MANAGING MACRO- AND MICRONUTRIENTS FOR IMPROVED CITRUS PRODUCTION

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CITRUS SHOW

May 12, 2021

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OUTLINE

- Roles of nutrients in improving plant health
- 4Rs in citrus nutrient management
- Macronutrients-Lessons from the field research
- Micronutrients-Theraupitic effects
- Take home message

ROLES OF NUTRIENTS IN IMPROVING PLANT HEALTH

Liepig'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!!

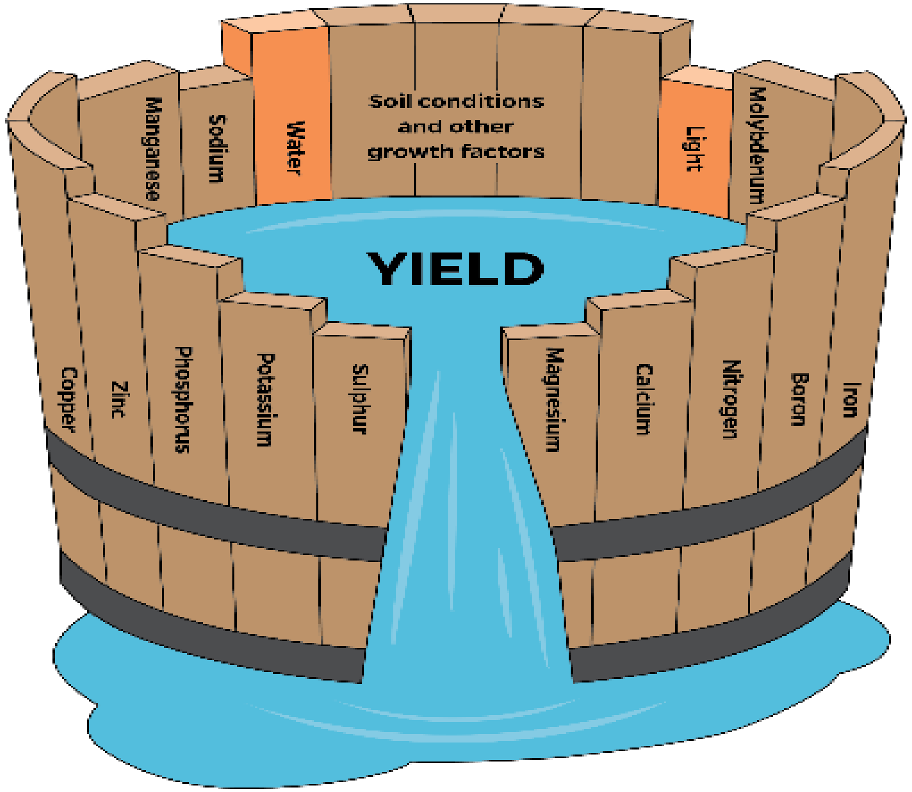

Figure 1. Liebig's Law of Minimum illustrated for plant growth and nutrition with a leaking barrel. Credit UF/IFAS Communications

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ROLES OF NUTRIENTS IN IMPROVING PLANT HEALTH (2)

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 IN IMPROVING PLANT HEALTH (3)

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 IN IMPROVING PLANT HEALTH (4)

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 IN IMPROVING PLANT HEALTH (5)

Molybednum: 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

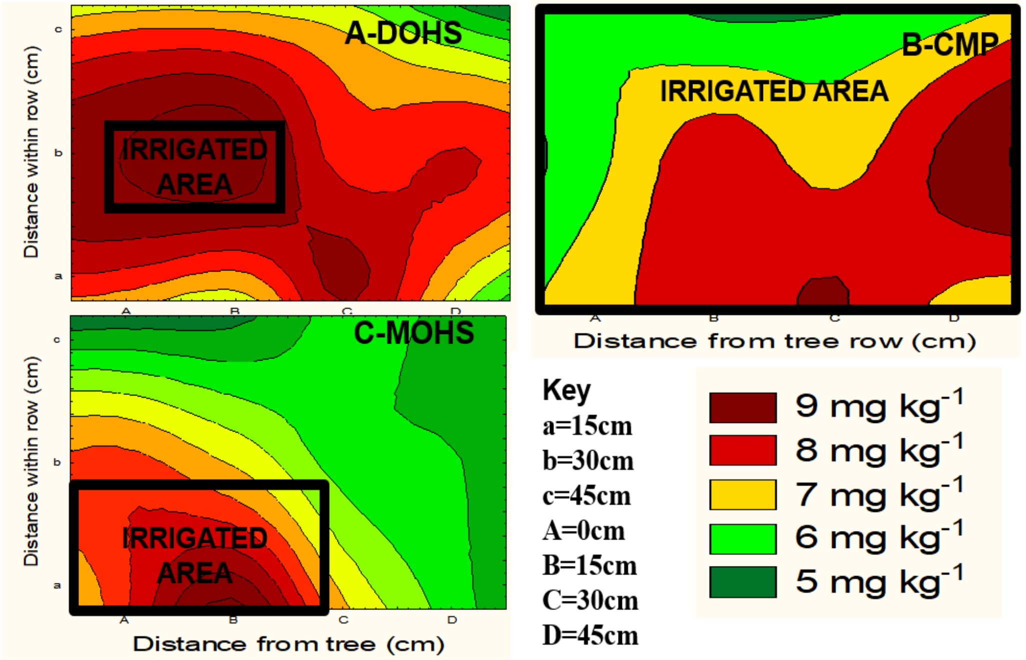
	Source	Rate	Time	Place
Examples of scientific principles	• Ensure balanced supply of nutrients • Suit soil properties	• Assess nutrient supply from all sources (check fertilizer label and note what's available or missing) • Assess plant demand (e.g. look at tree size, blooming, flushing or fruit loading)	• Assess dynamics of crop uptake and soil supply (do a leaf and soil test to determine when and how much fertilizer to add) • Determine timing of loss risk (avoid fertilization during rains)	Recognize crop rooting patterns (for citrus, 70% of roots are in the top 12 inch) Manage spatial variability by randomly sampling soil and tissue samples across blocks

4 RS OF NUTRIENT MANAGEMENT (2)

	Source	Rate	Time	Place
Examples of practical applications	• Commercial fertilizer • Livestock manure • Crop residue	• Test soils for nutrients • Calculate economics to check costs and benefits • Balance crop removal	• Pre-plant • At planting or active vegetative growth • At flowering • At fruiting	• Fertigation • Spreader or broadcast • Variable rate application (GIS based on nutrient requirements by block)

