Citrus Nutrition Research Leading to Revised Fertilzier Recommendations for HLB-affected

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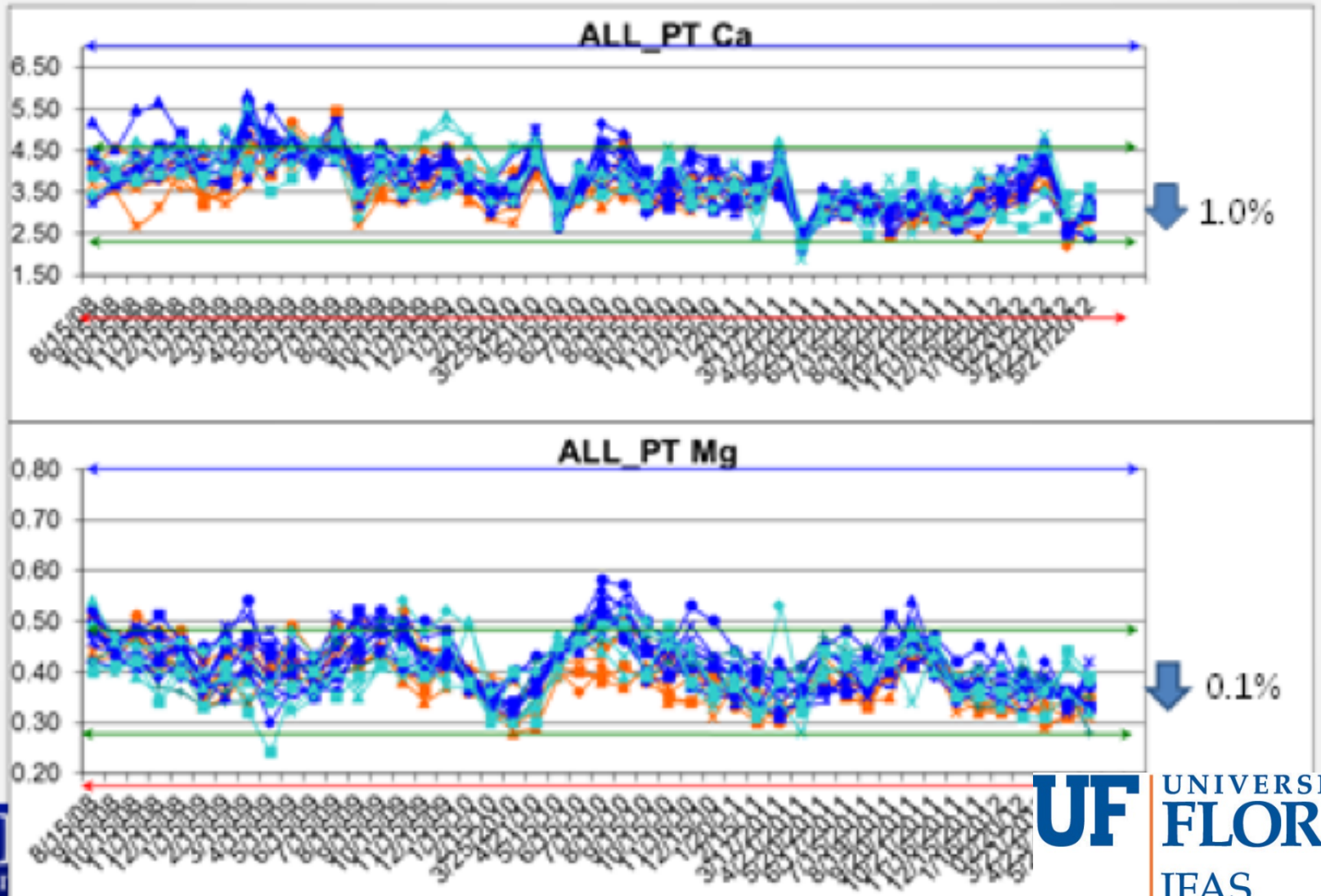
Impact of HLB root damage: decline in Ca and Mg leaf status over in ridge and flatwoods groves (Data from Bill Barber – Lykes Citrus)



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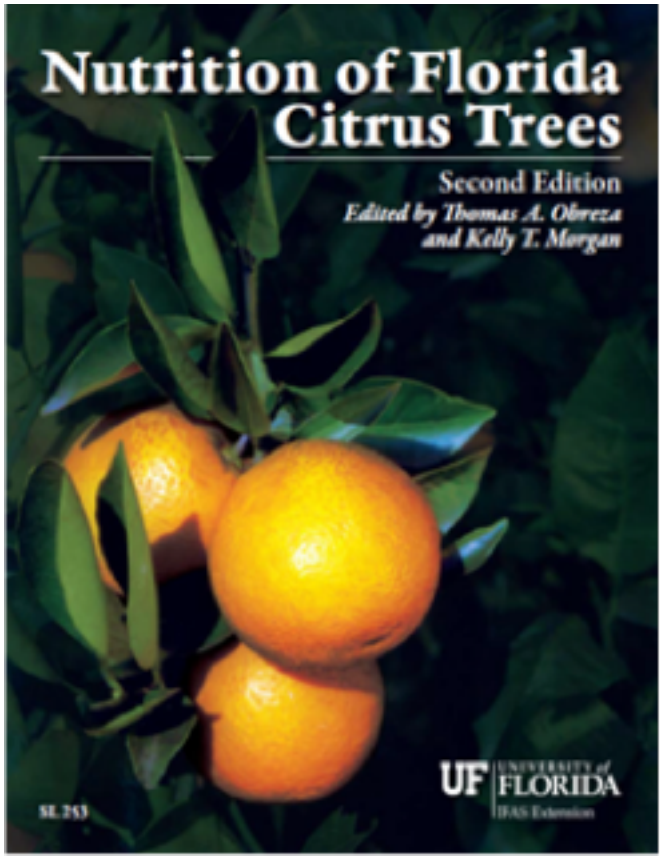
Nutrient recommendations for HLB affected trees

- Last Revision to the citrus nutrient recommendations – 2008
- Currently being revised to include information on nutrition of HLB affected trees



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Effect Micronutrients on HLB Affected Citrus Trees

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Greening Foliar Nutrient Study

- Duration = 5 years 2010 – 2015
- Commercial Grove – Valencia on Swingle – 16’ X 30’
- No Spray control
- Mn, Zn, B at three rates (0.5X, 1.0X, 2.0X)- 1X = IFAS recommendation, applied 3 times per year
- Annual applications of 1.5x, 3.0x and 6x IFAS recommendations
- Mn and Zn as sulfates and phosphites
- Sulfates with and without Potassium nitrate
- Leaf samples taken prior to (pre) and after sprays (post)

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Foliar Nutrient Rates

- Study rates were based on current IFAS recommendations below
- With 1X= IFAS recommendation

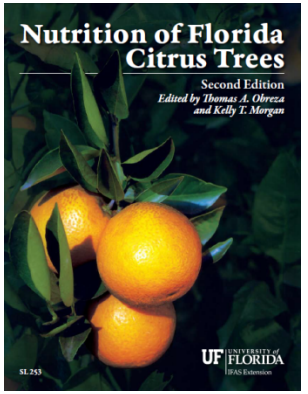

Table 8.4. Recommended methods, timing, and rates for micronutrient application to citrus groves.

