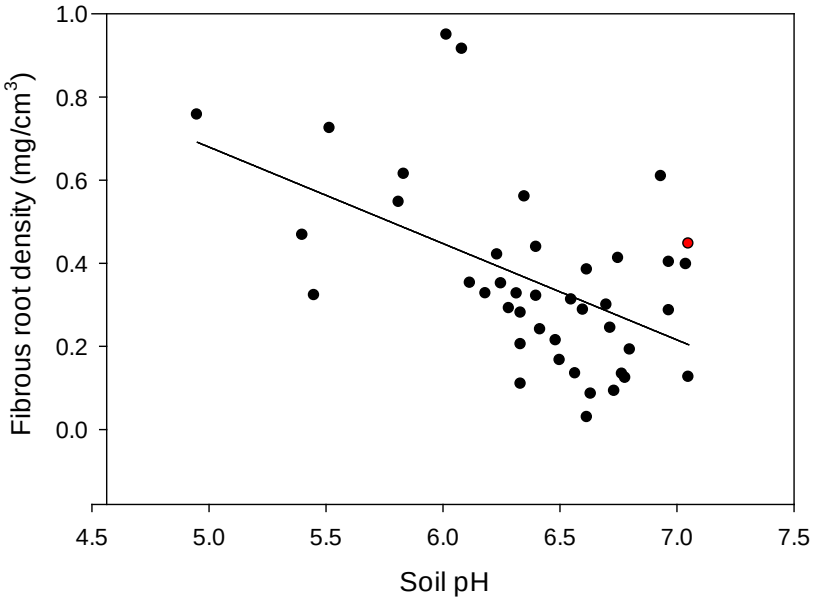
Shallow wells

Lower root density is related to well water pH>6.5 ($r^2 = 0.50$) and soil pH>6.2 ($r^2 = 0.25$)

Well water pH



Soil pH in the wetted zone



Health and fruit drop status of Valencia/Swingle trees planted in 2003

pH 6.4: Fruit drop minimal

pH 7.2: Fruit drop resulted in early harvest

Where to go from here?