EFFECTS MACRONUTRIENTS – LESSONS FROM FIELD STUDIES

POTASSIUM DISTRIBUTION IN THE ROOT ZONE



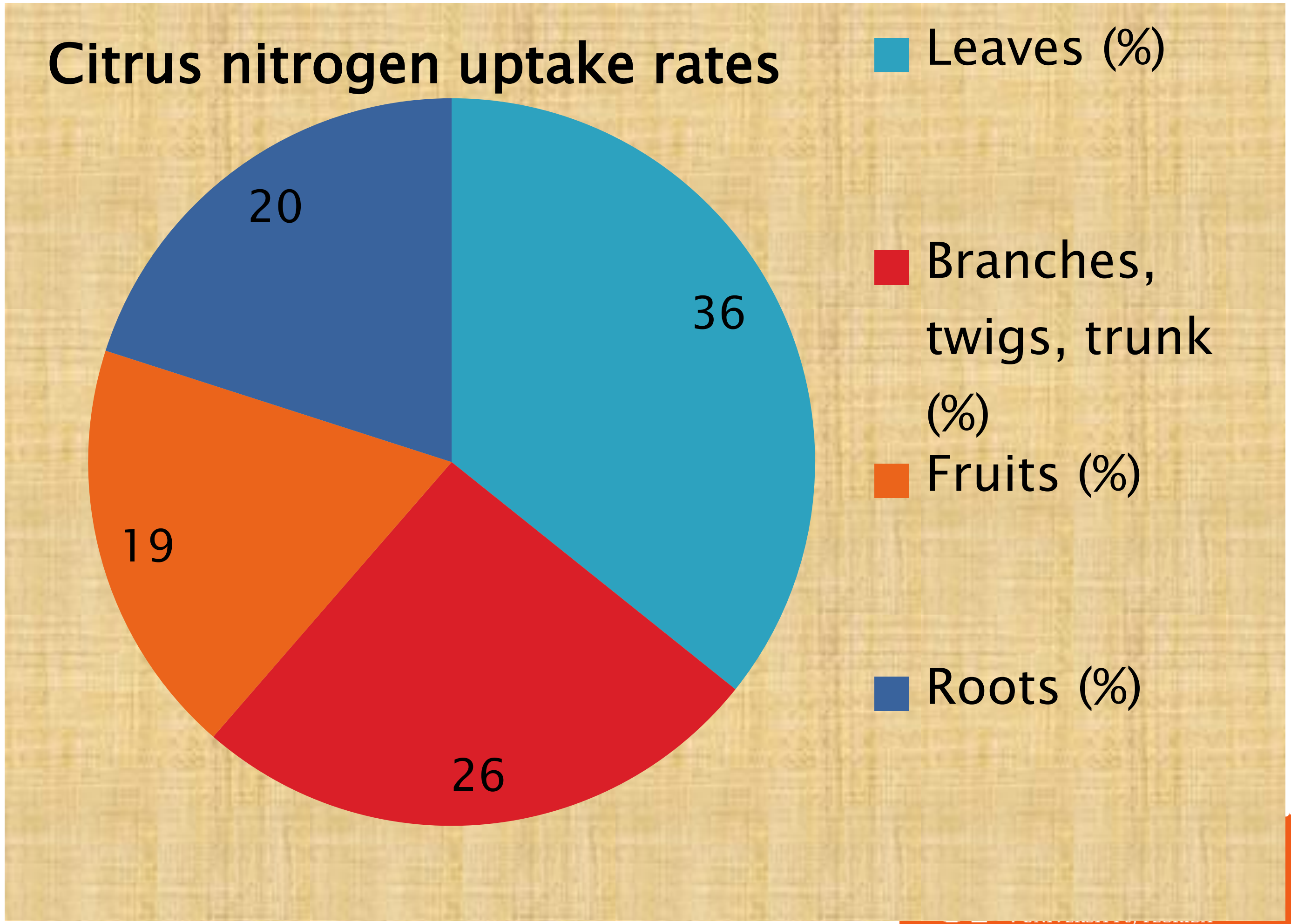
CMP-Conventional microsprinkler irrigation
MOHS-Microprinkler open hydroponic system with daily irrigation and weekly fertigaton.
DOHS-Drip open hydroponic system with daily irrigation and fertigation.

Greater K concentration the irrigated/fertigated zone than non-irrigated zone in the 0-15 cm (0-6 inch) depth. Strong potential for nutrient uptake because root density was 4x-8x greater than non-irrigated zone.

Kadyampakeni et al. 2014. Soil Science Society of America Journal 78:325–334.

Potassium (K) distribution in the 0-15 cm depth

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

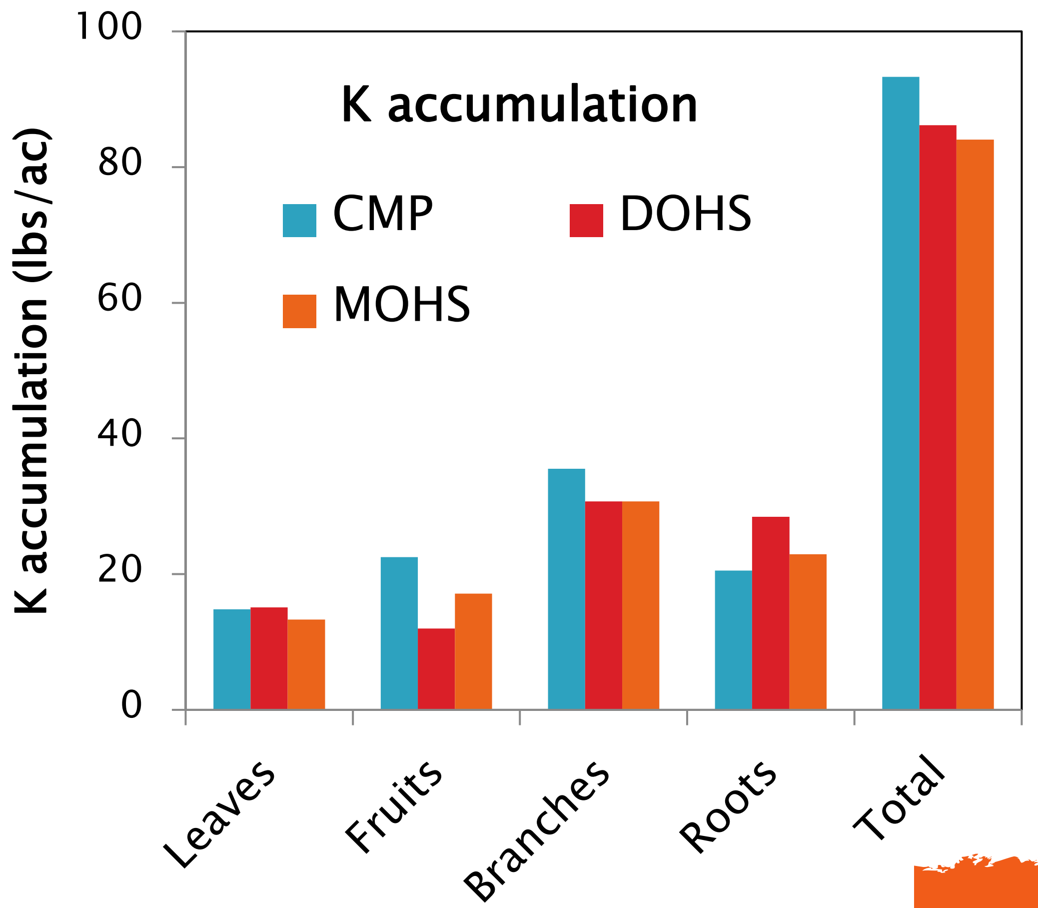
Fertigation method	CMP	DOHS	MOHS	CMP	DOHS	MOHS
Tissue	N (kg ha^{-1})			P (kg ha^{-1})		
Leaves	24.0	49.8	37.1	1.3	1.7	1.5
Fruits	22.4	15.8	30.0	2.7	1.0	2.3
Branches and trunk	20.7	28.4	26.4	4.8	3.8	4.2
Roots	11.6	20.8	20.2	2.9	3.0	3.0
Total	78.70	114.8	113.7	11.7	9.5	11.0