		Mn	Zn	Cu	B
Method	Foliar	Yes	Yes	Yes	Yes
	Soil	Yes[1]	No	Yes	Yes
Timing	Foliar	When spring flush leaves reach full expansion			
	Soil	Anytime as needed			
Rates		lbs metallic equivalent/acre			
	Foliar	3 to 5	5	3 to 5	¼
	Soil	7 to 10	---	5	1

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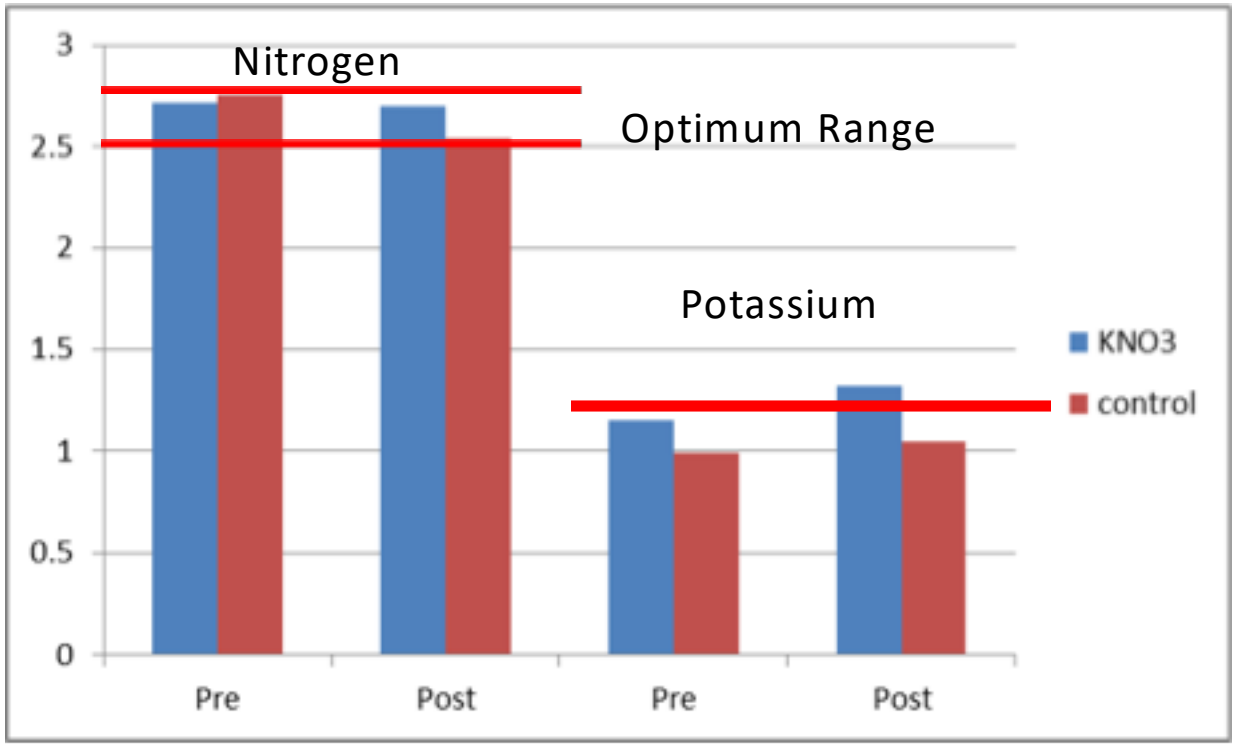
Effect of Potassium Nitrate (KNO_3) on Leaf Concentrations



- N was not greater in leaves of trees receiving KNO3
- K in leaves not receiving KNO3 was similar to sprayed leaves prior to application
- Leaf K was greater following applications

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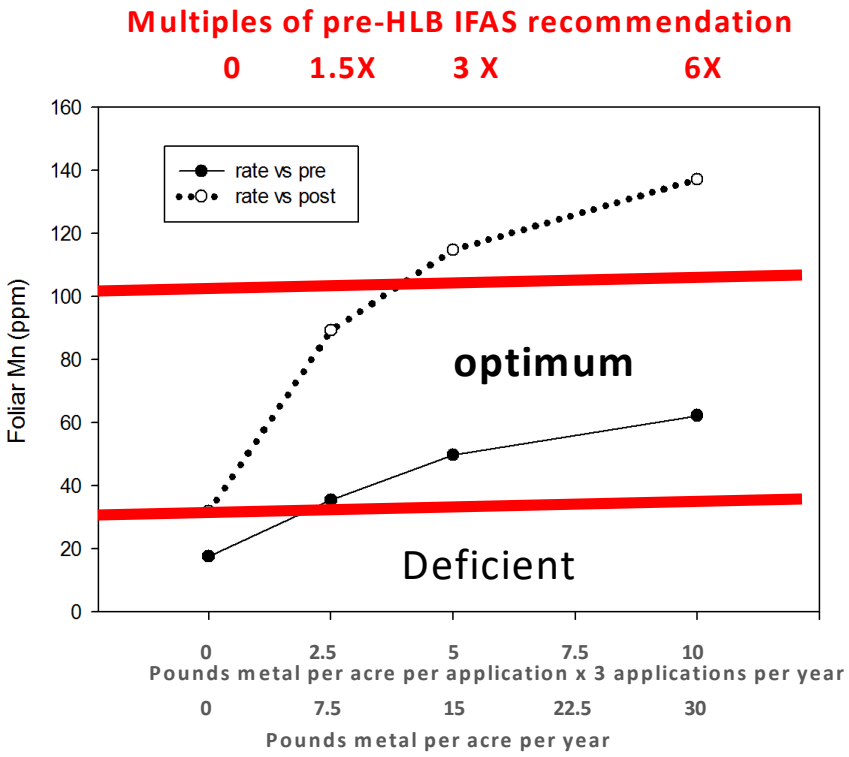
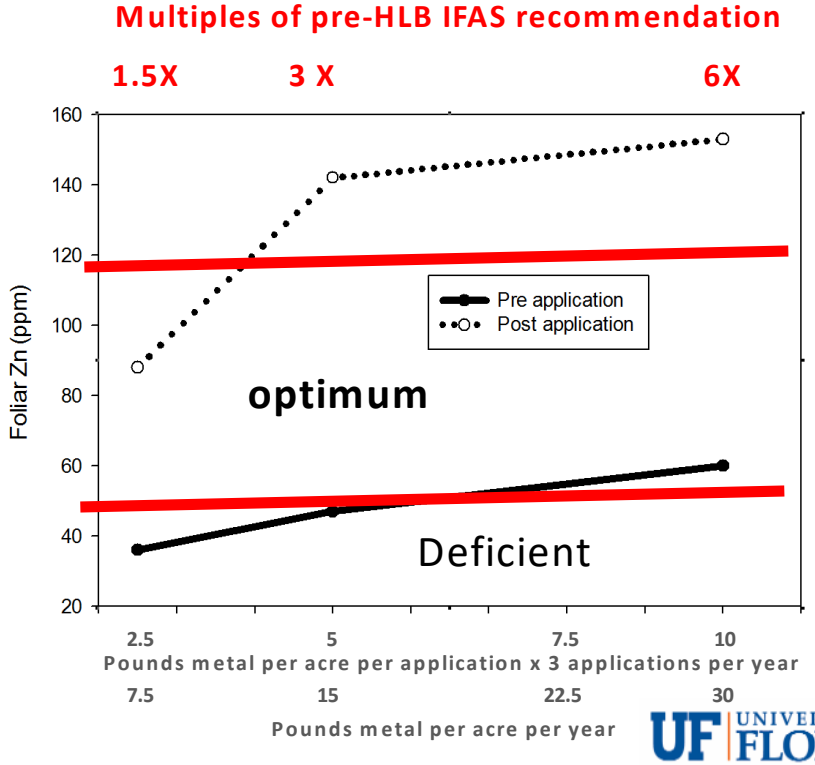
Effect of Sprays on New Growth