California Central Valley Tour*

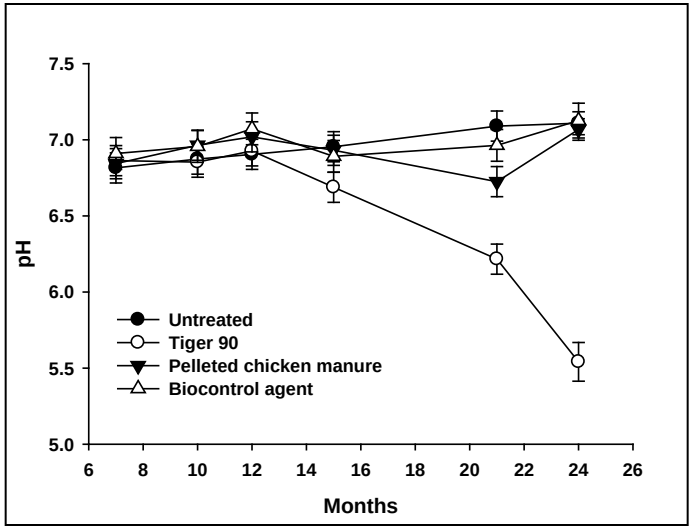
*Sponsored by Syngenta

e. g. Water conditioning

N-furic acid (15-0-0) to adjust water to pH 6.5

e. g. Soil conditioning

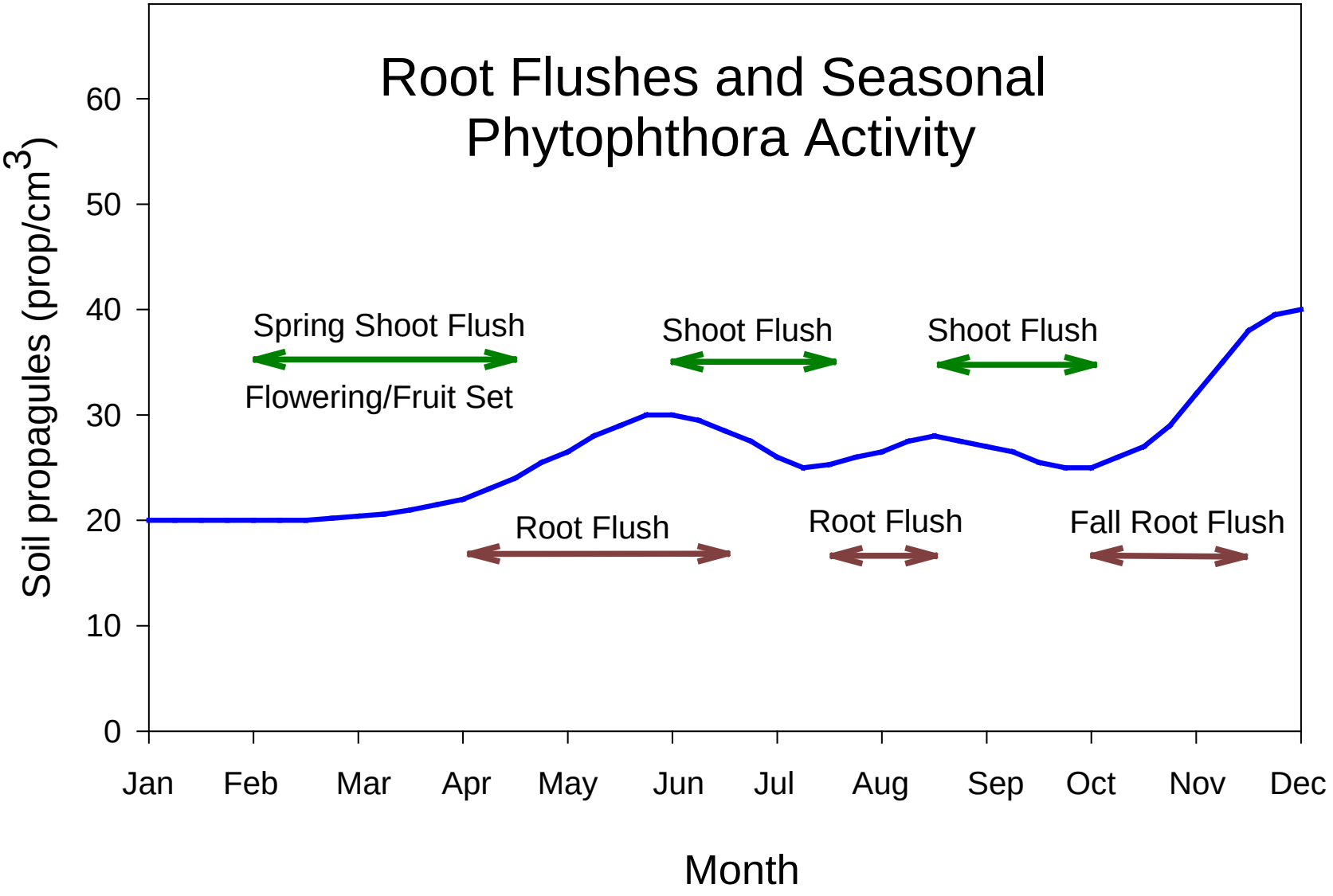
Tiger 90 pelletized sulfur to drop soil pH from 6.8 to 5.5 (2 yr)



