Updates on BMPs in Citrus

Dr. Kelly T. Morgan

Professor, Crop Nutrition

UF/IFAS Soil, Water, and Ecosystem Sciences

conserv@ufl.edu

863 289 1910

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Senate Bill 1000

- SB 1000 Nutrient Application Rates;
- Defines the terms **“certified professional”** and **“site-specific nutrient management”;**
- Authorizes citrus producers to use **written recommendations from certified professionals** to tailor their recommended nutrient application rates under certain circumstances;
- Directs the **UF/IFAS to analyze the use of site-specific nutrient management for certain crops**, **develop a research plan and certain recommendations**, and submit an annual report to the Governor and Legislature.

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Program Goals

- Goal of the project is to improve current IFAS recommendations for a wide range of commodities at multiple locations on a state-wide basis.
- The program started with tomato and potato by calibration of the Mehlich 3 phosphorus soil test and testing of current rate recommendations for a two-year period.
- Recommendations for additional crops will be evaluated in future years if funding continues.

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Artificial Intelligence

- An artificial intelligence team has been formed in Gainesville made up of faculty and students.
- The team will collect data from the field teams and other sources (including past research projects) to determine ways of improving the project.
- Relationships between Mehlich 3 calibration, soil characteristics, and other soil test results will be used to determine better fertilizer recommendations.
- Data Analysis of multiple data streams to evaluate current and future recommendations.

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Current and Future Activities

- The work will continue with current funding on tomato and potato to June 2023.
- Fertilizer rate studies on Citrus, snap bean, and corn started in 2022/23.
- Additional legislative support will be requested to continue the project through June 2024.
- A five-year plan has been developed for 2023 – 2028 with additional crops added to the studies starting in 2024 if funded.

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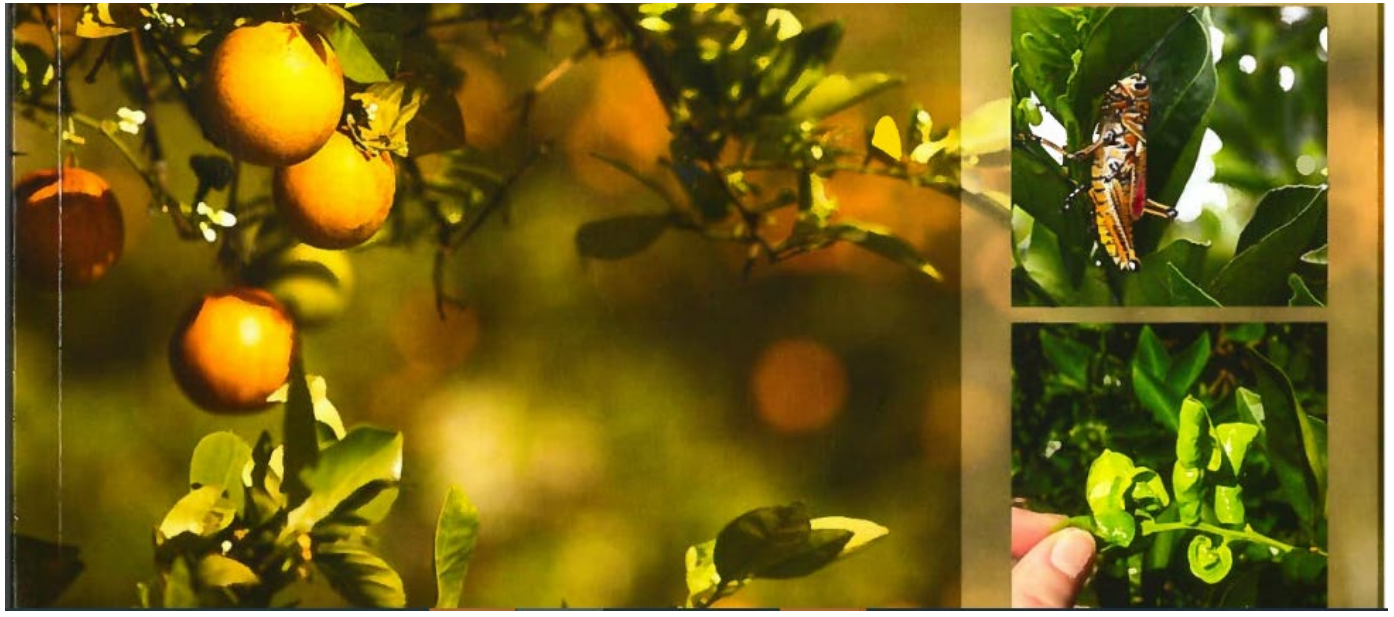
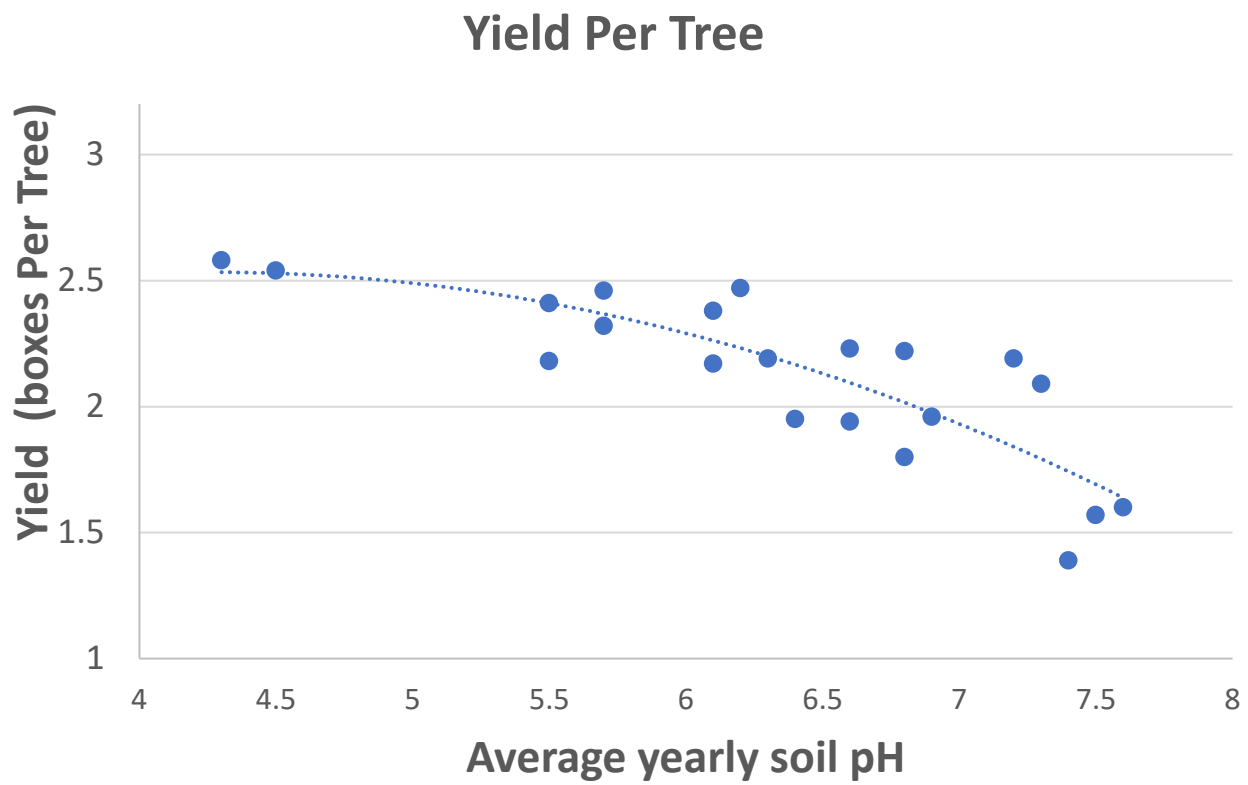
Nutrient Recommendation Updates



