

# Managing Macro and Micronutrients for Sustaining Citrus Productivity in the HLB-Era

**Davie Kadyampakeni**

**Assistant Professor**

**Citrus Research and Education Center,**

**700 Experiment Station Rd, Lake Alfred, FL33850**

**Email: [dkadyampakeni@ufl.edu](mailto:dkadyampakeni@ufl.edu)**

**October 23, 2019**

# OUTLINE

- **Roles of nutrients in improving plant health**
- **4Rs in citrus nutrient management**
- **A description of soil orders of Florida**
- **Macronutrients - Lessons from the field research**
- **Micronutrients - Therapeutic effects**
- **Take home message**

# ROLES OF NUTRIENTS IN IMPROVING PLANT HEALTH

**Liebig's Law of the minimum:** The Law of the Minimum, made by Justus von Liebig, describes how plant growth is constrained by resource limitation. Plants need many nutrients to grow well. If only one of these nutrients is deficient, plant growth will be inhibited, even if all the other essential nutrients are available in abundance. This is also true for all other resources such as light, temperature and water for the respective plant species. **The scarcest resource always restricts plant growth and therefore is referred to as the limiting factor!!**

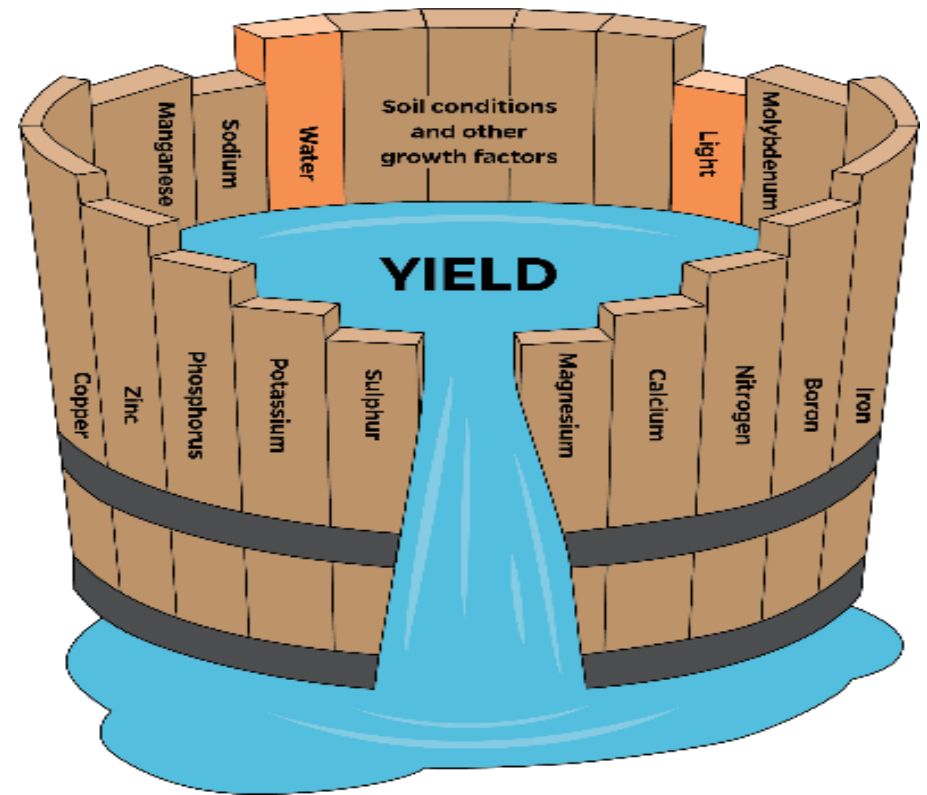


Figure 1. Liebig's Law of Minimum illustrated for plant growth and nutrition with a leaking barrel. Credit UF/IFAS Communications

# ROLES OF NUTRIENTS-MACRONUTRIENTS

**Nitrogen:** Vegetative growth, metabolism, flowering and fruit yield

**Potassium:** Physiological functions, fruit formation and enhances fruit size, flavor, and color.

**Phosphorus:** Photosynthesis, synthesis, and breakdown of carbohydrates, and the transfer of energy within the plant. Phosphorus is involved in nutrient uptake and translocation.



# ROLES OF NUTRIENTS-MACRONUTRIENTS

**Calcium:** Involved in cell division and cell elongation, is an important constituent of cell walls, and plays a major role in cell membrane integrity. It is an important element for root development and functioning. Root growth is severely restricted in Ca-deficient plants.

**Magnesium:** Involved in photosynthesis, and it plays an important role as an activator of several enzymes.

**Sulfur:** Essential constituent of many proteins, vitamins, and some plant hormones.

# ROLES OF NUTRIENTS-MICRONUTRIENTS

**Manganese:** Involved in the production of amino acids and proteins, An activator of several enzymes, Plays an essential role in respiration and nitrogen metabolism, Plays a role in photosynthesis and in the formation of chlorophyll

**Iron:** Catalyzes the production of chlorophyll, Involved in some respiratory and photosynthetic enzyme systems

**Zinc:** Involved in several enzyme systems that regulate various metabolic activities within plants

# ROLES OF NUTRIENTS-MICRONUTRIENTS

**Molybdenum:** Assists in the formation of plant proteins, Helps starch, amino acid, and vitamin formation; Acts as a catalyst that aids the conversion of gaseous N to usable forms by nitrogen-fixing microorganisms