Ridge grove in Lake Garfield
Data from L. W. Duncan, CREC

Recommendations

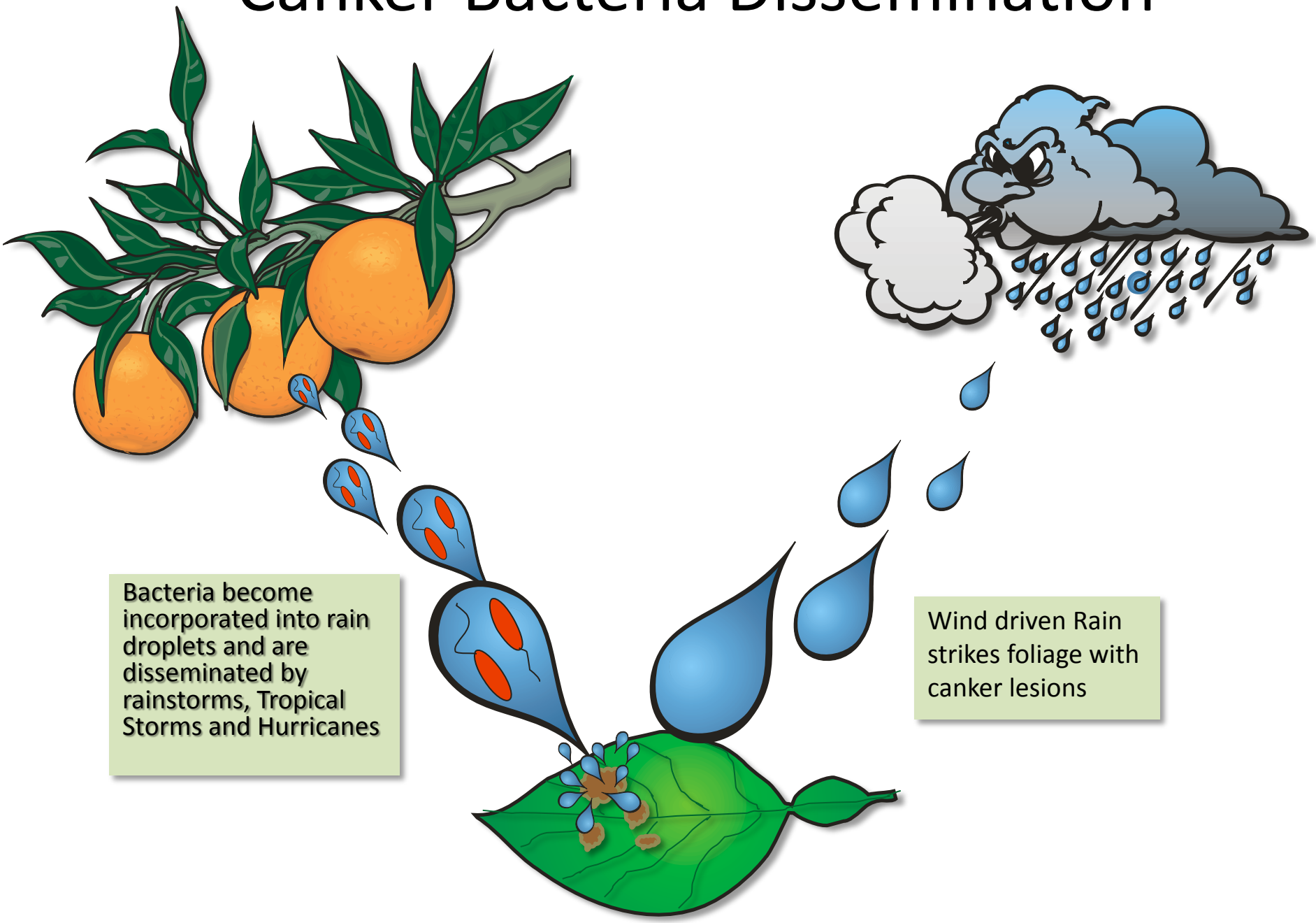
- Phytophthora, nematodes, weevils should be managed more aggressively to sustain root health – details in FCPMG
- www.crec.ifas.ufl.edu/extension/pest/
- If Phytophthora count is >10-20 propagules/cm^3 recommend rotation of fungicides:
- Aliette/phosphite after spring shoot flush
- Mefanoxam after spring-early summer rains begin
- Aliette/phosphite after midsummer shoot flush
- Mefanoxam after fall shoot flushes
- Remember root flushes follow shoot flushes


Root Flushes and Seasonal Phytophthora Activity
Soil propagules (prop/cm3)
60
50
40
30
20
10
0
Spring Shoot Flush
Flowering/Fruit Set
Shoot Flush
Shoot Flush
Root Flush
Root Flush
Fall Root Flush
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Final recommendations

- Match nutritional supply with tree demand with leaf testing of the nutrient status of both HLB+ and HLB- trees (See Citrus Industry June, Zekri & Obreza)
- Balance the costs of root health management with other resources for HLB, i.e. psyllid control, irrigation and nutritional programs, control of other pests and diseases
- Check status of soil pH in wetted zone and well water for pH, bicarbonates and salinity
- Investigating whether there is benefit for reducing bicarbonates by acid treatment of irrigation water and/or amending soil with S to lower pH (collaboration with Kelly Morgan, SWFREC)

Canker Bacteria Dissemination



Bacteria become incorporated into rain droplets and are disseminated by rainstorms, Tropical Storms and Hurricanes

Wind driven Rain strikes foliage with canker lesions

High levels of canker losses occur depending on cultivar, leafminer, timing of wind-blown rain events w/ fruit size