Effect of soil pH on Yield



- Yield per tree increases with average yearly soil pH.
- No significant increase in yield below soil pH of 6.0
- Recommendation – monitor soil pH and adjust to 6.0 – 6.5 as needed

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

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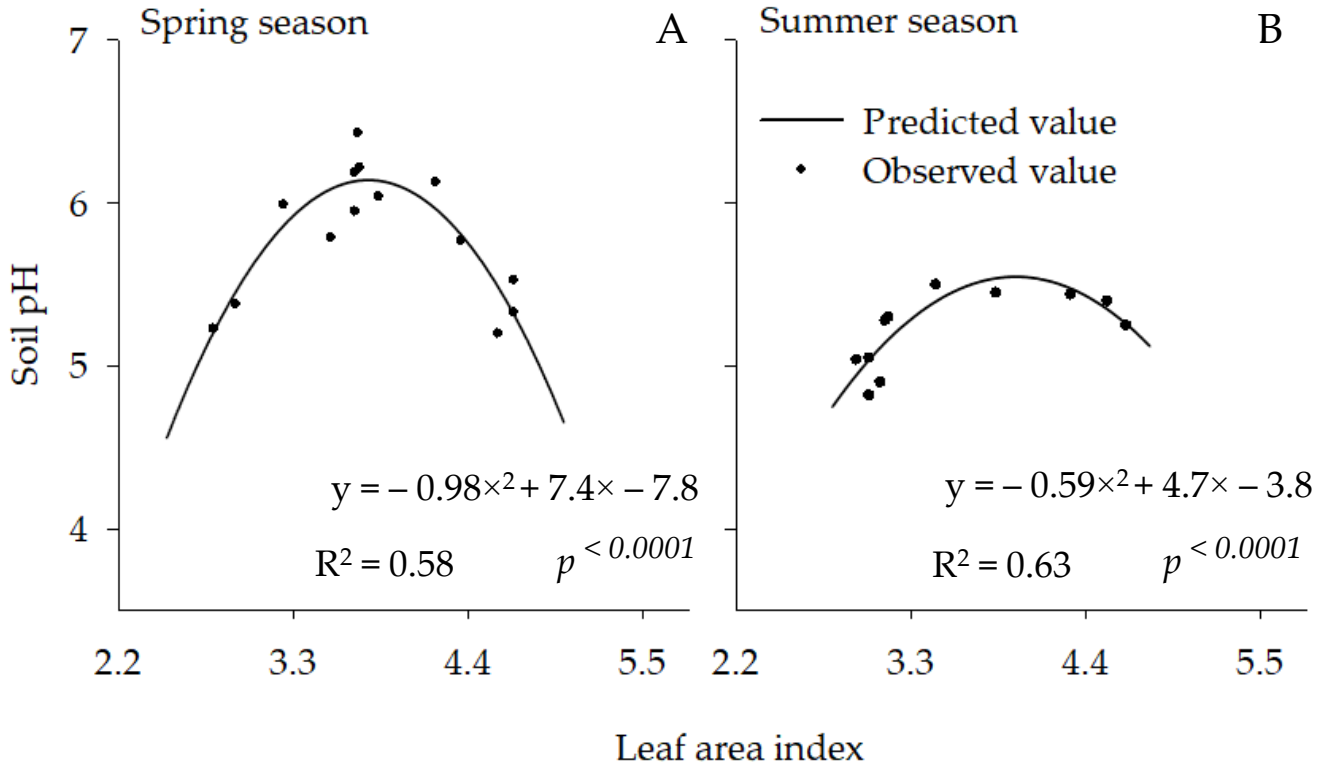
Soil pH Effects on Nutrient Uptake



- HLB symptoms worsen in groves with well water containing dissolved bicarbonates.
- High pH reduces availability of Ca, Mg, Fe, Zn, and Mn in groves with high bicarbonate levels.
- Feeder root density reducing nutrient uptake.
- Soil pH should be maintained in pH 6.0–6.5 range.