**Boron:** Plays a key role in plant physiological and biochemical processes.

**Copper:** Fruit formation and vegetative growth; plant defense against bacterial infection.

# 4 RS OF NUTRIENT MANAGEMENT

	Source	Rate	Time	Place
Examples of scientific principles	<ul style="list-style-type: none"><li>• Ensure balanced supply of nutrients</li><li>• Suit soil properties</li></ul>	<ul style="list-style-type: none"><li>• Assess nutrient supply from all sources (check fertilizer label and note what's available or missing)</li><li>• Assess plant demand (e.g. look at tree size, blooming, flushing or fruit loading)</li></ul>	<ul style="list-style-type: none"><li>• Assess dynamics of crop uptake and soil supply (do a leaf and soil test to determine when and how much fertilizer to add)</li><li>• Determine timing of loss risk (avoid fertilization during rains)</li></ul>	<p>Recognize crop rooting patterns (for citrus, 70% of roots are in the top 12 inch)</p> <p>Manage spatial variability by randomly sampling soil and tissue samples across blocks</p>



# 4 RS OF NUTRIENT MANAGEMENT (2)

	Source	Rate	Time	Place
Examples of practical applications	<ul style="list-style-type: none"><li>• Commercial fertilizer</li><li>• Livestock manure</li><li>• Crop residue</li></ul>	<ul style="list-style-type: none"><li>• Test soils for nutrients</li><li>• Calculate economics to check costs and benefits</li><li>• Balance crop removal</li></ul>	<ul style="list-style-type: none"><li>• Pre-plant</li><li>• At planting or active vegetative growth</li><li>• At flowering</li><li>• At fruiting</li></ul>	<ul style="list-style-type: none"><li>• Fertigation</li><li>• Spreader or broadcast</li><li>• Variable rate application (GIS based on nutrient requirements by block)</li></ul>

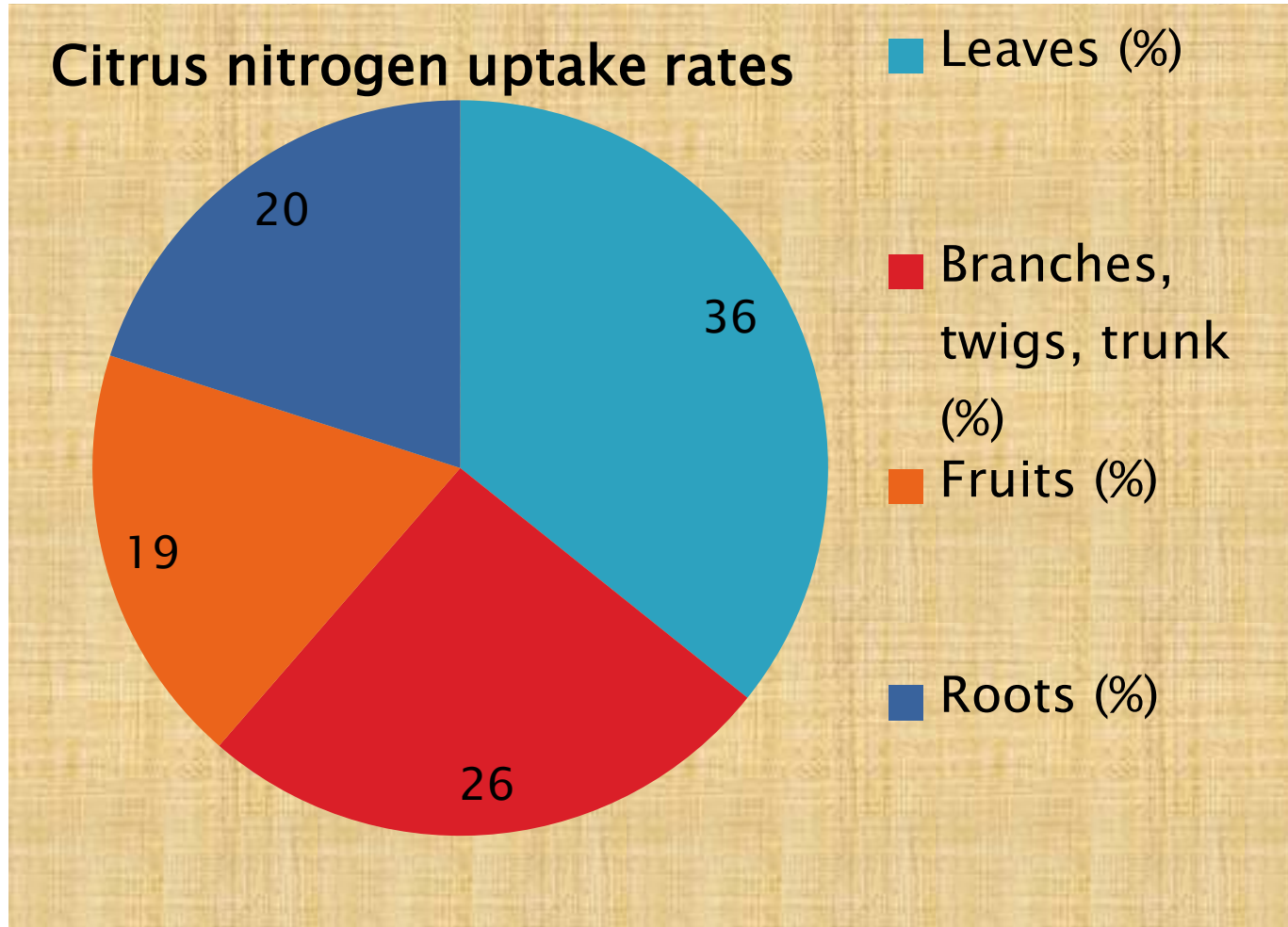
# SOIL PHYSICAL & CHEMICAL CHARACTERISTICS

Typical root zone soil physical and chemical properties for common soil orders found in Florida citrus groves (Source: Obreza and Morgan, 2008).