- Leaf Mn and Zn were lower in leaves of trees prior to foliar sprays but increased after spray applications
- 3.0 and 6.0 times recommendation were most effective





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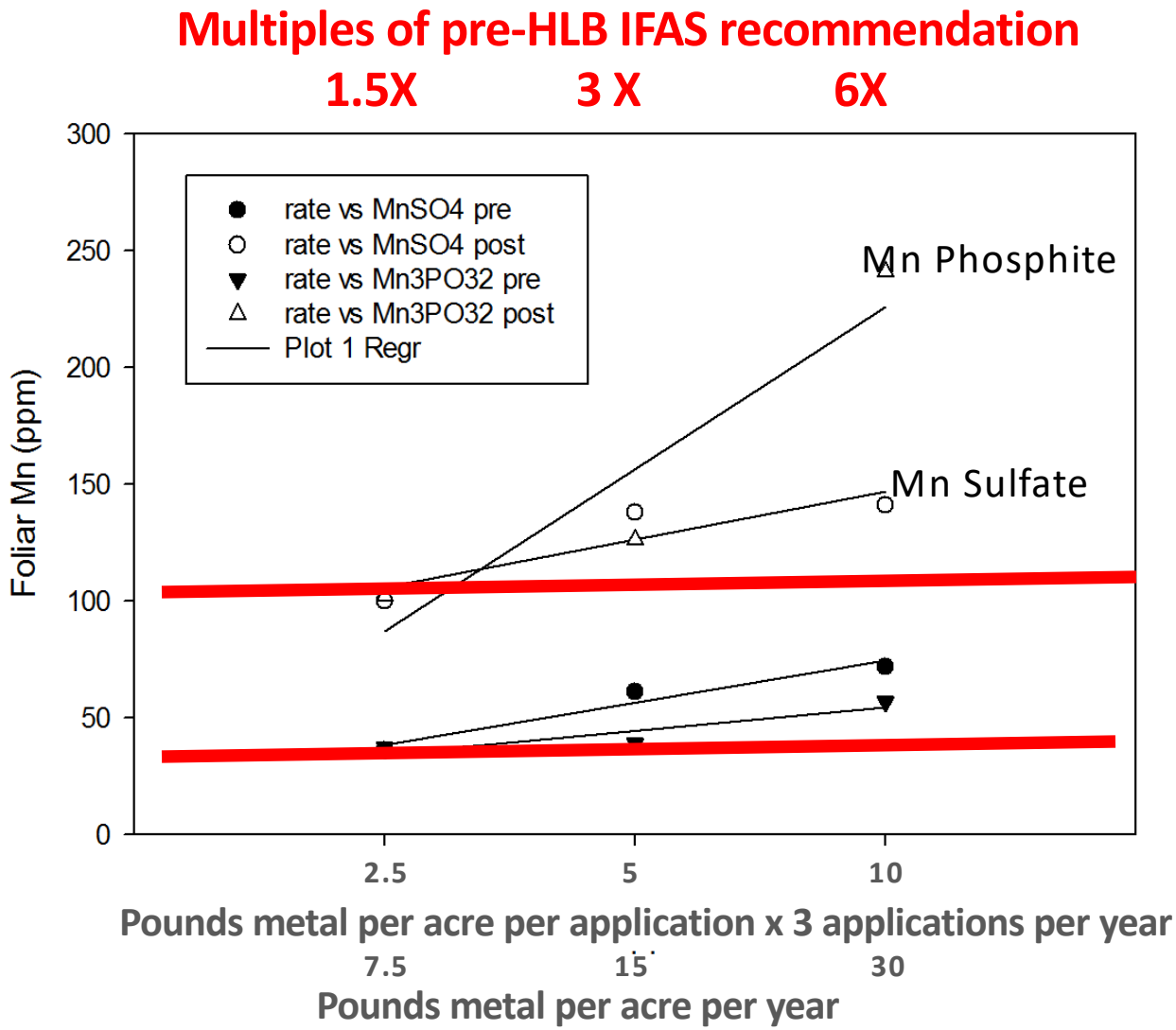
Effect of Nutrient Form Leaf Mn Concentrations



- Phosphites greater leaf concentrations
- Increase after spray application because of growth dilution

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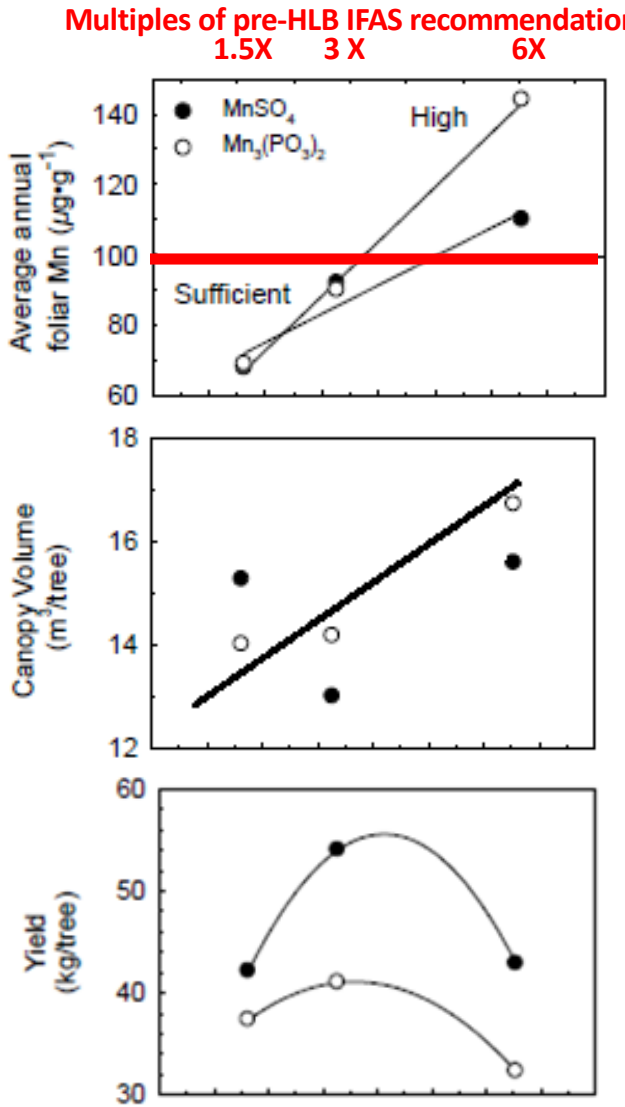
Effect of Leaf Nutrient Concentrations on Tree Growth and Yield



- Similar trends for both Mn and Zn
- Similar canopy volume at 3X rate
- Slight but significantly Greater canopy volume at 6X
- Increasing yield with increased rate to 3X but lower at 6X

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Recommendations

- Keep foliar concentrations of macro (N and K) and micro (Mn, Zn, and probably Fe) are in the upper optimum range or higher.
- Avoid deficient and excess foliar Mn and Zn.
- If want to increase yield, keep foliar Mn and Zn in the upper range of the sufficiency range (50-100 ppm)
- If want to rebuild the canopy , keep foliar Mn and Zn slightly over the sufficiency range (>100 ppm).