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Current Nitrogen Recommendation Found in SL 253

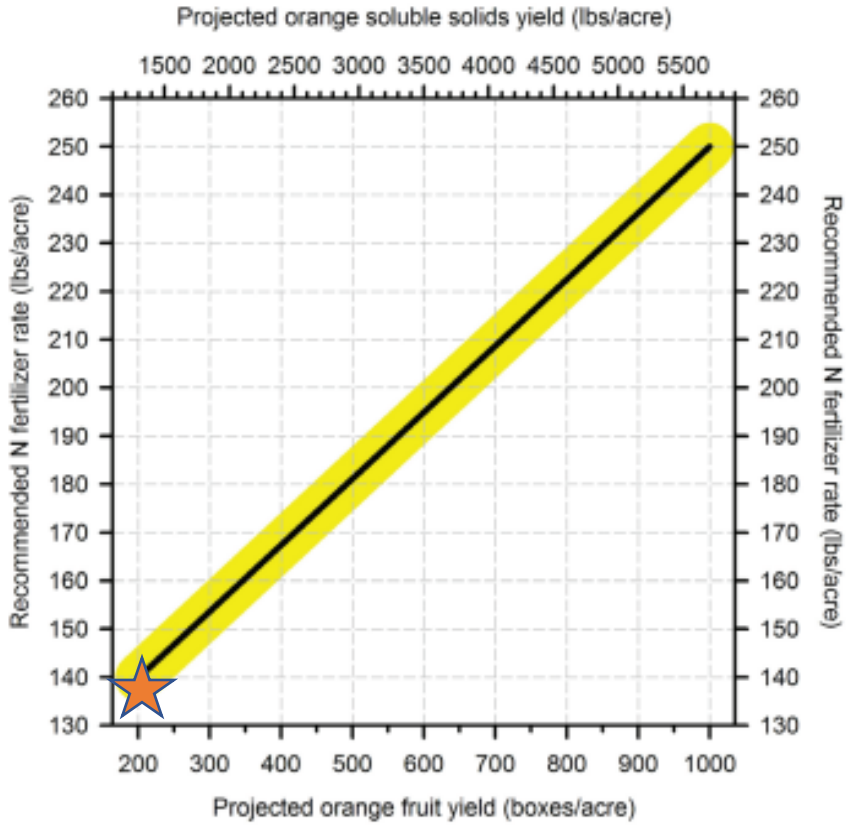

Figure 3. Production-based N fertilizer rate recommendations for Florida oranges. Find the expected yield potential (8-to-11-year-old trees) or 4-year running average production (trees 12 years or older) on the x-axis, move up or down to the straight line, and find the recommended N rate range on the y-axis.

★ Florida orange production 2020-2022, Citrus Fruits 2022 Summary

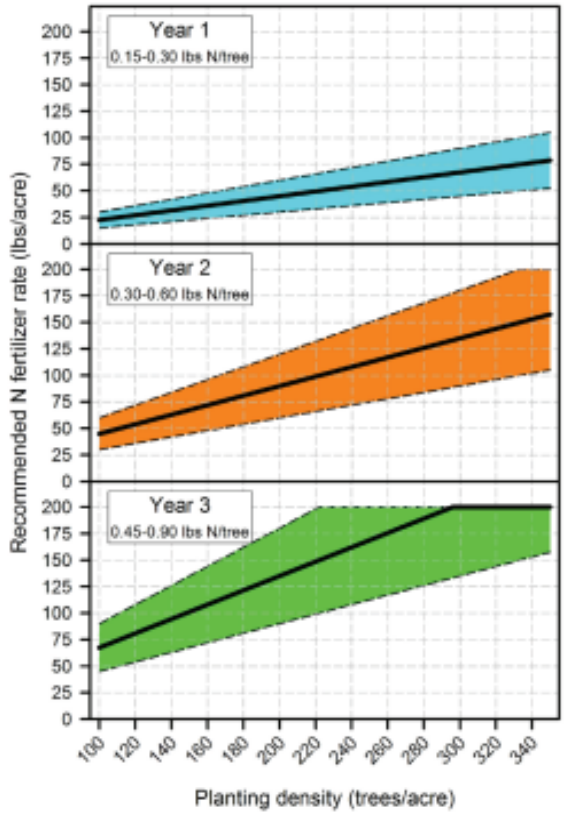

Figure 1. Recommended N rates for nonbearing citrus trees on a **per-acre** basis as a function of planting density. To determine the per-acre rate, find the planting density on the x-axis, move up into th band, and find the recommended N rate range on the y-axis