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.

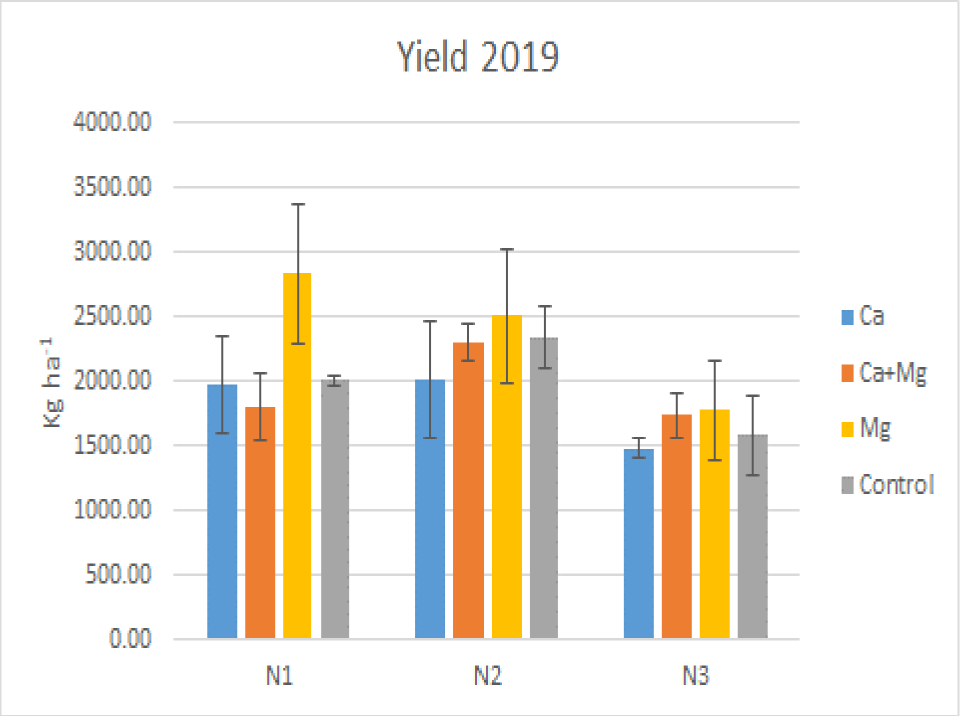
K ACCUMULATION FOR HLB-AFFECTED TREES



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^{-1}, 1 box= 40.8 kg

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

Sole Mg applied at 45 kg/ha

Sole Ca applied at kg/ha

Combined Ca+Mg applied at 22.5 kg/ha

each in combination

Control received no additional Ca or Mg.

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

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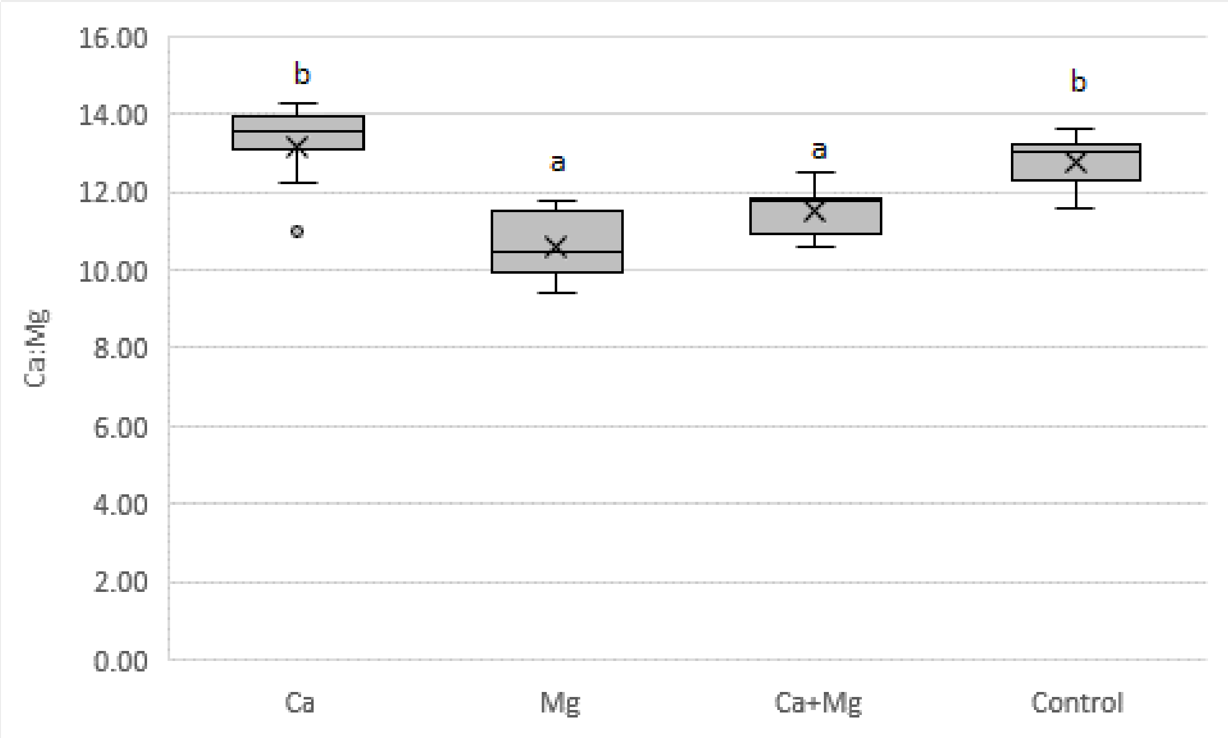
EFFECT OF CALCIUM AND MAGNESIUM OF LEAF CONCENTRATION OF HLB-AFFECTED TREES