Common soil orders for citrus groves	Soil texture			Organic matter	Water-holding capacity		pH	Cation exchange capacity
	sand	silt	clay		Inches per ft	Inches in the root zone		
	----- %-----			%				meq/100g
Entisols	97-98.5	0.5-1.25	0.75-1.5	0.5-1	0.3 – 0.8	0.6-2.1	3.6-7.3	2-4
Alfisols	85-96.5	2-6	1.5-9	0.5-3	0.3-1.2	0.5-1.8	4.5-8.4	2-18
Spodosols	96-98.5	1-3.5	0.5-1	1-3	0.3-1.0	0.5-1.2	3.6-7.3	2-6

# EFFECTS MACRONUTRIENTS – LESSONS FROM FIELD STUDIES

# NITROGEN ACCUMULATION FOR HEALTHY TREES



Cameron and Appleman (1935);  
Cameron and Compton (1945);  
Feigenbaum et al. (1987);  
Quiñones et al. (2005); Legaz et al.  
(1982); Legaz et al. (1995)  
Quiñones et al. (2003)

**N concentration follows the pattern:  
leaves > branches > roots > fruits**



# N AND P ACCUMULATION FOR HLB-AFFECTED TREES

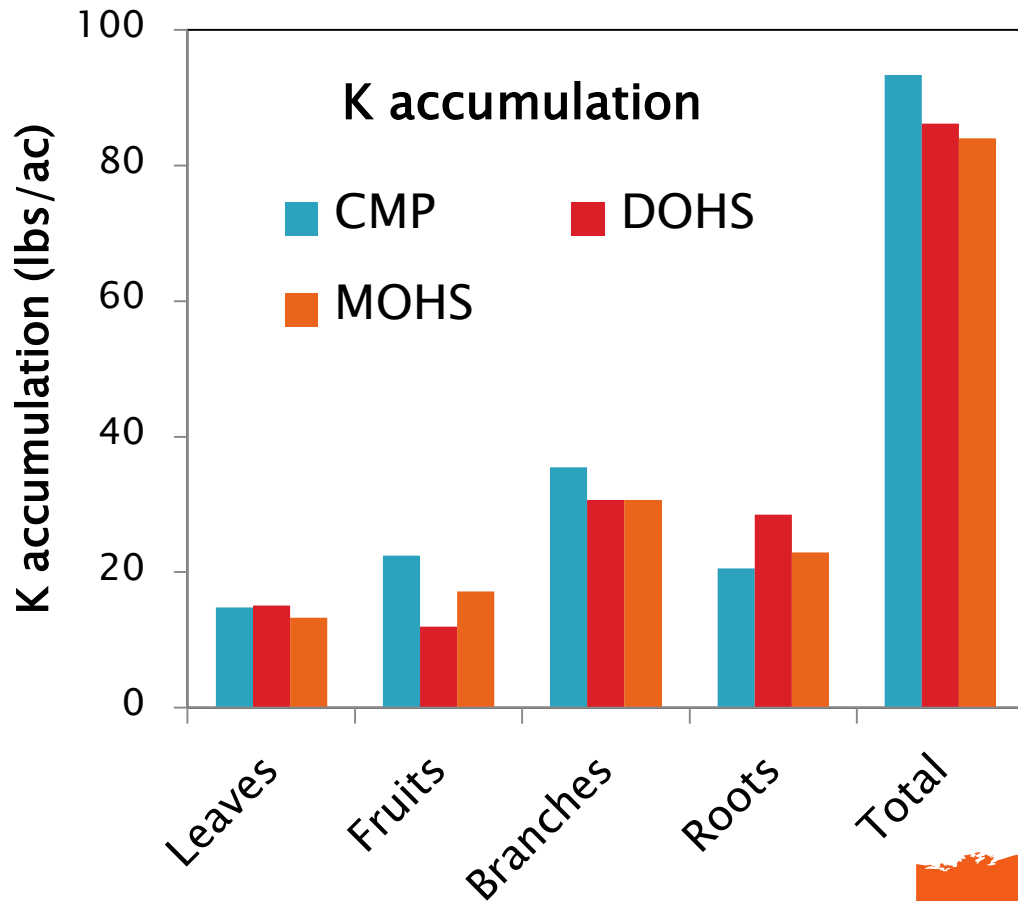
Fertigation method	CMP	DOHS	MOHS	CMP	DOHS	MOHS
Tissue	N (kg ha <sup>-1</sup> )			P (kg ha <sup>-1</sup> )		
Leaves	24.0	49.8	37.1	1.3	1.7	1.5
Fruits	22.4	15.8	30.0	2.7	1.0	2.3
Branches and trunk	20.7	28.4	26.4	4.8	3.8	4.2
Roots	11.6	20.8	20.2	2.9	3.0	3.0
<b>Total</b>	<b>78.70</b>	<b>114.8</b>	<b>113.7</b>	<b>11.7</b>	<b>9.5</b>	<b>11.0</b>

DOHS–Drip open hydroponic system; MOHS–Microsprinkler open hydroponic system; CMP–Conventional microsprinkler practice

**45%** greater N accumulation with DOHS and MOHS than CMP at Immokalee but P accumulation **similar** for all practices.

Kadyampakeni et al. 2016. J. Plant Nutr. 39(5):589-599.