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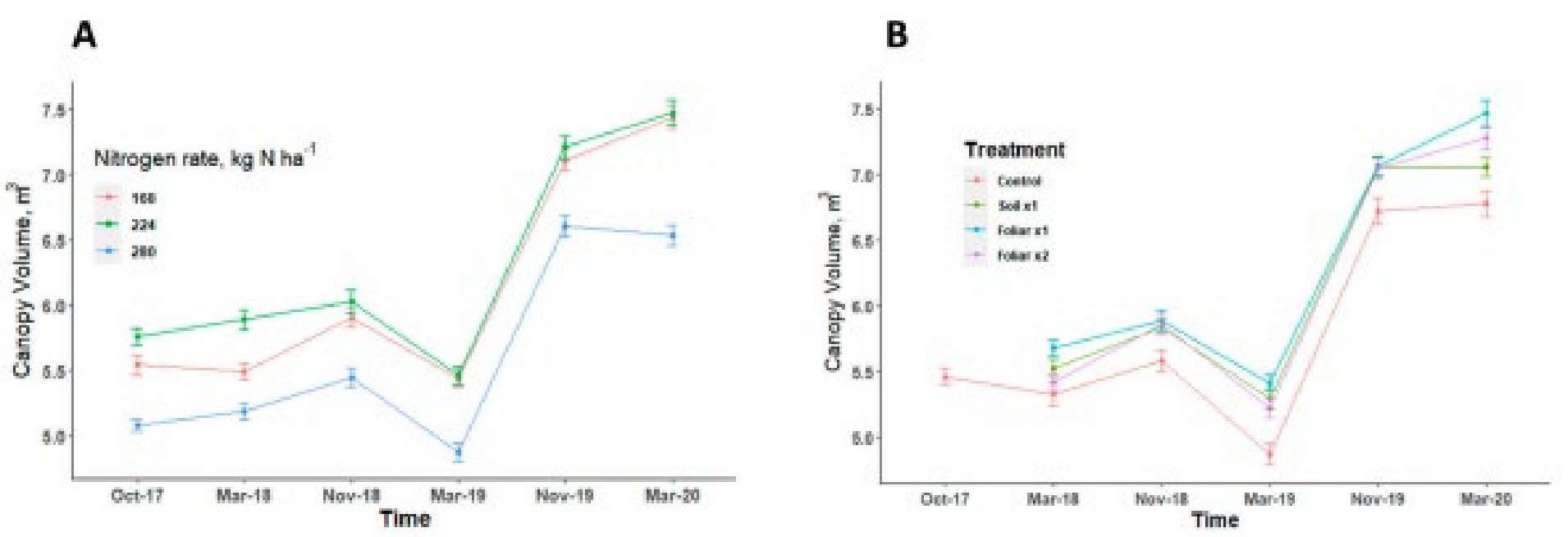
Effect of Nitrogen Rate on Citrus Tree Growth



Comparative Response of Huanglongbing-Affected Sweet Orange Trees to Nitrogen and Zinc Fertilzation under Microsprinkler Irrigation
Uthman, QO, DM Kadyampakeni, P Nkedi-Kizza, N. Barlas, Aatta, K.T. Morgan

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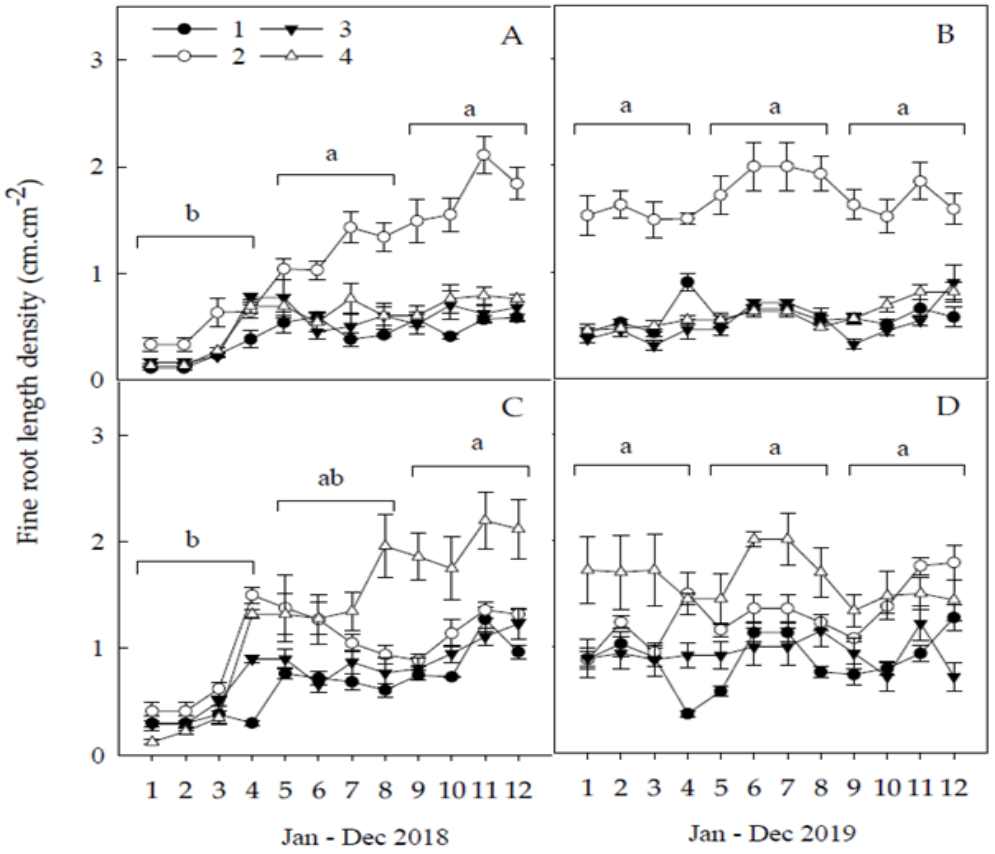
Fine Root Density Response



1 = control
2 = Ca only
3 = Mg only
4 – Ca + Mg

- **Initial soil pH of 6.7 – recommendation – no Ca or Mg application**
- **Consistent significant increase in fine root density with Ca application**
- **No increase in root density with application of Mg**

Figure 1. Root length density dynamics of citrus tree cv. Hamlin budded on Cleo (**A**,**B**) or Swc rootstocks (**C**,**D**) during spring (Jan.–May), summer (Jun.–Sep.), and fall (Oct.–Dec.) of 2018 and 2019 growing seasons. Treatments: untreated Control (1), full Ca dose (2), full Mg dose (3), and half Ca and half Mg doses (4), (full dose = 45 kg ha^{-1}). The average seasonal FRLD are the mean values of (n = 8 trees) ± standard error of the mean (SEM).