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Effect of soil pH on HLB Affected Citrus Trees

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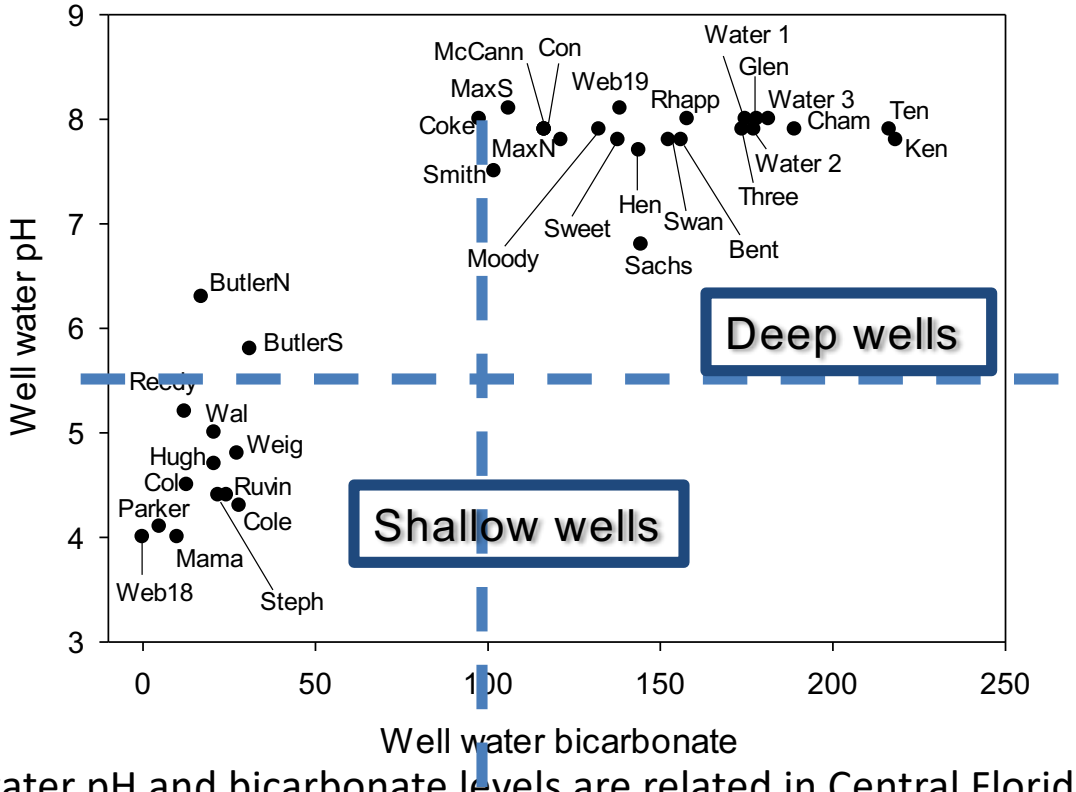
Survey of groves on Swingle and Carrizo

Data from Davis Citrus Management



Well water pH and bicarbonate levels are related in Central Florida citrus groves

J.H. Graham, 2014 survey of central Florida citrus groves for effect of bicarbonates

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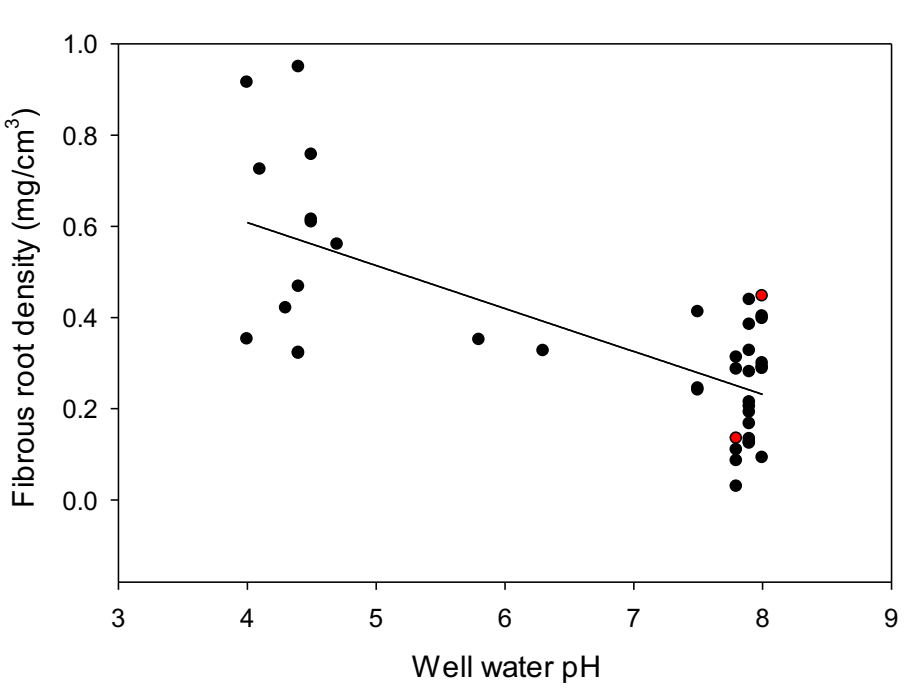
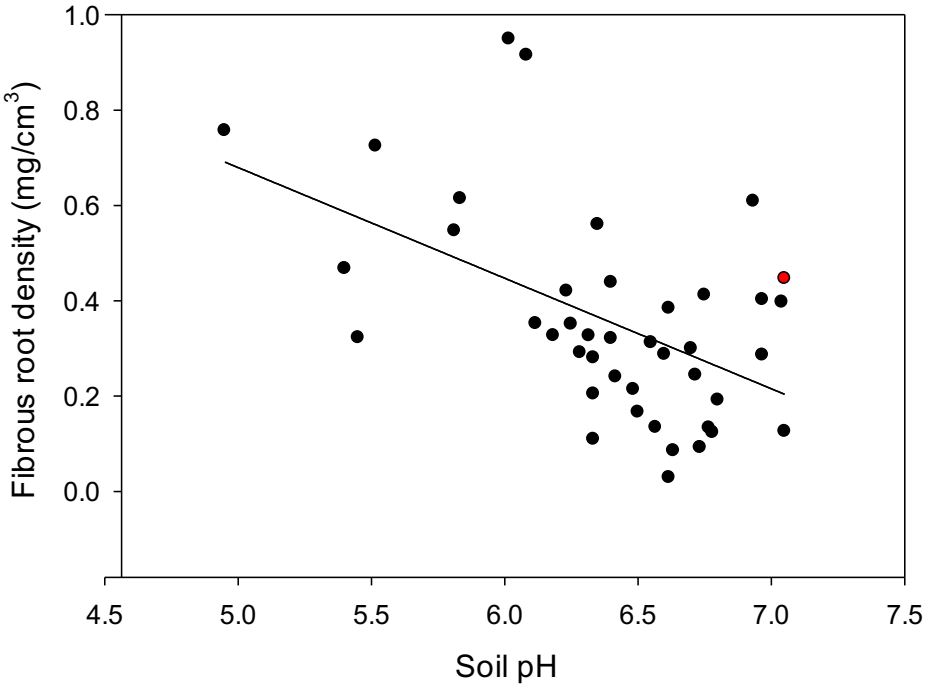
Lower Root Density is related to higher pH

Well water pH



Soil pH in the wetted zone



J.H. Graham, 2014 - 2016 survey of central Florida citrus groves for effect of bicarbonates

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Effect of soil pH on Nutrient status