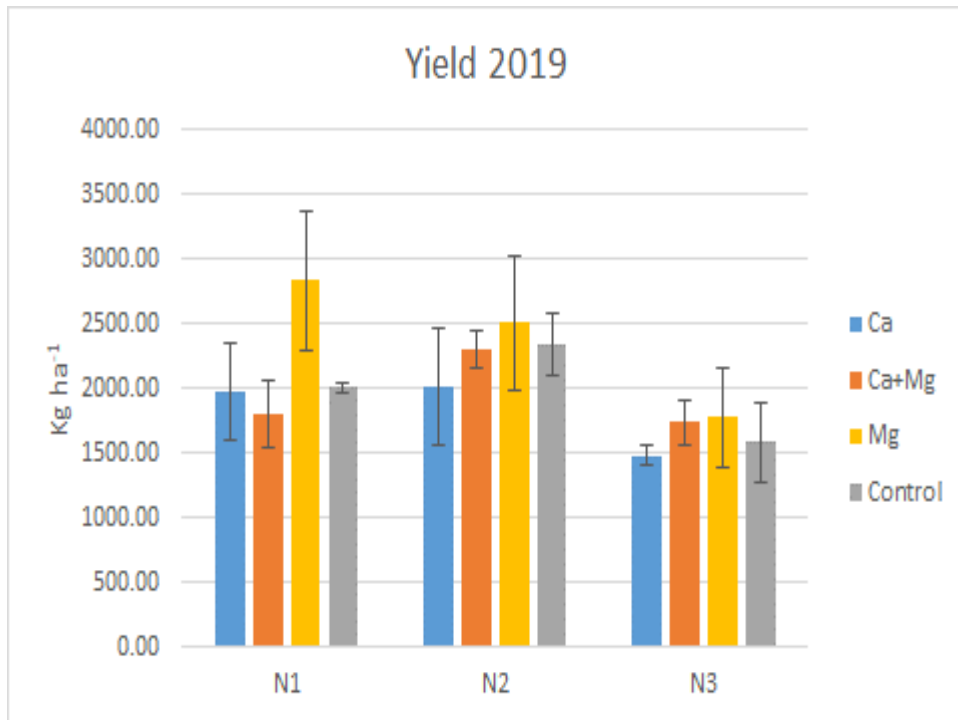
# POTASSIUM (K) ACCUMULATION FOR HLB-AFFECTED TREES



DOHS–Drip open hydroponic system  
MOHS–Microsprinkler open hydroponic system  
CMP–Conventional microsprinkler practice

- Greatest K accumulation in branches, twigs and trunk than other parts
- K accumulation in  $CMP > DOHS > MOHS$

# EFFECT OF CALCIUM AND MAGNESIUM OF YIELD OF HLB-AFFECTED TREES



Yield of Valencia orange on HLB-affected trees

Yield reported in kg ha<sup>-1</sup>, 1 box= 40.8 kg  
1 ha = 2.47 ac

N1, N2, N3 refer to 150, 200 and 250 lbs N/acre

Sole Mg applied at 45 lbs/acre

Sole Ca applied at 45 lbs/acre

Combined Ca+Mg applied at 22.5 lbs/acre, each in combination

Control received no additional Ca or Mg.

Yield differences observed at 150 lbs N/acre, with greater yield with sole Mg.