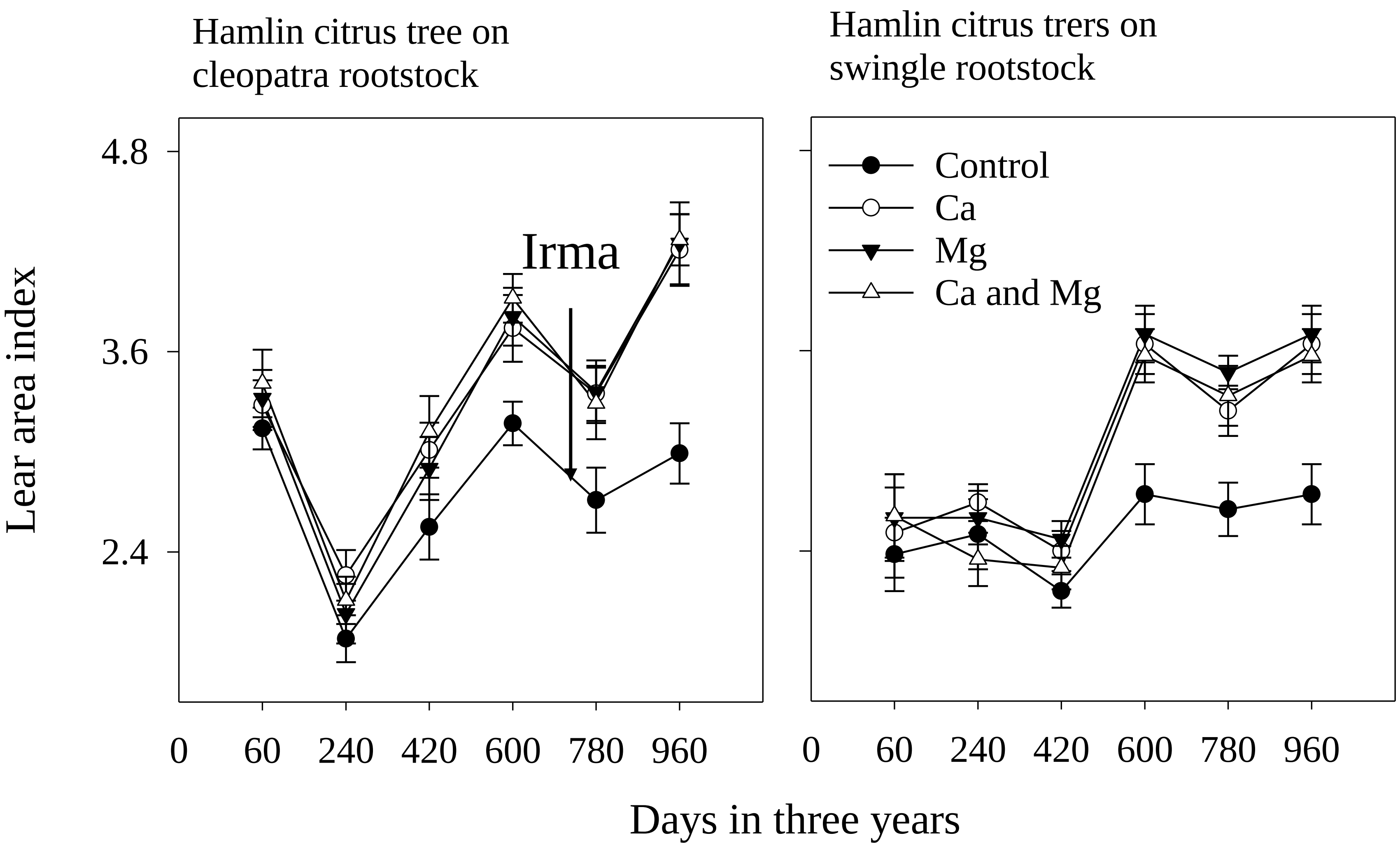


- **Greater Ca:Mg ratio in Ca and control treatments Mg and Ca+Mg treatments.**
- **Background Ca was greater, thus response observed in controls.**
- **PH remained around 6.5 to 7.0 in all plots.**