Site conditions that promote canker are wide areas without natural windbreaks

Frequent and vigorous flushes on young trees with leafminer combined with wind exposure promotes canker even on resistant Valencia

Period of greatest fruit susceptibility

- Occurs when the fruit reaches 0.25-0.5 inches in diameter until fruit is about 1.5 inches in diameter
- Rains in April-May promote early season infection
- The rind is susceptible throughout the entire period of fruit growth, but becomes more resistant with time

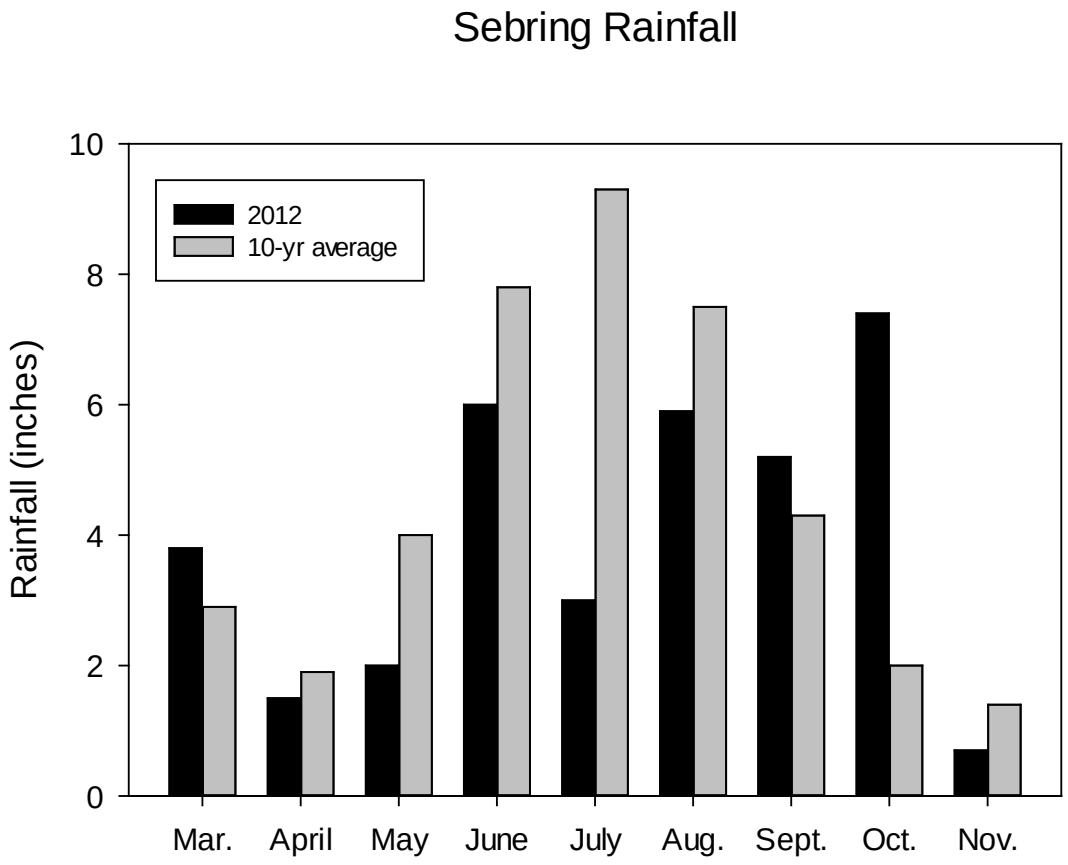
Challenges posed by Hamlins for canker control

- Hamlin is the most susceptible sweet orange cultivars and comprises 50% of FL orange crop
- Previously, copper fungicide was applied to Hamlin 1-2 times per season to control greasy spot
- To control canker, additional copper sprays at 21 day interval are required for optimal cost/benefit (Behlau et al. 2009)
- In young groves number of copper sprays increases
- How many additional sprays are necessary?
- What rates and copper formulations are effective?