- Mature Hamlin/Swingle – initial soil pH 7.3
- Irrigation water acidified for 36 months
- Soil pH range from 4.5 to 7.3
- Increased leaf Ca, Mg, Mn, and Zn with reduced soil pH
- Numeric yield increase but not significant
- May take a few years of improved leaf nutrition to improve yields

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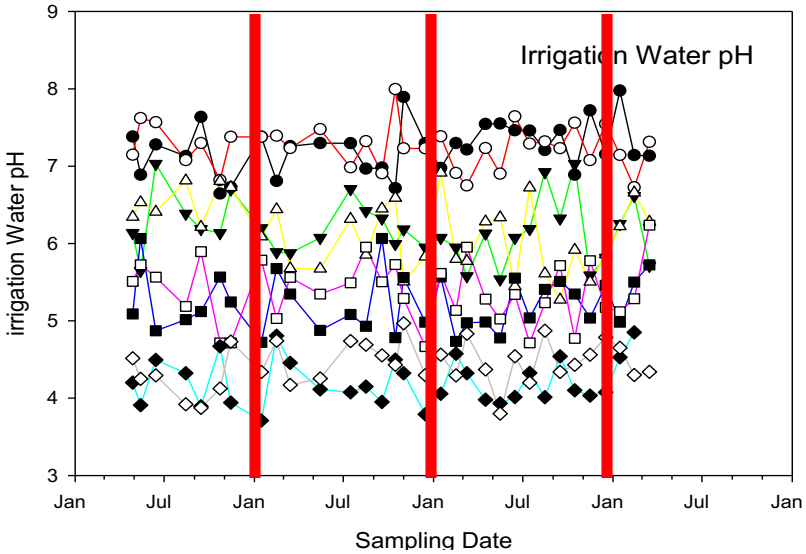
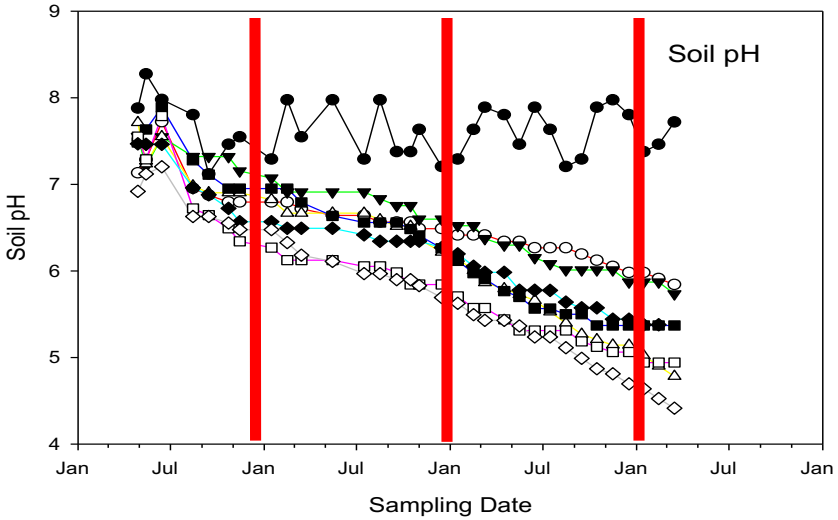
Irrigation Water and Soil pH





- Significant differences among irrigation water pH from beginning of study
- Gradual reduction in soil pH as soil bicarbonate concentrations decreased.

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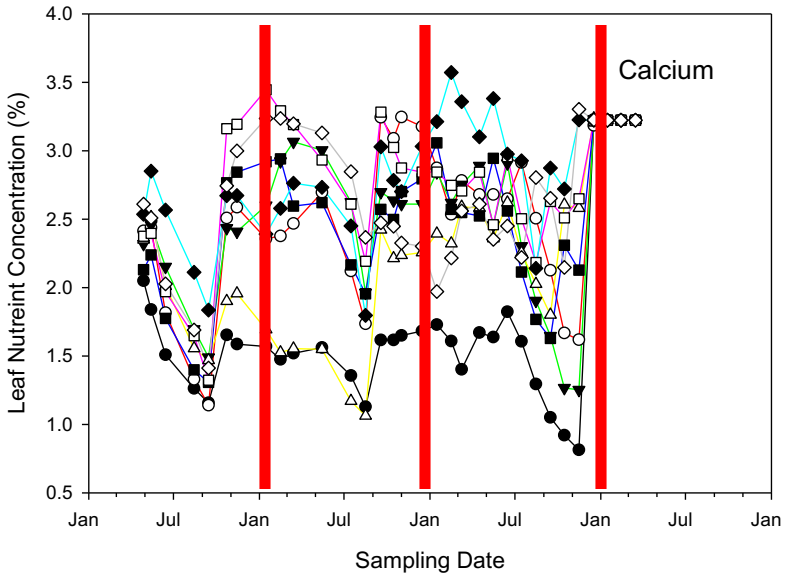
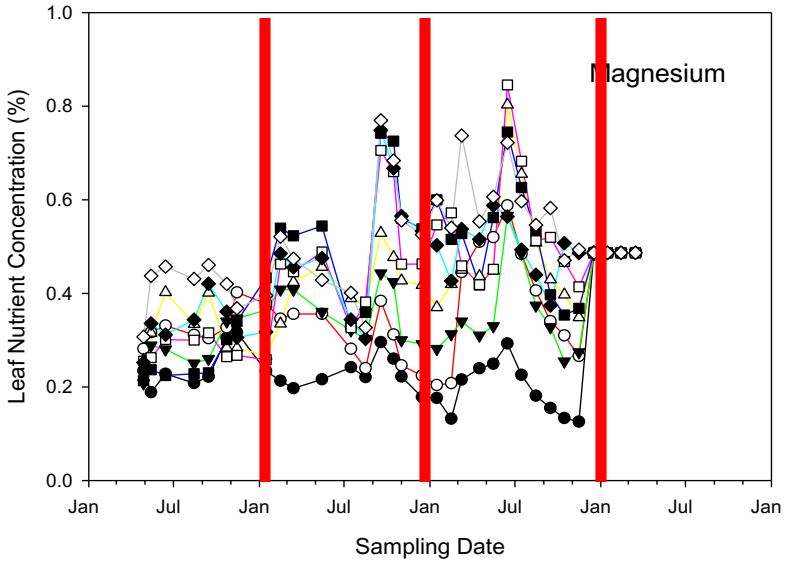
Leaf Concentrations





- No significant difference until the second year of pH moderation
- Significant higher for all pH levels compared with control
- No significant increase below pH of 5.5