SOIL CALCIUM AND MAGNESIUM APPLICATIONS

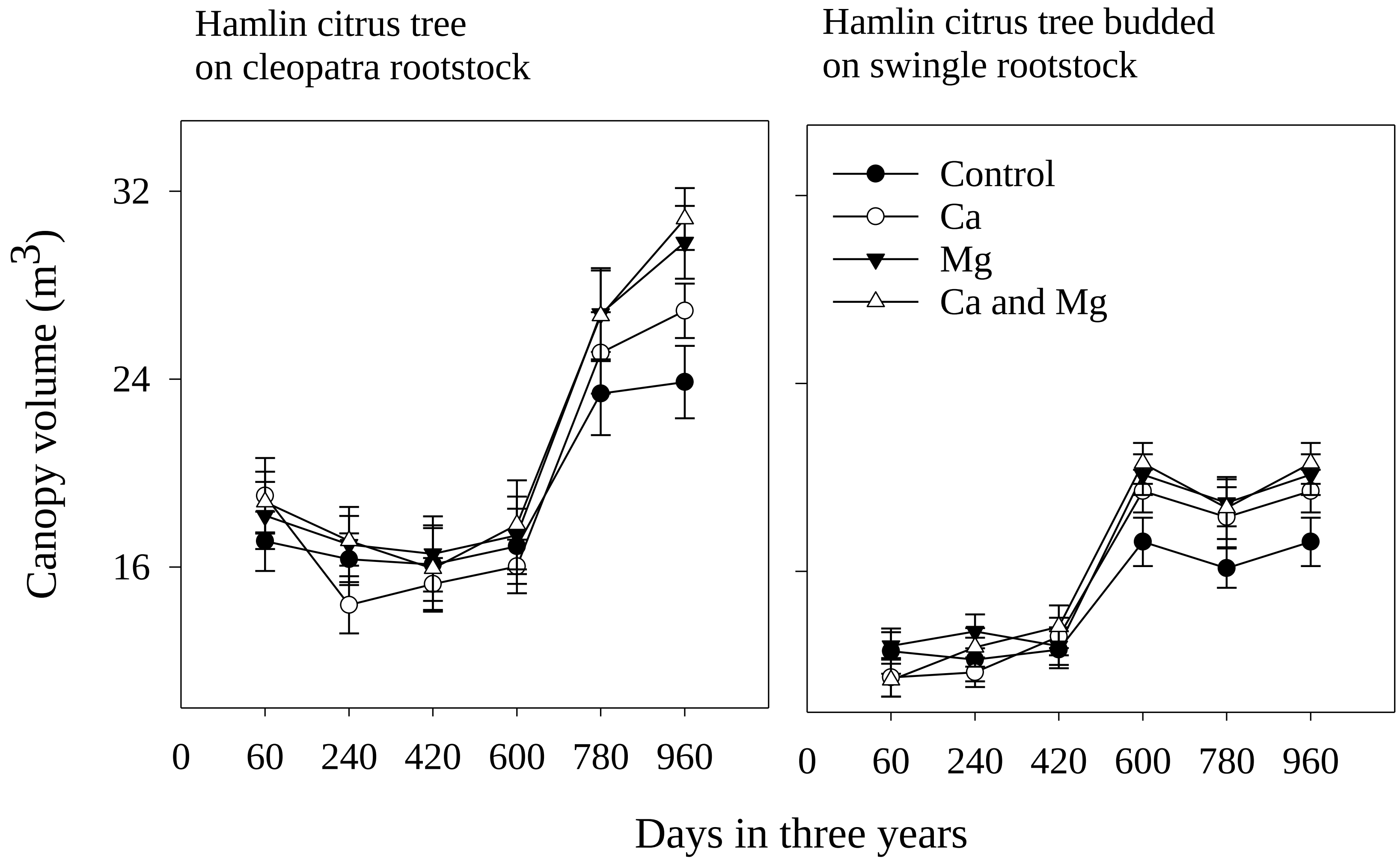
- **Study started in Jan. 2017, set as zero day of the three years study.**
- **10 year-old Hamlin on Cleo and Hamlin on Swingle**
- **Treatments (T): control (T1), full Ca dose (T2), full Mg dose (T3), and half Ca and half Mg doses (T4), (full dose=45 kg ha^{-1}).**

EFFECT OF CALCIUM AND MAGNESIUM ON LEAF AREA



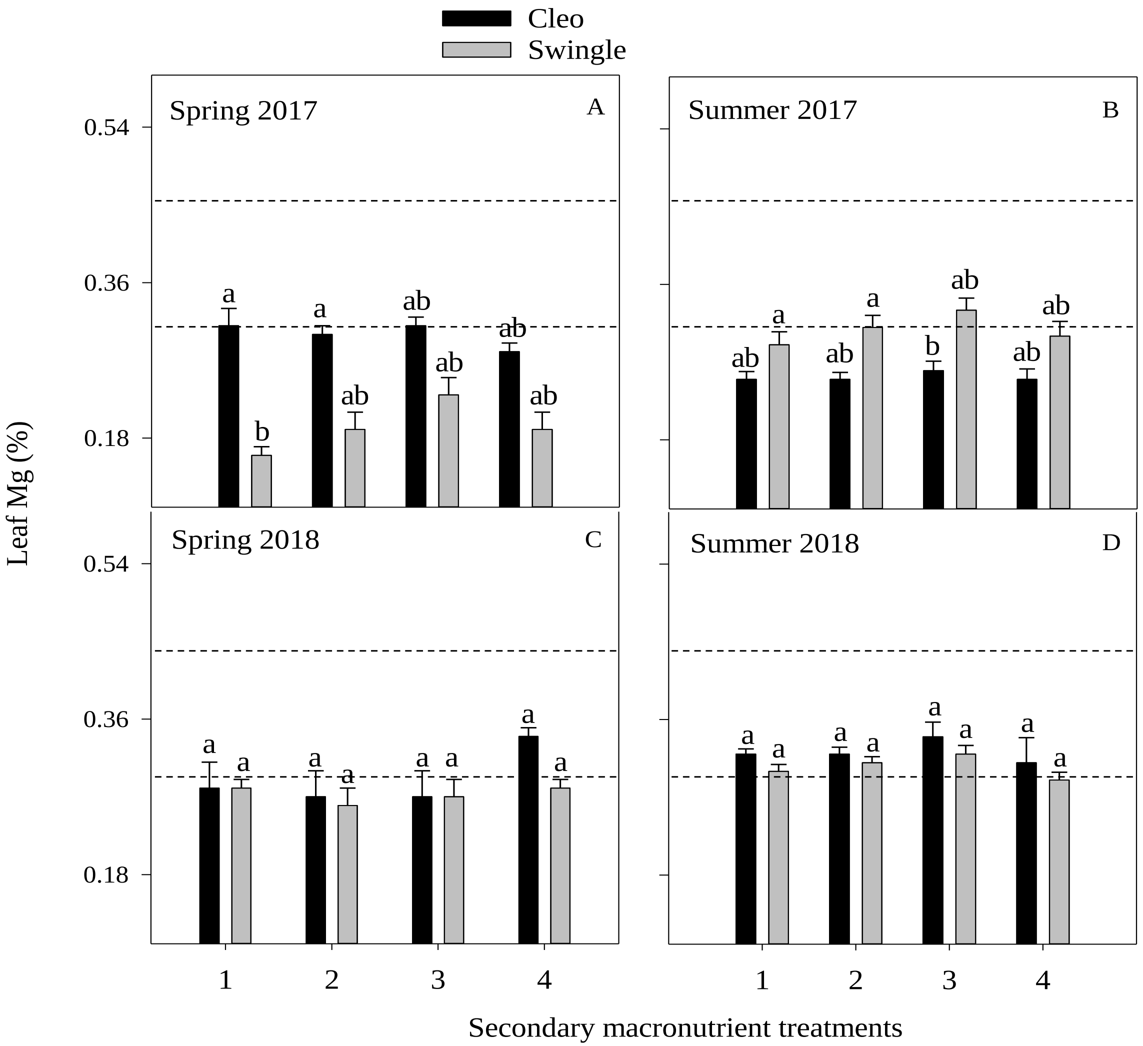
Improved leaf area index for Hamlin orange on the two rootstock with adjusted Ca, Mg and Ca+Mg over the control