Integrated management doesn't solely rely on copper sprays for inoculum control

- Hedgerows act as internal windbreaks/for reducing wind speed
- Citrus leafminer control is essential
- Copper sprays with metallic rates that are effective and minimize copper loading
- Systemic control of bacterial infection with soil applied neonicotinoids and Actigard as SAR inducers

2012: dry spring, wet late summer-early fall



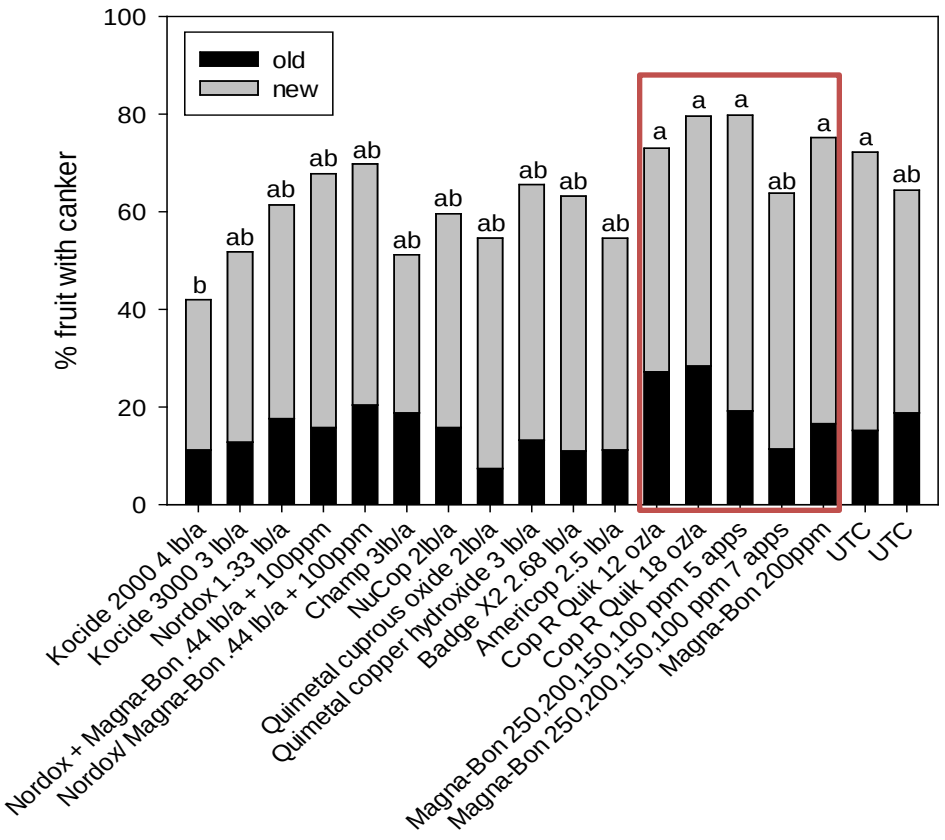
Formulations, rates and manufacturers of products tested