# EFFECTS OF MICRONUTRIENTS ON HLB-AFFECTED TREES



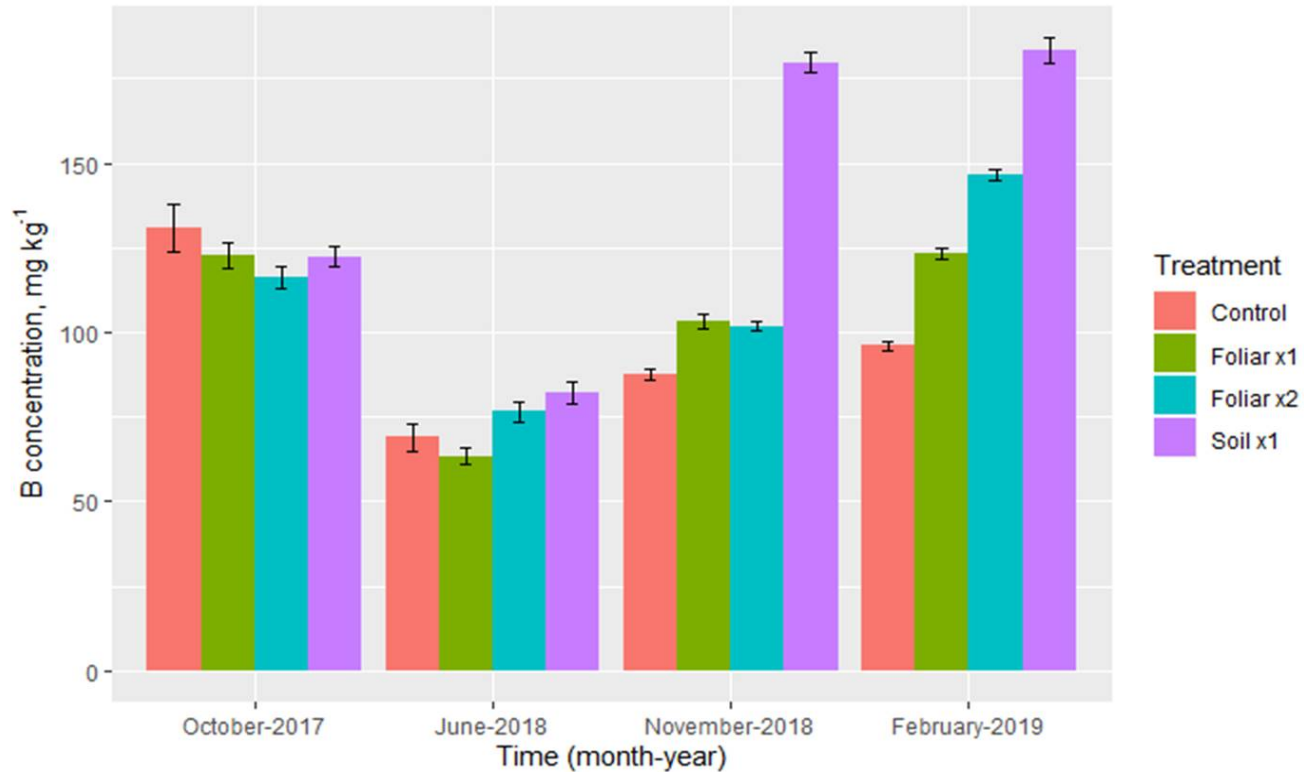
## SOIL MICRONUTRIENT AVAILABILITY FOR HLB-AFFECTED TREES

Retardation factor (R) of B, Mn and Zn at field capacity and saturation

Soil depth	R( $\theta_s$ )			R( $\theta_{FC}$ )		
	B	Mn	Zn	B	Mn	Zn
0-15	1.38	9.34	25.54	3.23	50.03	145.19
15-30	1.14	1.59	13.12	1.50	3.17	45.81
30-45	1.16	1.41	1.21	1.64	2.61	1.81
45-60	1.13	1.38	1.21	1.54	2.63	1.91

Zinc and manganese are strongly held in the rooting zone and might be available or unavailable depending on soil moisture conditions and pH. Boron might leach easily. Regular foliar fertilization is desirable for all the nutrients depending on leaf analysis.

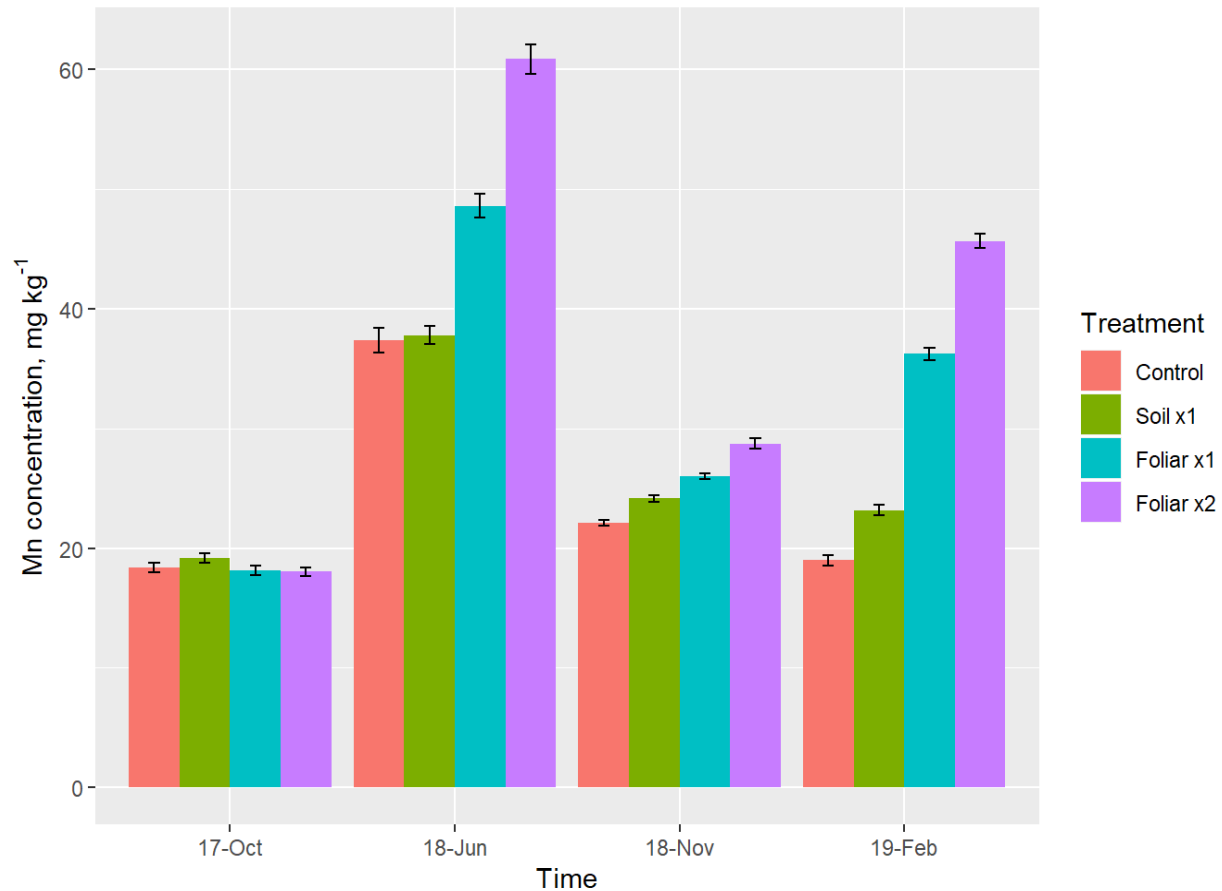
# LEAF BORON CONCENTRATION OVER TIME IN HLB-AFFECTED CITRUS



Variability in leaf concentration of boron in response to seasons and treatments. Treatments are:

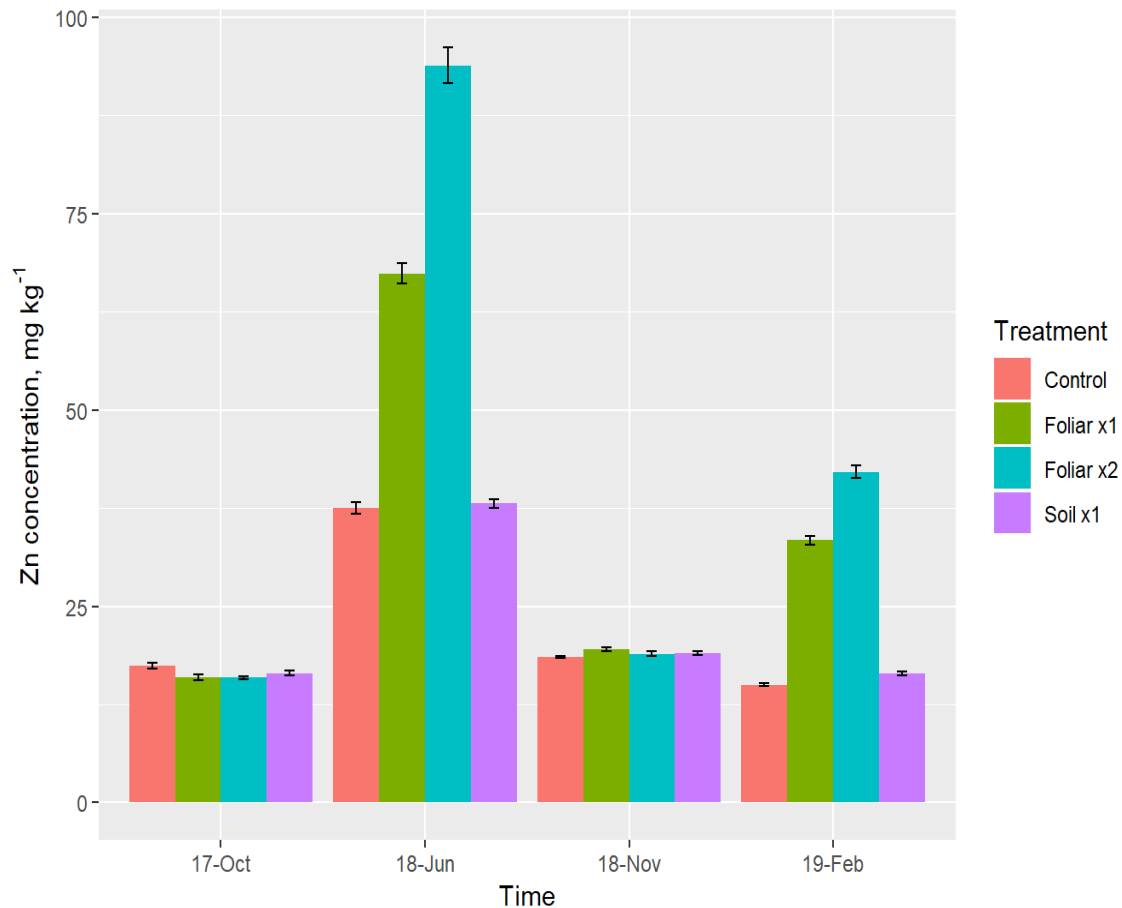
- 1) no nutrient applied (control),
  - 2) foliar-applied B based at 1x UF/IFAS recommendation,
  - 3) 2x foliar applied UF/IFAS recommendation, and
  - 4) 2x soil applied UF/IFAS recommendation (1x = 1.12 kg B ha<sup>-1</sup>).
- Error bars denote 95% confidence intervals.

# LEAF MANGANESE CONCENTRATION OVER TIME IN HLB-AFFECTED CITRUS



Variability in leaf concentration of Mn in response to seasons and treatments. Treatments are 1) standard soil Mn applied (control), 2) standard soil Mn applied + foliar applied Mn based at 1x IFAS recommendations + 1x standard soil nutrient application, 3) 2x foliar applied Mn UF/IFAS recommendations + 1x standard Mn application, and 4) 2x soil applied UF | IFAS recommendations (1x = 10.08 kg Mn ha<sup>-1</sup>). Error bars denote 95% confidence intervals.