EFFECT OF CALCIUM AND MAGNESIUM ON CANOPY VOLUME



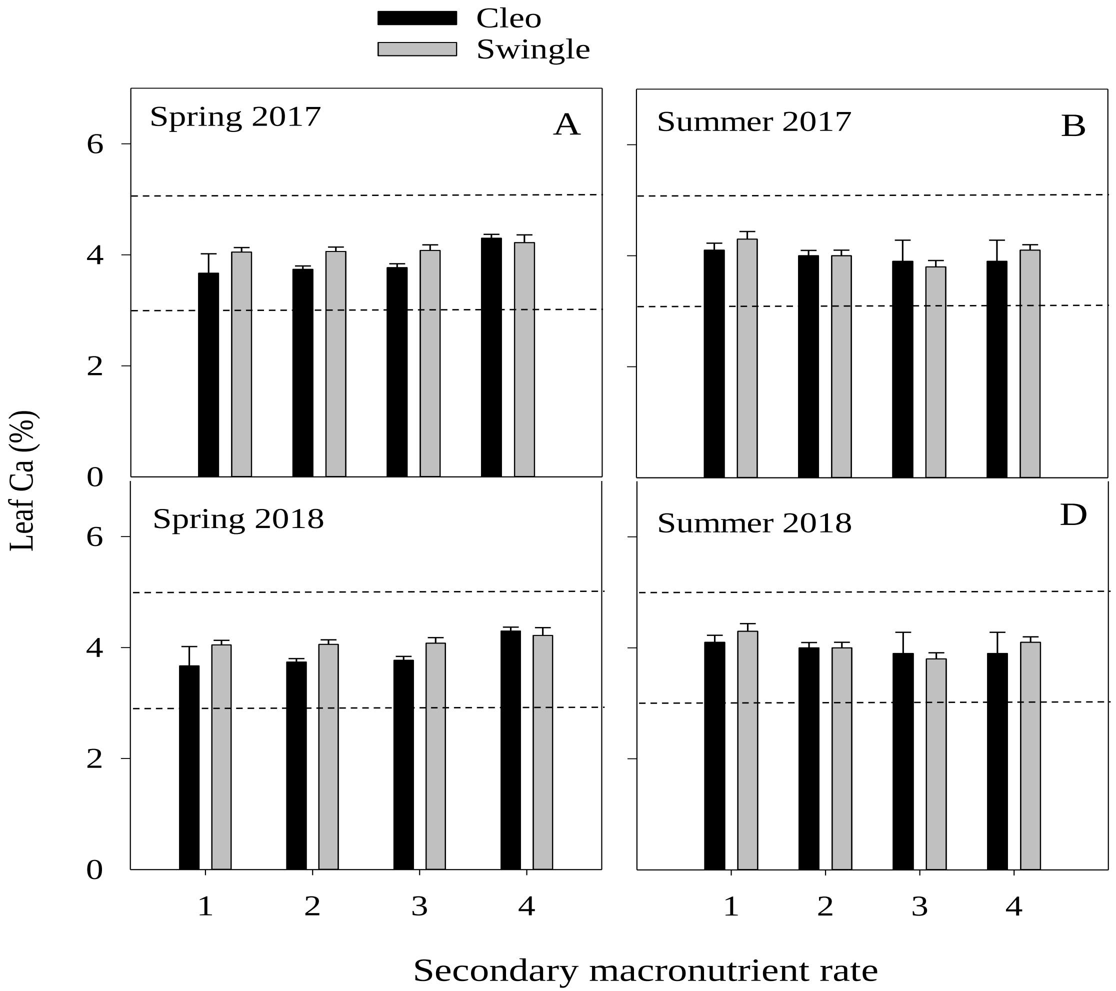
Improved canopy density for Hamlin orange on the two rootstock with adjusted Ca, Mg and Ca+Mg over the control

EFFECT OF MAGNESIUM ON LEAF CONCENTRATION



Treatments (T):
control (T1),
full Ca dose (T2),
full Mg dose (T3), and
half Ca and half Mg doses (T4)
(Full dose=45 kg ha^{-1}).

EFFECT OF CA ON LEAF CONCENTRATIONS



Treatments (T):

control (T1),

full Ca dose (T2),

full Mg dose (T3), and

half Ca and half Mg doses (T4)

(Full dose=45 kg ha^{-1}).

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EFFECTS OF MICRONUTRIENTS ON HLB-AFFECTED TREES

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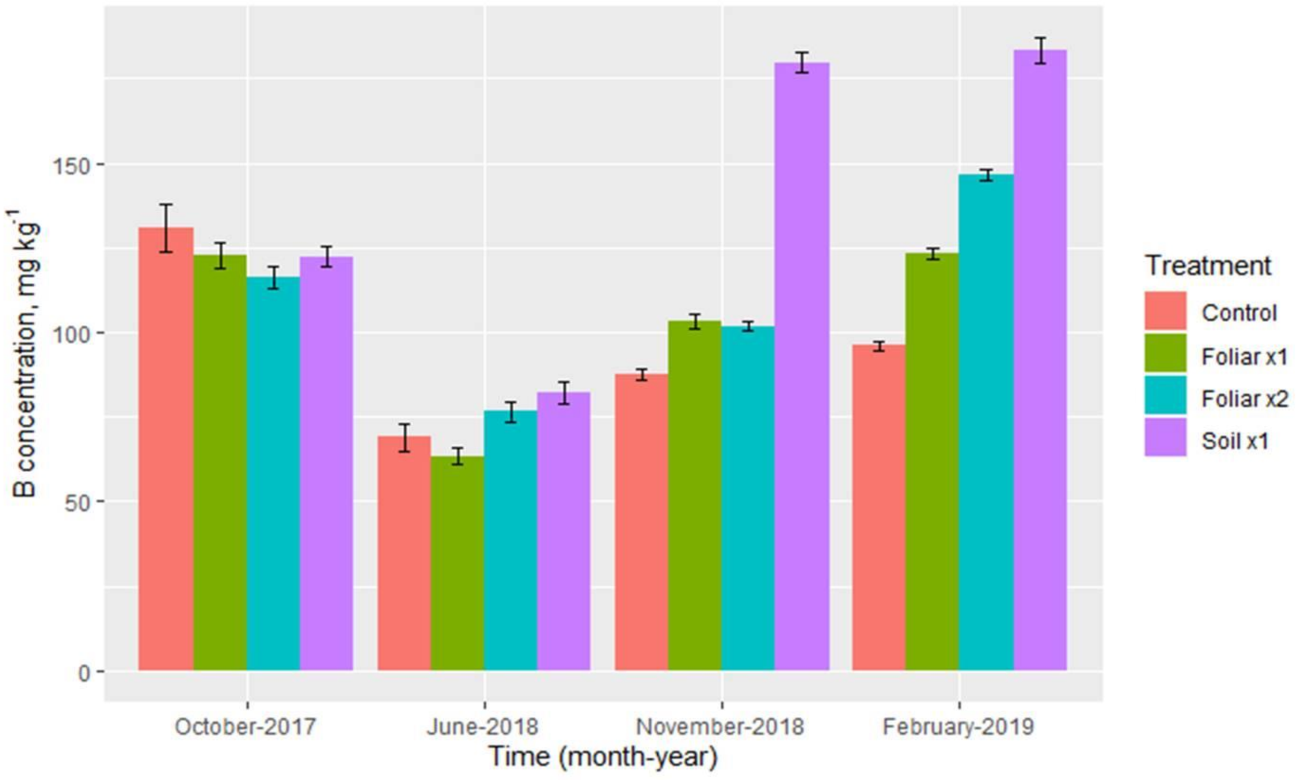
SOIL MICRONUTRIENT AVAILABILITY FOR HLB-AFFECTED TREES