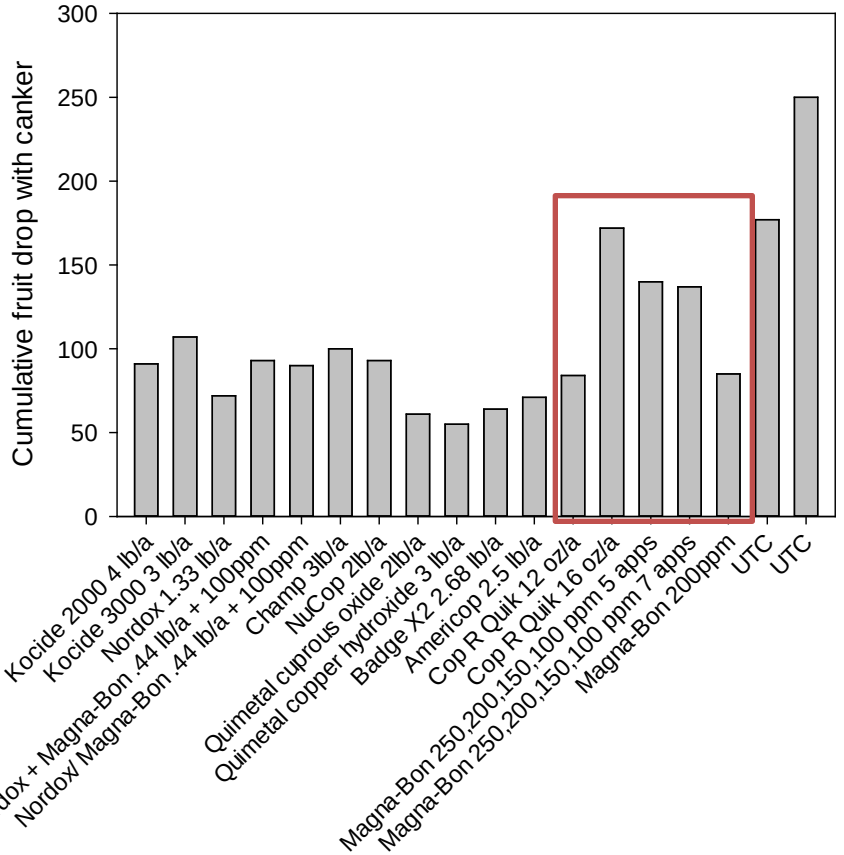
Treatment	Manufacturer /supplier	Metallic Cu (%)	Rate (lb or oz/acre)	Metallic Cu (lb/acre)
1) Kocide 2000	Dupont	35	4.0	1.4
2) Kocide 3000	Dupont	30	3.0	1.0
3) Nordox	Brandt	75	1.33	1.0
4)Nordox +Magna-Bon (MB)	Brandt/MB	75/5	0.44/37oz	0.47
5)Nordox 3 apps, MB 2apps	Brandt/MB	75/5	1.33/37oz	1.0/0.14
6) Champ 30WP	Nufarm	30	3.0	0.9
7) NuCop 50HB	Albaugh	50	2.0	1.0
8) Quimetal cuprous oxide	Quimetal	50	2.0	1.0
9) Quimetal Cu hydroxide	Quimetal	30	3.0	1.0
10) Badge X2	Isagro	28	2.68	0.75
11) Americop 40 DF	IQV	40	2.5	0.66
12) Cop-R-Quik	Nat.Ag. Sol.	12	12.0 oz	0.28
13) Cop-R-Quik	Nat.Ag. Sol.	12	16.0 oz	0.37
14) Magna-Bon[z] - 5 apps	Magna-Bon	5	92.8 oz	0.35
15) Magna-Bon[z] -7 apps	Magna-Bon	5	92.8 oz	0.35
16) Magna-Bon[y]	Magna-Bon	5	74 oz	0.28
17) Untreated check 1(UTC)	--	--	--	--
18) Untreated check 2(UTC)	--	--	--	--