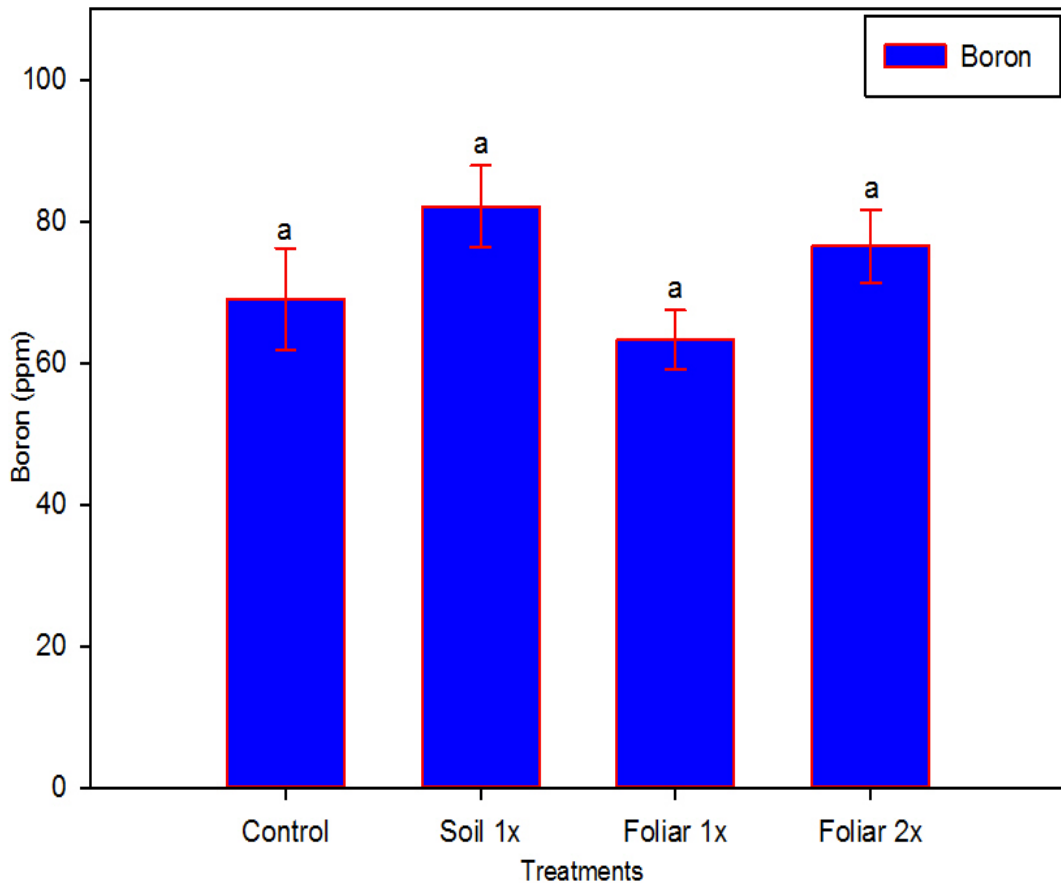
# LEAF ZINC CONCENTRATION OVER TIME IN HLB-AFFECTED CITRUS



Leaf concentration of Zn in response to seasons and treatments. Treatments are 1) standard soil Zn applied (control), 2) foliar applied Zn based at 1x IFAS recommendations + 1x standard soil nutrient application, 3) 2x foliar applied Zn UF/IFAS recommendations+ 1x standard Zn application, and 4) 2x soil applied UF/IFAS recommendations (1x = 5.60 kg Zn ha<sup>-1</sup>). Error bars denote 95% confidence intervals.



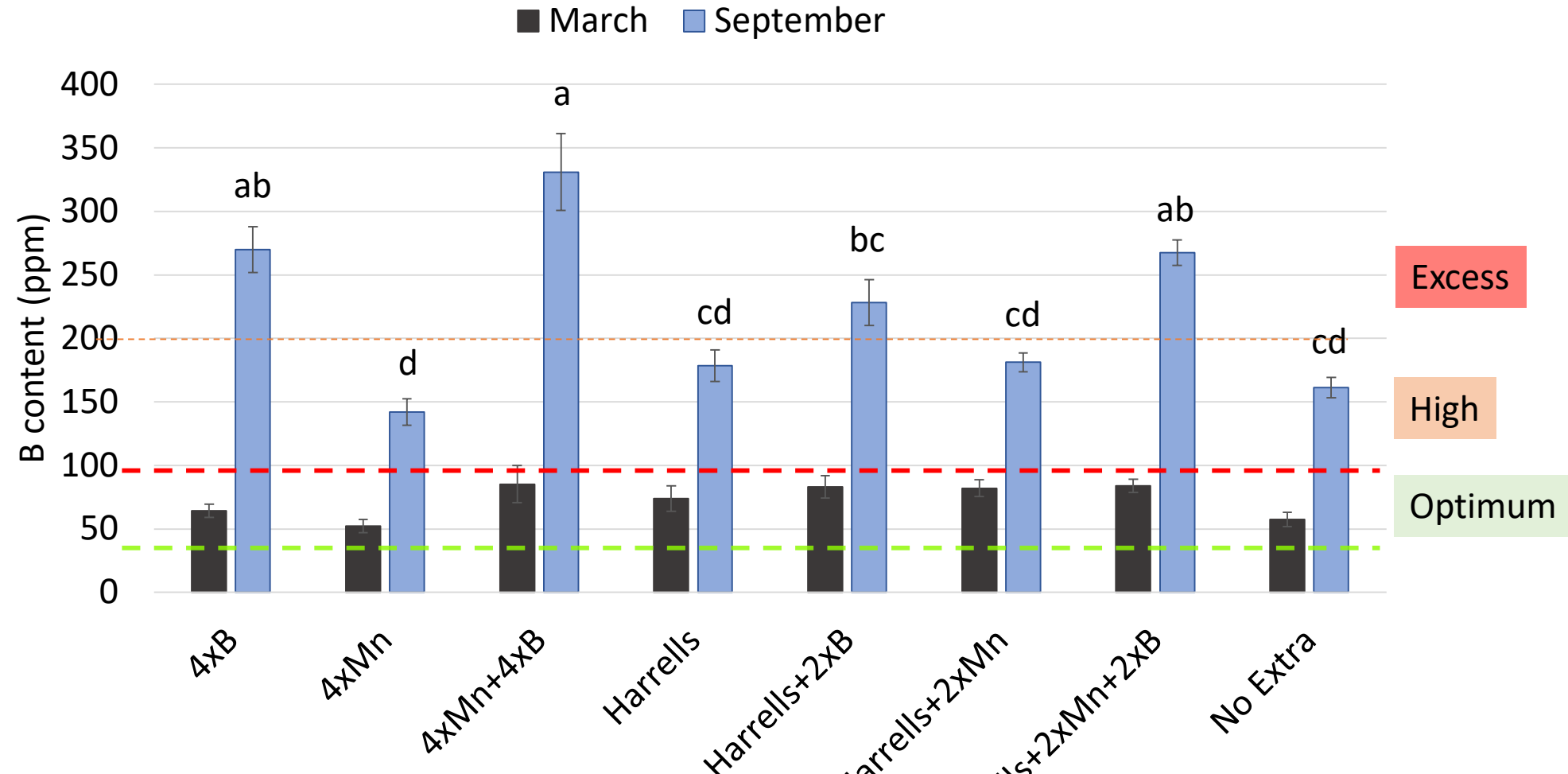
# SOIL BORON AVAILABILITY FOR HLB-AFFECTED TREES



**Boron concentration in leaf tissue of 6-year old Valencia orange on Valencia orange on Swingle root stock**

**B concentration was between 60 and 90 ppm as a result of soil and foliar application of B uptake efficiency. Mn and Zn followed similar pattern. Soil application (1x IFAS) resulted in greater concentration over 1x and 2 x foliar application rate.**