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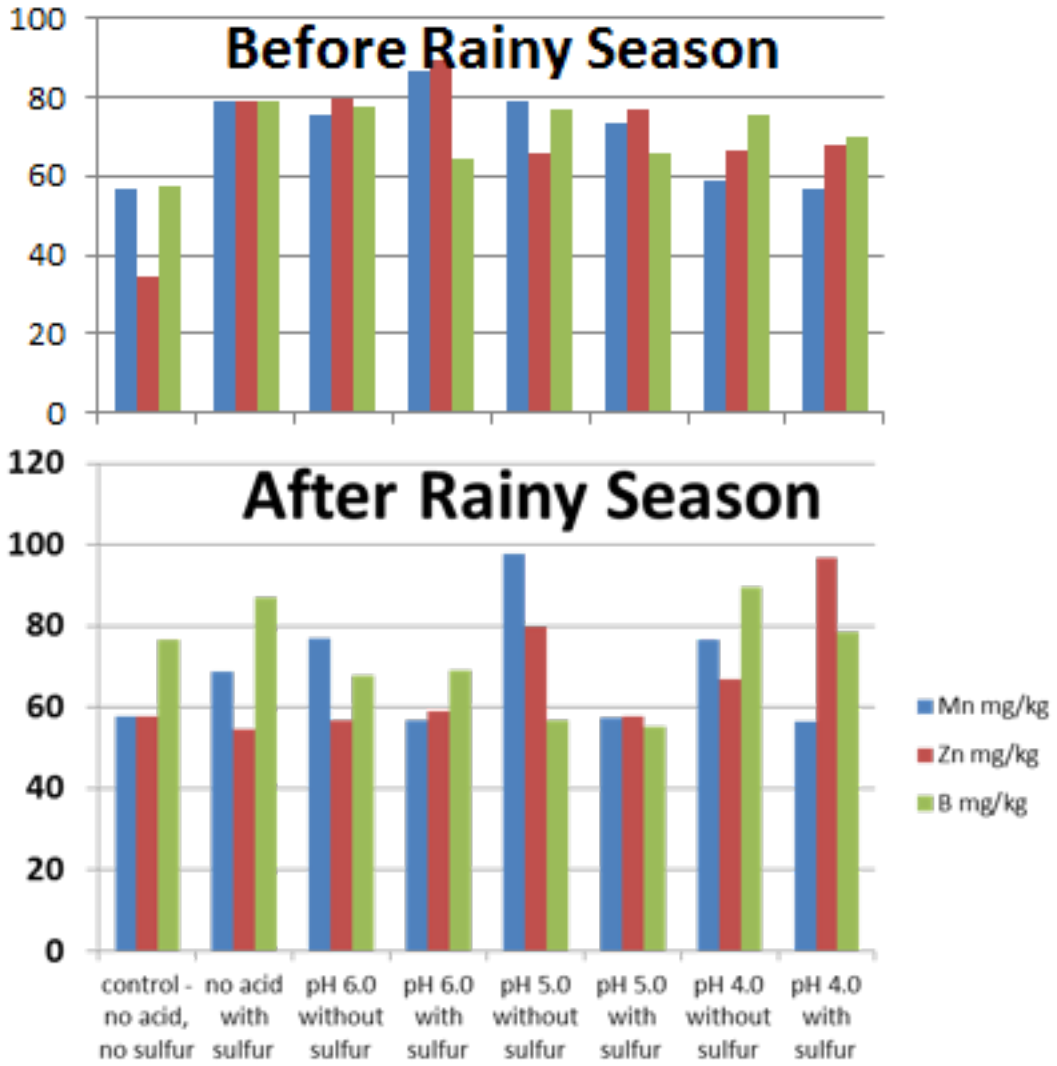
Effect of irrigation and Soil pH Moderation on Nutrient Availability



- Mn, Zn and B content of flush leaves increase prior to rainy season
- Leaf concentrations decrease after rainy season
- Because of reduced irrigation ???

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Yields

Treatment	Fruit Weight (40 representative fruit, pounds)	Fruit Yield (Boxes per tree)	Pounds Solid
Control without sulfur	19.51 D	1.57	5.23 BC
Control without sulfur	20.93 C	2.03	5.06 C
pH 6.0 with Sulfur	20.94 C	2.79	4.60 D
pH 6.0 with Sulfur	21.92 B	2.19	5.14 C
pH 5.0 without Sulfur	20.69 C	1.96	5.05 C
pH 5.0 with Sulfur	21.47 BC	1.80	5.34 ABC
pH 4.0 without sulfur	21.58 BC	1.94	5.45 AB
pH 4.0 with sulfur	23.21 A	2.55	5.53 A

Conclusions

- ✓ Soil pH affects crop plants ability to extract nutrients, including N, P, K, Mg, Ca, Mn, Zn
- ✓ Soil pH reduce plant nutrient uptake by reducing soil water nutrient solubility,
- ✓ Water and soil bicarbonates should be addressed to allow for proper nutrient uptake,
- ✓ Irrigation water acidification or application of acidifying fertilizer materials should be used to reduce soil pH in the irrigated area.

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Effect of Copper Applications on HLB Affected Citrus Trees

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Greenhouse Study on application of Copper or HLB affected trees

- A greenhouse irrigation study determined that HLB trees accumulated copper from soil when no copper sprays were applied
- Literature sources indicate that healthy can accumulate copper reducing leaf and root growth
- Study was conducted for 18 months until Hurricane Irma damaged the center greenhouse

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Greenhouse Study on application of Copper or HLB affected trees

- A greenhouse study was conducted with healthy and HLB affected trees
- Cu was applied as $Cu(OH)_2$ 3x/year over two years during active growth at 0, 0.5x, 1.0x, and 2.0x of the rate commercially recommended for suppressing *citrus canker*
- Study was conducted for 18 months until Hurricane Irma damaged the center greenhouse

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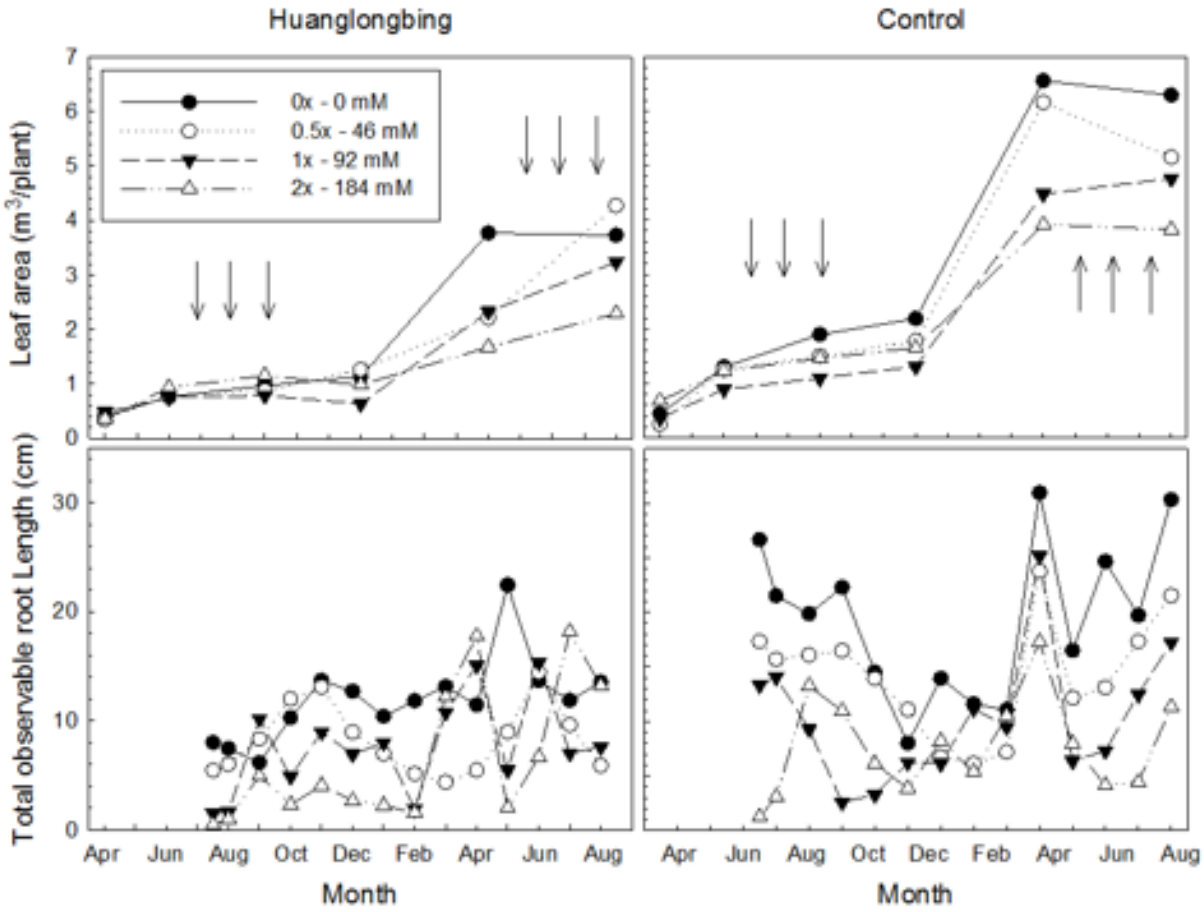
Root Area and Length