Atta, A. A., Morgan, K. T., & Mahmoud, K. A. (2021b). Split application of nutrients improve growth and yield of Huanglongbing-affected citrus trees. *Soil Science Society of America Journal*, 85(6), 1–14. https://doi.org/10.1002/saj2.20310

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Canopy Volume Response

TABLE 4 Tree canopy volume and ANOVA table showing a level of significance (p values) in response to rootstock, N, and secondary macronutrient application of HLB-affected 'Hamlin' citrus trees budded on Cleopatra (Cleo) or Swingle (Swc) rootstocks trees near Immokalee, FL, during 2017–2019 growing seasons

	Tree canopy volume											
	2017				2018				2019			
Macro[a]	Cleo	Swc	Cleo	Swc	Cleo	Swc	Cleo	Swc	Cleo	Swc	Cleo	Swc
	m^3											
Control	17.1	12.6	16.3	12.4	15.8	11.8	16.9	13.3	22.6b[c]	15.2	23.7b	15.9b
Ca	19.0	11.5	14.4	11.0	15.3	13.2	16.0	13.9	25.1ab	18.3	26.9ab	19.4ab
Mg	18.2	12.8	17.0	13.4	16.6	12.8	17.4	13.5	26.8a	18.9	29.8a	20.1ab
Ca + Mg	18.8	11.4	17.1	12.8	17.0	13.6	17.8	14.3	26.7a	18.7	29.1a	20.6a
Significance	NS†	NS	NS	NS	NS	NS	NS	NS	*	NS	**	*
	ANOVA											
Effect[c]												
R		**		***		**		***		***		***
S		NS		NS		NS		NS		**		**
R × N		**		***		**		*		NS		NS

[a]Secondary macronutrients: control; full Ca dose (Ca); full Mg dose (Mg); and half Ca and half Mg doses each (Ca + Mg; full dose, 45 kg ha^{-1}).

[b]Means on a vertical column followed with different letters are significant at $p \leq .05$ probability level, based on the Tukey–Kramer honestly significant difference test ($n = 12$ trees).

[c]R = rootstock, N = nitrogen rate, and S = secondary macronutrients.

*Significant at the .05 probability level.

**Significant at the .01 probability level.

***Significant at the .001 probability level. †NS, nonsignificant.

- **Significant increase in canopy volume for trees on both rootstocks in third year**
- **Consistently highest canopy volume increase with application of both Ca and Mg**

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Yield and Juice Quality Response

TABLE 5 Fruit yield, juice content, and ANOVA table showing a level of significance (p values) in response to rootstock, N, and secondary macronutrient application under HLB-affected 'Hamlin' citrus trees budded on Cleopatra (Cleo) or Swingle (Swc) rootstocks trees near Immokalee, FL, during 2017 and 2018 growing seasons

Year	Macro[b]	Fruit yield		Fruit drop		Total fruit[a]		Fruit weight		Fruit juice	
		Cleo	Swc	Cleo	Swc	Cleo	Swc	Cleo	Swc	Cleo	Swc
		kg tree^{-1}						g fruit^{-1}		%	
2018	Control	23.9[c]	20.6	12.1	9.0	36.0	29.6	137.3	173.3b	61.5	58.5
	Ca	24.4	22.0	12.8	7.9	37.2	29.9	141.3	183.5ab	61.5	58.6
	Mg	28.0	19.3	16.4	9.7	44.4	29.0	142.5	197.8a	60.9	59.9
	Ca + Mg	29.3	22.1	12.4	8.5	41.7	30.5	134.2	187.6ab	59.9	57.9
	Significance	NS†	NS	NS	NS	NS	NS	NS	*	NS	NS
		2019									
2019	Control	36.9b	35.1	28.0	21.4	64.9b	56.5	149.4	142.4	54.6	59.8
	Ca	59.7a	36.6	26.3	18.0	86.0a	54.6	143.8	137.4	60.1	54.2
	Mg	58.8ab	36.6	27.0	18.9	85.9a	55.6	151.1	137.9	58.5	55.4
	Ca + Mg	63.0a	36.6	32.6	20.5	95.6a	57.1	146.8	141.5	61.4	56.8
	Significance	*	NS	NS	NS	**	NS	NS	NS	NS	NS
	Effects[d]					ANOVA					
2019	R	***		***		***		*		*	
	S	*		NS		*		NS		NS	
	R × S	NS		NS		*		NS		NS	
	R × N	NS		*		NS		NS		NS	

[a]Total fruit weight indicates the sum of marketable and preharvest fruit drop of the harvest year.
[b]Secondary macronutrients: control; full Ca dose (Ca); full Mg dose (Mg); and half Ca and half Mg doses each (Ca + Mg; full dose, 45 kg ha^{-1}).
[c]Means on a vertical column followed with different letters are significant at $p \leq .05$ probability level, based on the Tukey–Kramer honestly significant difference test.
[d]R, rootstock; N, nitrogen rate; S, secondary macronutrients.
*Significant at the .05 probability level.
**Significant at the .01 probability level.
***Significant at the .001 probability level. †NS, nonsignificant.