[z] 250 ppm, 200 ppm, 150 ppm and 100 ppm for rest of applications

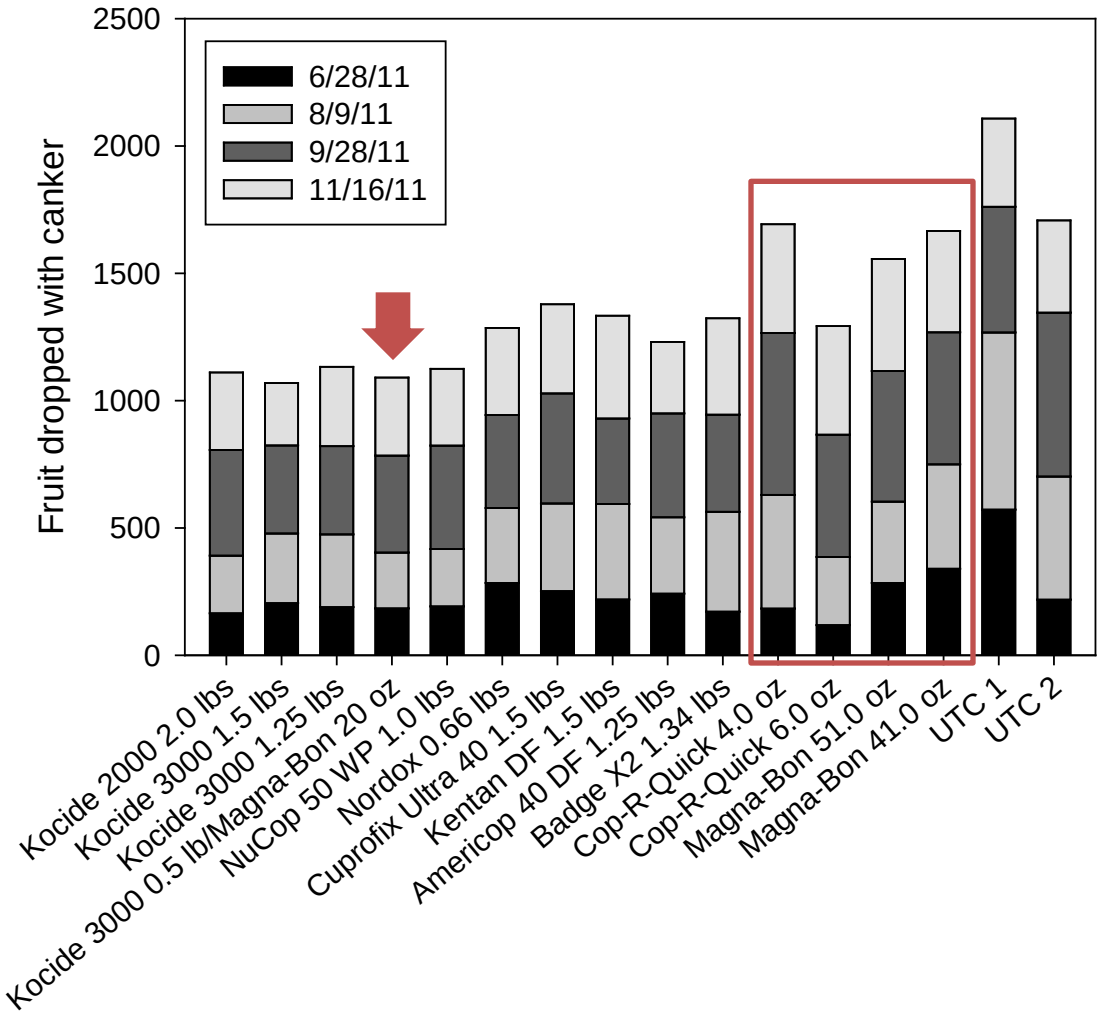
[y] 200 ppm for all apps

Effect of copper formulations on incidence of fruit with old, young and total lesions on 5 yr-old 'Hamlin' orange. Copper treatments reduced drop from 0.33 to 0.1 box/ tree.

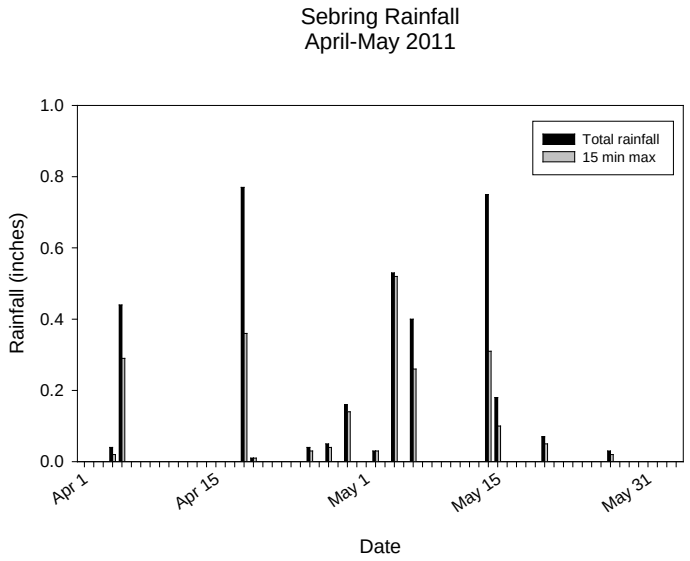




2011: Wet Spring
>80% drop (10x higher than in 2012)