- Root area and length reduced by HLB and increased spray rates



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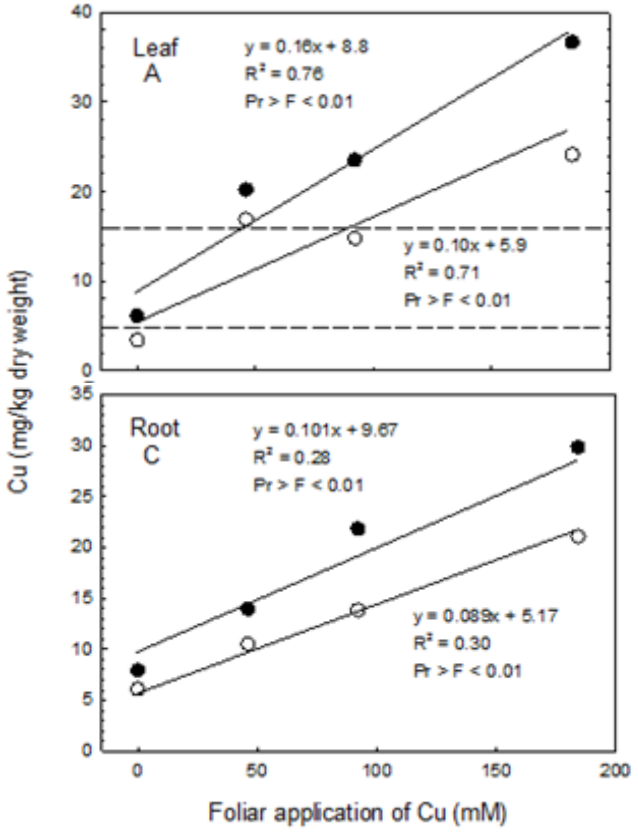
Leaf and Root Concentrations

- Leaf copper concentration above recommended levels at 0.5 X recommended spray concentrations
- Roots above leaf recommended levels at 1 X spray concentrations



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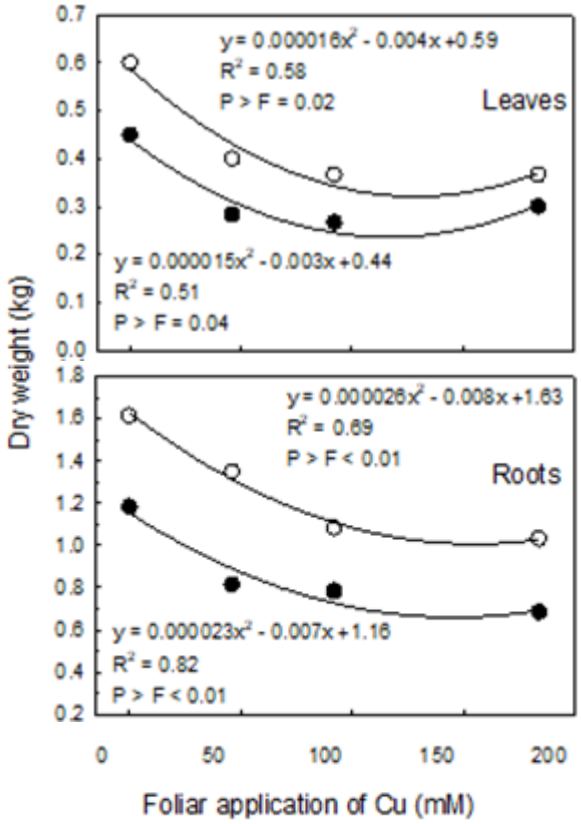
Leaf and Root Dry Weight

- Leaf and root dry weight lower at end of the study for HLB affected trees and decreased with copper application rates



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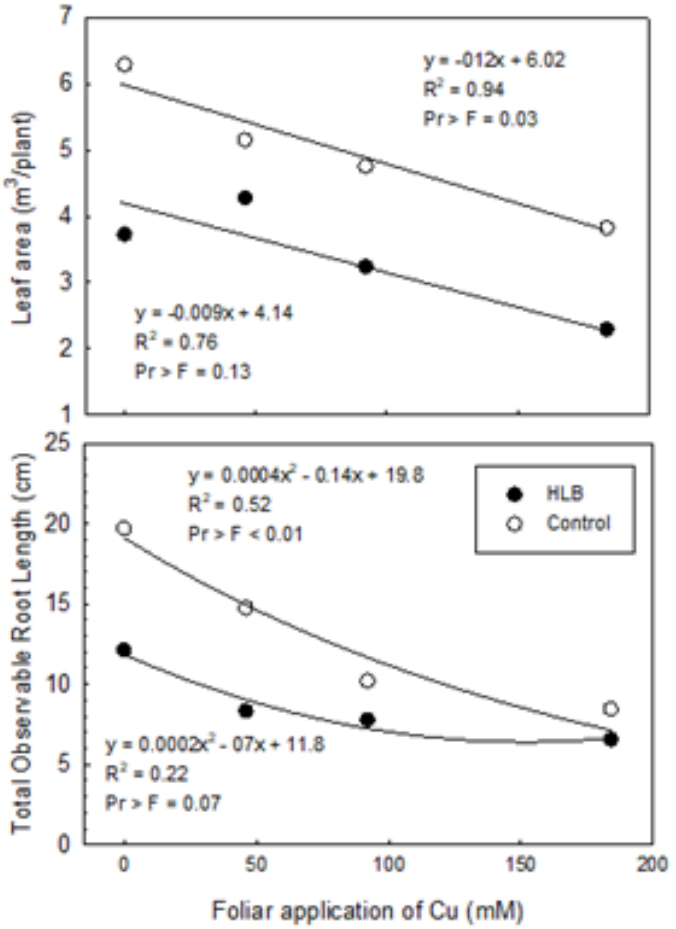
Leaf Area and Root Length

- Average leaf area and root length reduced by HLB and copper rate
- Summary: copper has negative impact on reduced growth caused by HLB. Alternative for copper should be used



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Current Citrus Nutrient Studies

- Three studies at three locations.
- Immokalee (second year), lake Alfred, and Fort Pierce.
- N rate of Flatwood oranges, Ridge oranges, East Coast grapefruit.
- Compare combinations of micronutrients (Mn, Zn, B) applied foliar only, and combination of foliar and ground applied (at two different rates).
- Determine the amount of Ca and Mg required in ground applications.