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 nutreints depending on leaf analysis.

LEAF BORON CONCENTRATION OVER TIME IN HLB-AFFECTED CITRUS



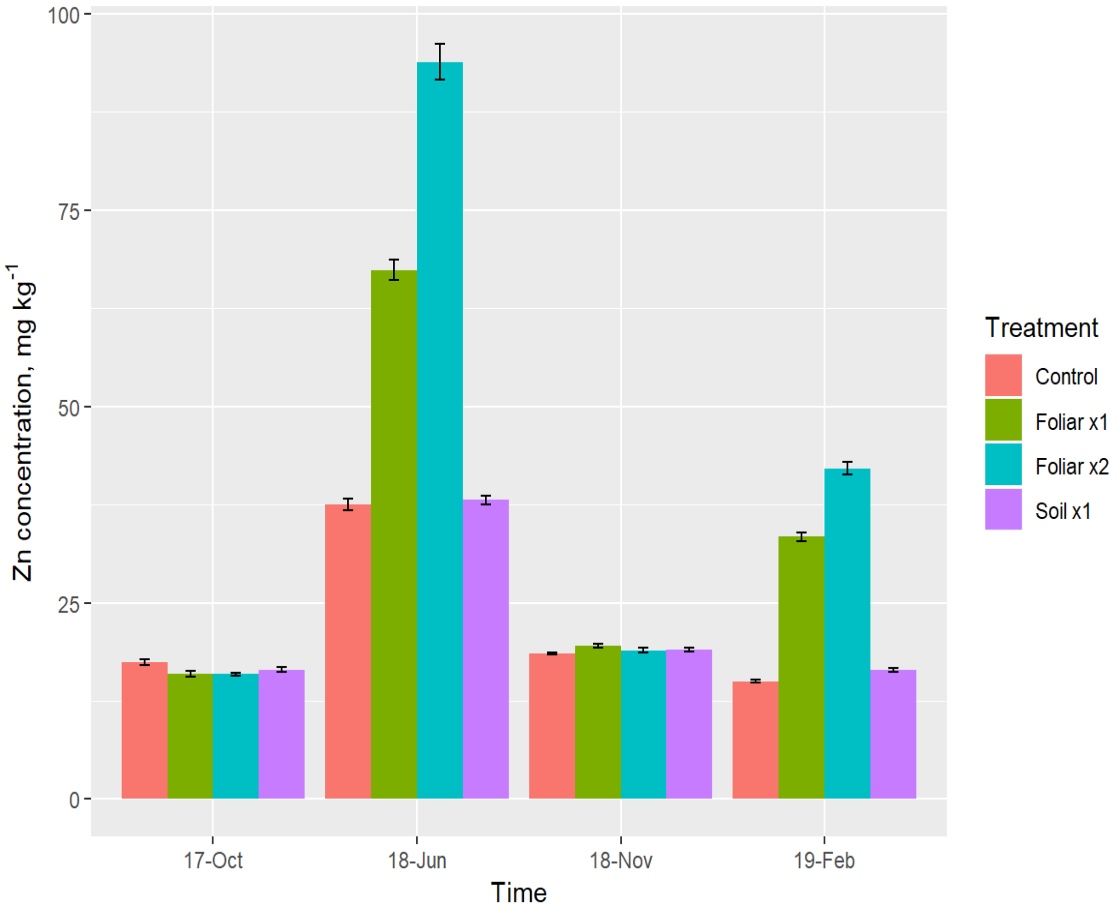
Variability in leaf concentration of boron in response to seasons and treatments. Treatments are:

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^{-1}).

Error bars denote 95% confidence intervals.

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 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^{-1}). Error bars denote 95% confidence intervals.