Periodic April-May rains



Conclusions

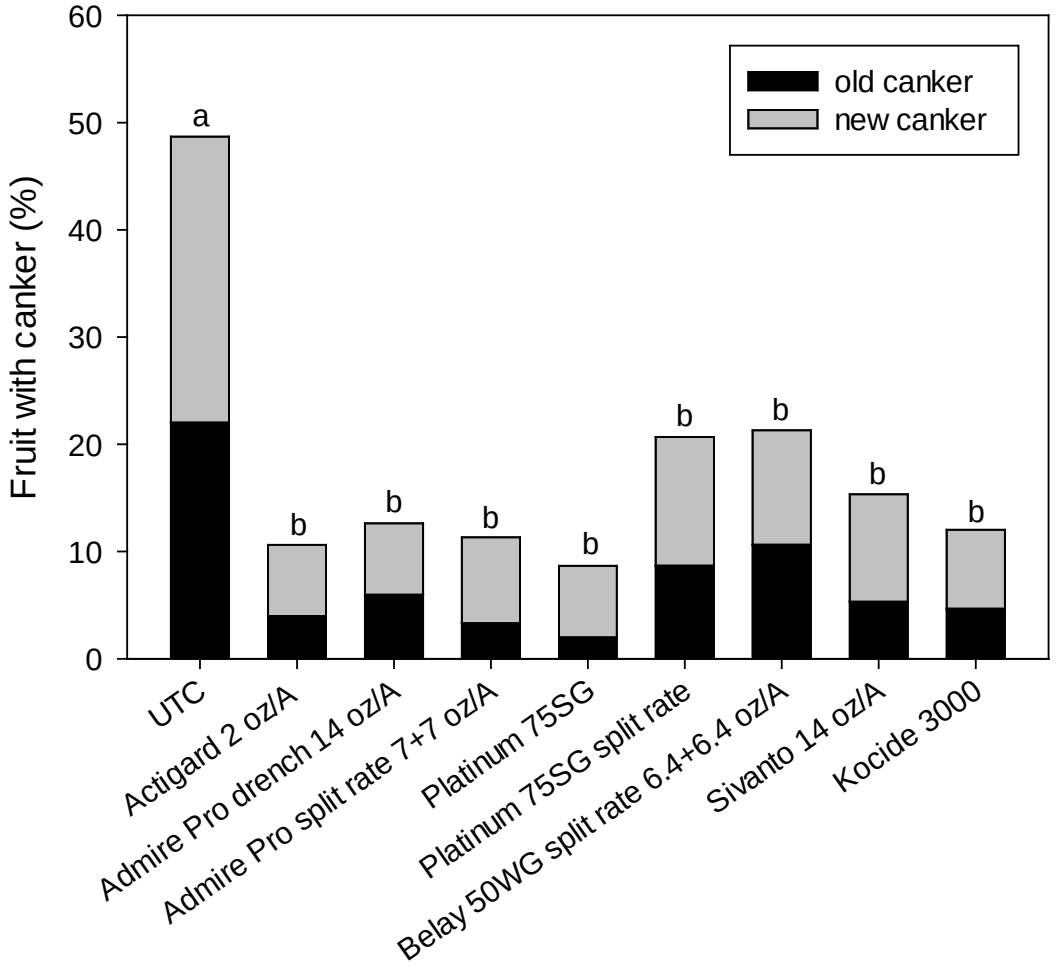
- Hamlin fruit drop is highly related to early season fruit infection
- Copper sprays reduce early season infection and fruit drop and provide economic return for the cost of the additional sprays
- No more than 4 sprays are necessary to prevent crop loss as later season infections do not cause fruit drop
- Copper formulations at rates of 0.5-1.0 lb metallic copper are effective,
- Magna Bon at lower metallic mixed or alternated with insoluble copper gives comparable control with 50% less Cu metal/acre
- As trees develop hedgerows they become more resistant to canker due to reduced windblown rain penetration of the grove
- Fewer copper sprays are needed after trees canopy closure- "Internal windbreak"
- Proper spacing of trees is important to promote canopy closure as rapidly as possible

Soil drenches of Actigard and neonicotinoid insecticides (Admire Pro, Platinum, Belay) and Sivanto (Bayer) for Systemic Acquired Resistance (SAR) control of canker

Citrus leafminer control is essential on the leaf flushes to prevent inoculum build-up and defoliation

Lapse of leafminer and canker control in July and resumption of control after next Admire Pro

Single and split soil applications of SAR inducers Actigard, Admire Pro, Platinum, Belay and Sivanto compared 21 da sprays of Kocide on 3-yr old 'Vernia' orange



SAR for canker control in the field

- Soil drenches of SAR inducers Actigard, Admire Pro, Platinum, Belay (neonicotinoids) are as effective as 21 day interval foliar copper sprays for control of canker on young fruiting trees
- Integration of more than one SAR inducer is likely to be even more effective
- Sivanto, as a soil drench, controls canker in the same way as the neonicotinoids
- Sivanto is a new insecticide from Bayer Crop Science for aphids, psyllids and whiteflies (nAChR Agonist /Butenolide)

HLB and Canker Research Acknowledgements

- Citrus Research and Development Foundation

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- Product manufacturers
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