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Micro-nutrients- Second Year

- Application 3 times per year at flush
- Zero control and 3 times recommended foliar application
- Soil application of 0.0, 1.0, and 2.0 times recommended amounts 3 times per year (0.0, 3.0, and 6.0 X annual)

Treatment	Foliar	Soil	Soil Rate (lb. $acre^{-1}$)
1	None	None	0
2	1x/spray	None	0
3	1x/spray	1.0x	30
4	1x/spray	2.0x	60

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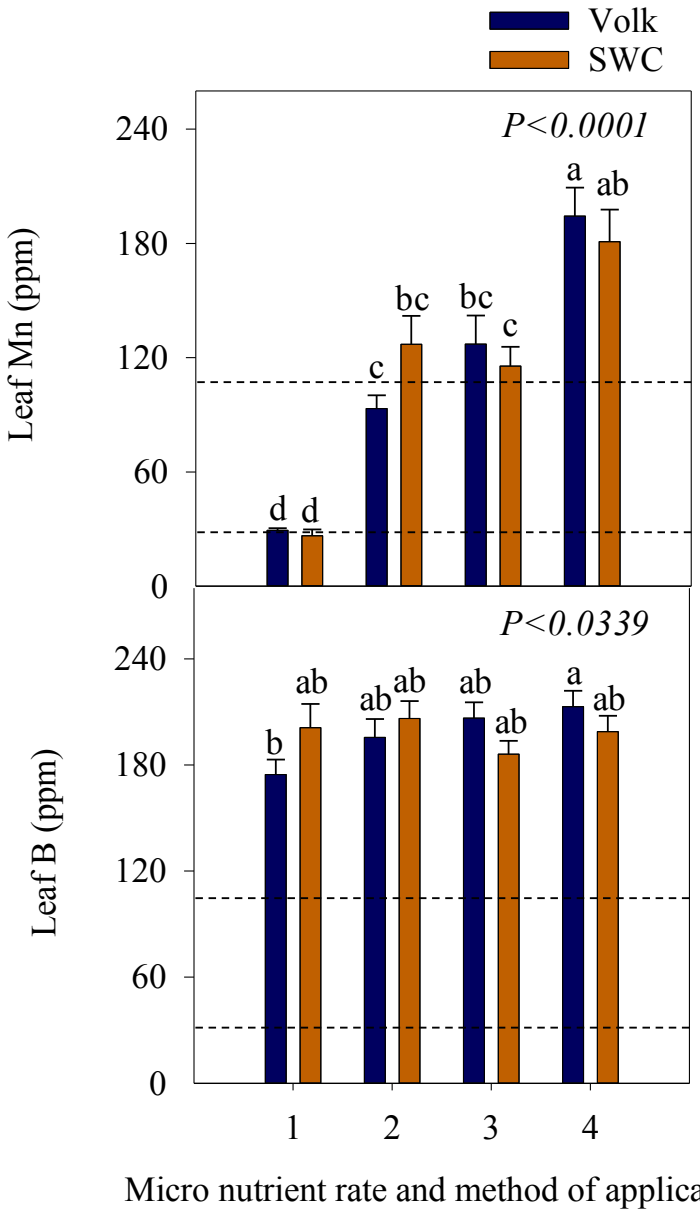
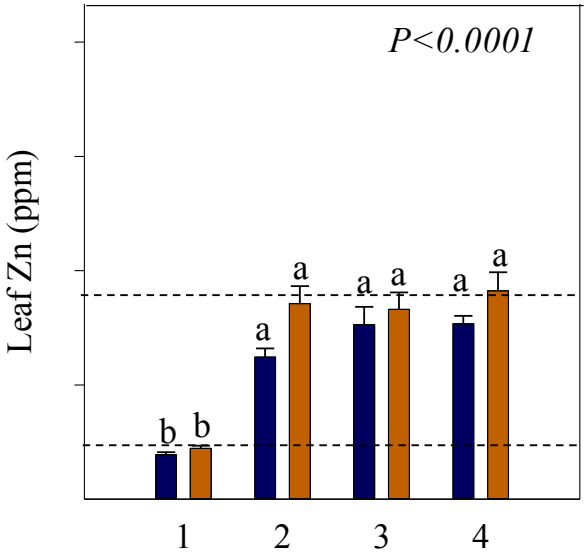
Preliminary Results: Leaf nutrient concentration





Dotted lines show optimum range for Florida citrus nutrition

- Mn: T4 > T2 = T3 > Control on Volk
- Zn: T4 = T3 = T2 > Control
- B: above the optimum range

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Secondary Macro-nutrients- First Year

- Application 3 times per year at flush
- Zero control and 1X recommended soil application
- Soil application of 0.0, 1.0 and 2.0 times recommended amounts 3 times per year (0.0, 3.0 and 6.0 X)

Treatment	Foliar	Soil	Soil Rate (lb. acre^{-1})
1	None	None	0
2	None	1X Ca	45
3	None	1x Mg	45
4	None	0.5x Ca/Mg	27.5/27.5

(IFAS recommendation = 20% of N rate)

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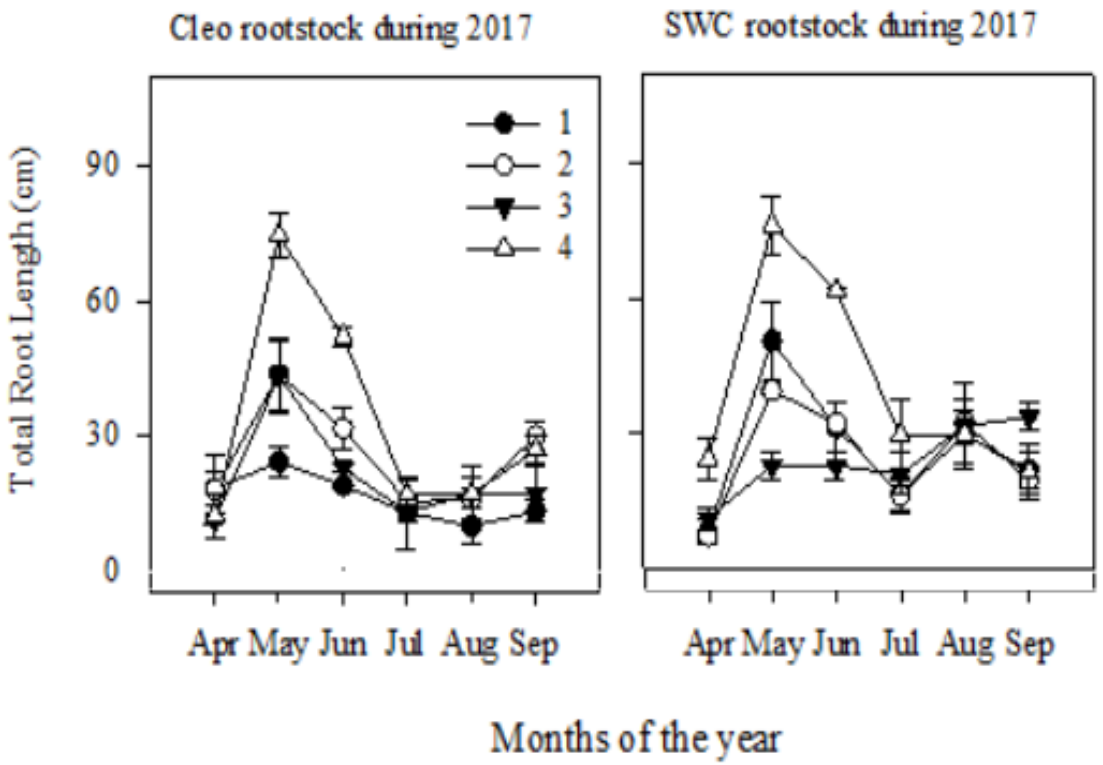
Root Length

- Increases with additions of Mg and Ca
- Additional increase with lower applications of both Mg and Ca



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Thank you for your attention

Questions

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