- **Significant increase in fruit yield and total fruit for trees on Cleopatra rootstock with application of Ca, Mg and Ca+Mg in third year**
- **Largest increase in yield and total yield with application of Ca and Ca+Mg**

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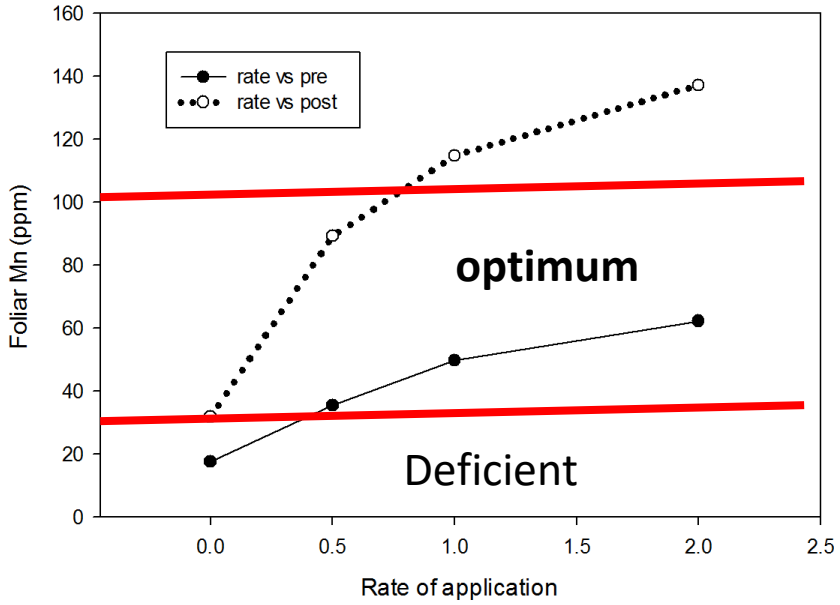
Effect of Sprays on New Growth

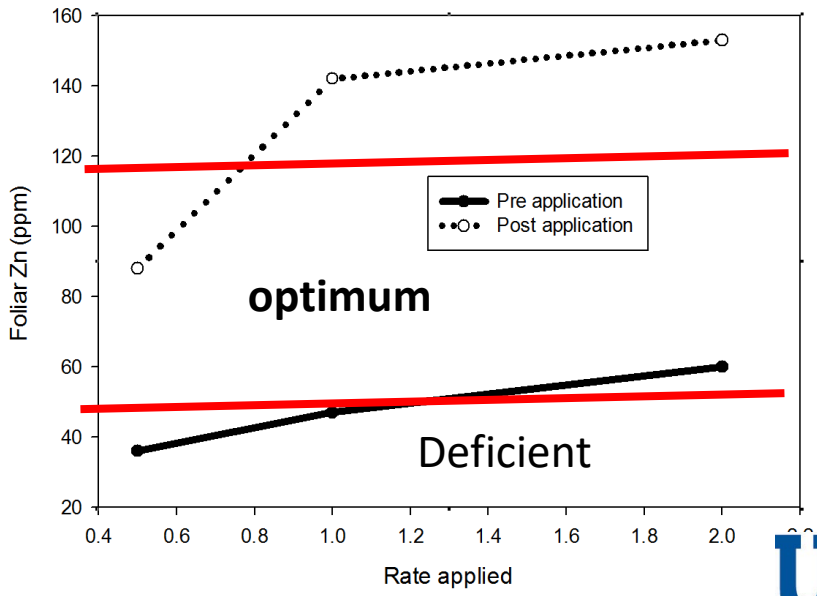
- **Leaf Mn and Zn were lower in Tissue of trees receiving Mn or Zn prior to foliar sprays but increased after spray application at all 3 rates**

Annual Rate 0 1.5 3.0 6.0

Annual Rate
X IFAS 5 lb/ac
recommendation



1.5 3.0 6.0



Morgan, K. T., Rouse, R. E., & Ebel, R. C. (2016). Foliar applications of essential nutrients on growth and yield of 'valencia' sweet orange infected with huanglongbing. *HortScience*, *51*(12), 1482–1493. https://doi.org/10.21273/HORTSCI11026-16

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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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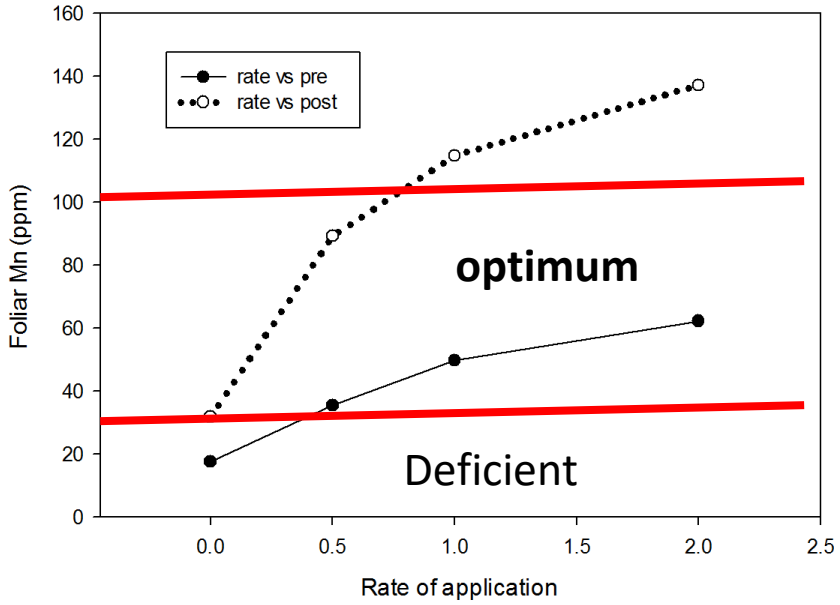
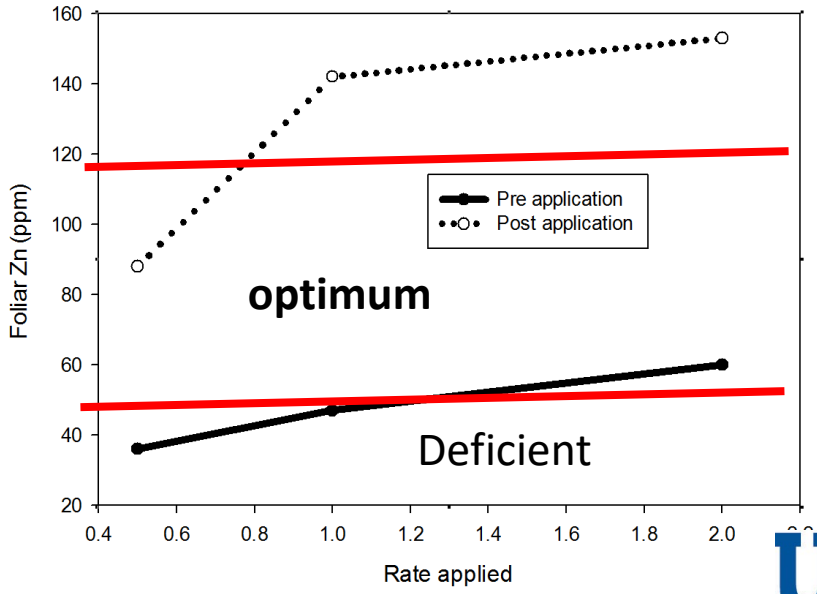
Effect of Sprays on New Growth