# LEAF NUTRIENT CONTENT (B)

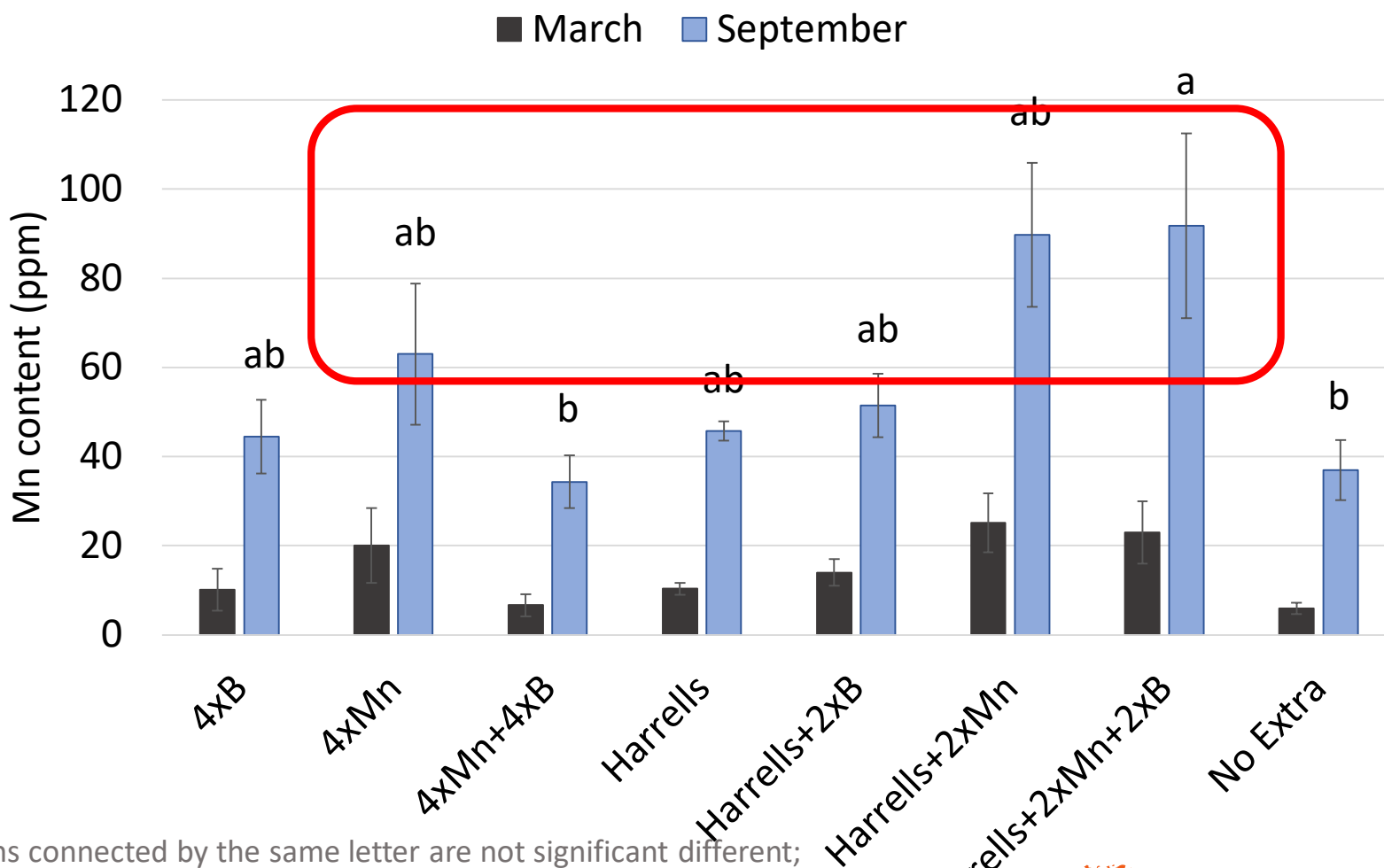


**0x B (or residual boron) up to 2xB keep B between in the range 150 to 250 ppm, but 4xB was excessive, in spring flush.**  
*Zambon et al. 2018*

Means connected by the same letter are not significant different; Tukey's HSD with P=0.05



# LEAF NUTRIENT CONTENT (MN)



Comparison of elevated Mn treatments on 8-year old Vernia sweet orange on rough lemon rootstock showed optimum leaf concentration with 2xMn and 4xMn. Antagonistic uptake was observed between Mn and B when both applied at 4x. **2x-4xMn kept Mn between 60 to 120 ppm in the spring flush leaves.** Need to adjust fertilization by season, March Mn leaf concentration was fairly low. No differences were observed in canopy.

**Zambon et al. 2018.**

Means connected by the same letter are not significant different; Tukey's HSD with alpha= 0.08

# TAKE HOME MESSAGE

- **Critical 4Rs for nutrient stewardship include: right rate, right source, right time and right place.**
- **Soils for citrus producing regions in FL are mostly sandy soils with low nutrient holding capacity that need good management practices.**
- **Optimal and balanced nutrient management is important for high nutrient use efficiency and minimizing leaching losses.**
- **Good nutrient management is critical for promoting tree performance under HLB conditions.**



# ACKNOWLEDGEMENTS

- **Collaborators:**
- **UF/IFAS CREC:** Dr. Jude Grosser, Dr. Schumann, and Dr. Flavia Zambon
- **UF/IFAS SWFREC:** Dr. Kelly Morgan
- **UF/IFAS IRREC:** Dr. Rhuanito Ferrarezi
- **My Program Team:** Dr. Wije Bandaranayake, William Ratnasiri, Alex Hernandez
- **Graduate students:** Qudus Uthman and Eduardo Esteves
- **Sponsors:** UF/IFAS Citrus Initiative, USDA NIFA

# QUESTIONS/COMMENTS?