- Leaf Mn and Zn were lower in Tissue of trees receiving Mn or Zn prior to foliar sprays but increased after spray application at all 3 rates

Annual Rate 0 1.5 3.0 6.0



1.5 3.0 6.0



Annual Rate
X IFAS 5 lb/ac
recommendation

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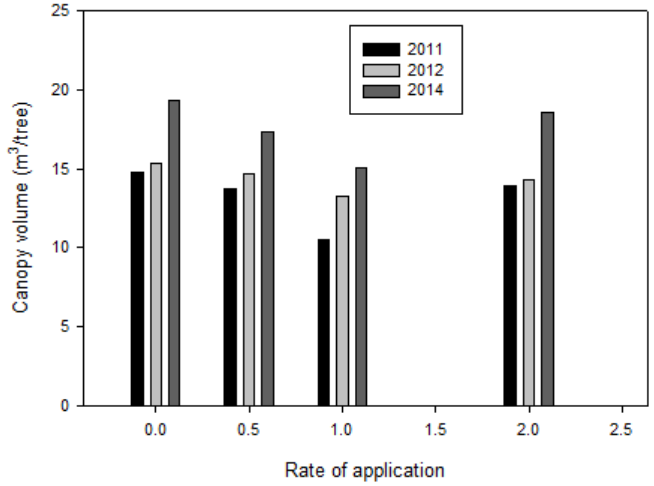
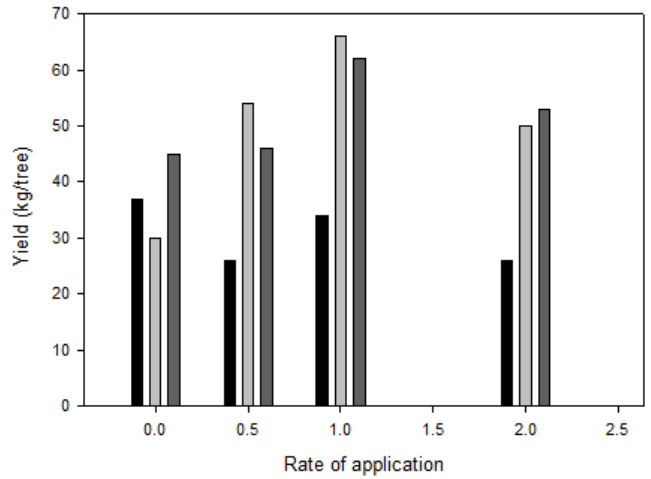
Effect of Leaf Nutrient Concentrations on Tree Growth and Yield

Annual Rate 0 1.5 3.0 6.0





- Similar trends for both Mn and Zn
- Slight but significantly lower canopy volume at 1X
- Generally increasing yield with increased rate to 1X but lower at 2X

Annual Rate
X IFAS 5 lb/ac
recommendation

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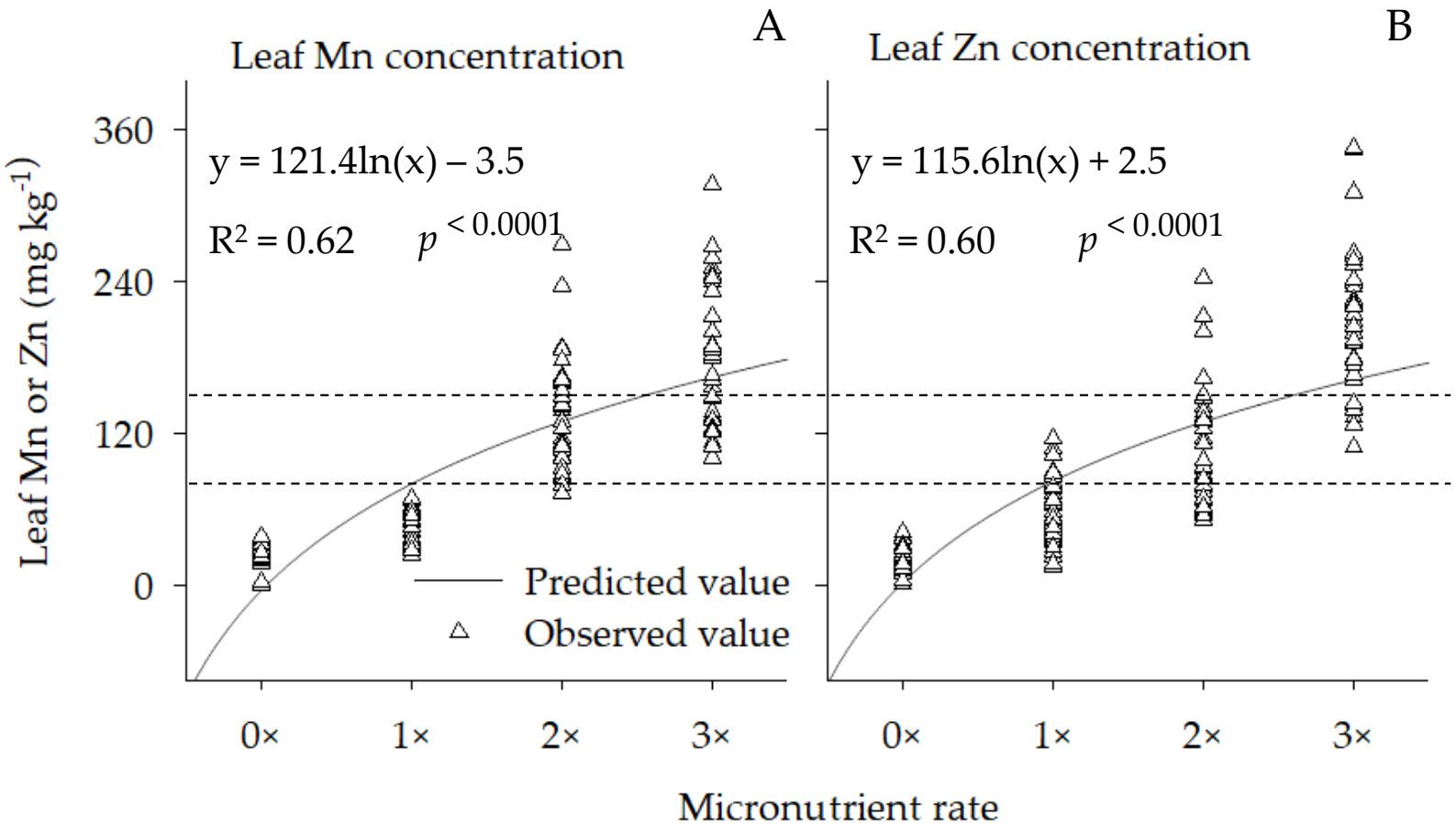
Foliar Micronutrients Sprays improved Leaf Content



0x = control
1x = foliar only
2x = 1 foliar + 1 ground
3x = 1 foliar + 2 ground

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Effect Mn and Zn Rate on Leaf Area

Leaf area index

	2019			2020			2021		
Micro [z]	168	224	280	168	224	280	168	224	280
0×	3.1 [y]	3.9 a	3.5 ab	3.7	3.7 b	3.2 c	3.0	3.1 a	3.3 a
1×	4.0	4.1 a	3.7 ab	4.4	4.5 a	4.0 ab	3.0	3.0 ab	3.3 ab
2×	4.0	4.0 a	4.1 a	4.1	4.2 a	4.0 a	3.2	3.0 ab	3.1 ab
3×	2.6	2.3 b	2.9 b	3.6	3.4 b	3.4 c	3.0	2.7 b	2.3 b
p-value	0.374	0.0001	0.0101	0.228	0.0082	0.0086	0.1276	0.0361	0.0211

0x = control
1x = foliar only
2x = 1 foliar + 1 ground
3x = 1 foliar + 2 ground

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Effect of Mn and Zn Rate on Canopy Volume

Canopy volume (m^3)

	2019			2020			2021		
Micro [z]	168	224	280	168	224	280	168	224	280
0×	18.2 [y]	19.9	18.2 b	22.0	22.4	20.4 b	20.3	21.1	19.7 b
1×	21.4	21.7	17.5 b	24.3	21.5	21.5 b	24.9	23.5	20.1 b
2×	22.5	20.6	24.9 a	24.5	22.8	26.2 a	24.7	21.5	25.9 a
3×	17.9	21.1	19.7 b	22.5	25.9	21.2 b	24.9	24.3	19.5 b
p-value	0.199	0.905	<.0001	0.887	0.602	0.0064	0.703	0.384	0.0008

0x = control
1x = foliar only
2x = 1 foliar + 1 ground
3x = 1 foliar + 2 ground

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Suggested Changes to Current IFAS Recommendations

Approved Ca and Mg changes

- Currently, IFAS has no set recommendations for Ca or Mg other than pH maintenance
- Recommendations should be set at 40 lb ac^{-1} yr^{-1} for HLB affected trees.

Approved Micronutrient changes

- Increase foliar Mn and Zn from 3-5 lb ac^{-1} yr^{-1} to 15 lb ac^{-1} yr^{-1}
- Increase soil Mn and Zn from 7-10 lb ac^{-1} yr^{-1} to 20 - 25 lb ac^{-1} yr^{-1}
- Leave current B rate at 0.25 lb ac^{-1} yr^{-1}

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Conclusions

- Nutrient management has always been a priority for IFAS.
- The current administration has elevated that priority by seeking legislature funding for a project that could become key component to IFAS programs.
- Improved fertilizer recommendations, including citrus will be an outcome of these efforts.
- pH, Ca, Mg, Mn, and Zn have been approved for HLB affected citrus trees.
- N and P fertilizer recommendation changes will be addressed in the next few years.

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