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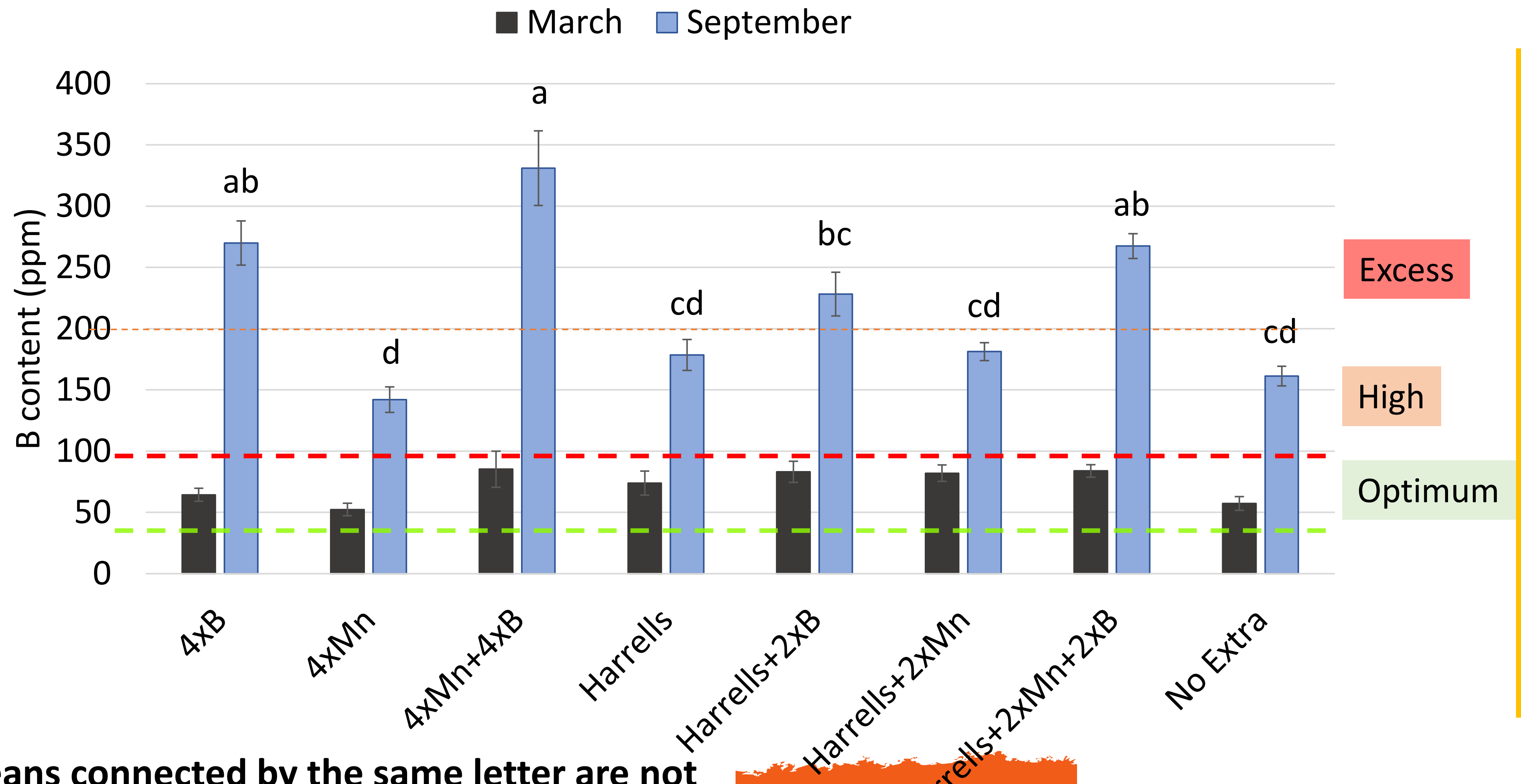
LEAF NUTRIENT CONTENT (B)



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. ***Kadyampakeni, 2020***

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

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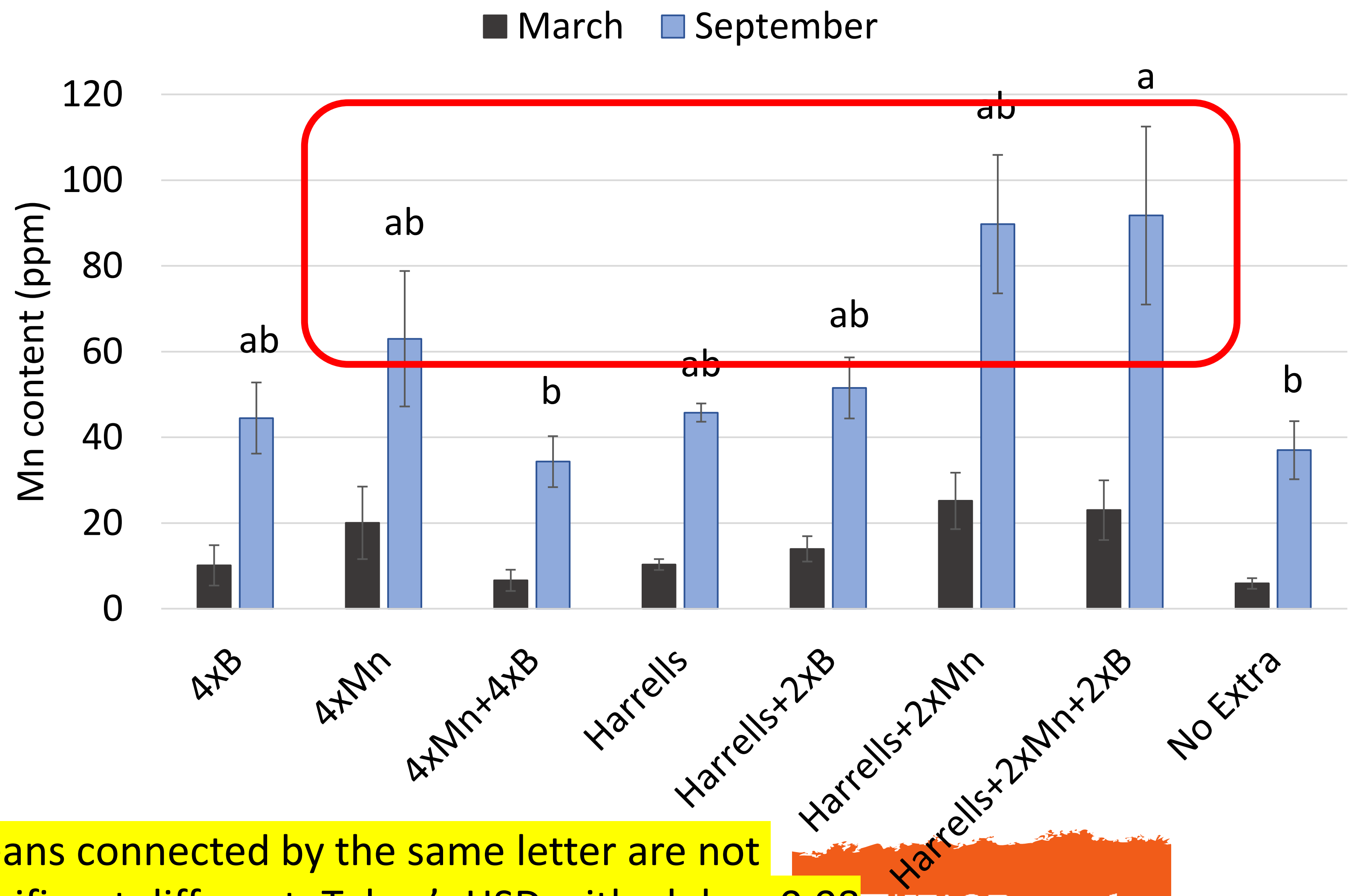
LEAF NUTRIENT CONTENT (MN)



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. 2019.

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

SUMMARY

- 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 Flavia Zambon
- **UF/IFAS SWFREC**: Dr. Kelly Morgan, Dr. Ali A. Atta
- **UF/IFAS IRREC**: Dr. Rhuanito Ferrarezi
- **My Program Team**: Dr. Wije Bandaranayake, William Ratnasiri, Alex Hernandez
- **Graduate students**: Qudus Uthman, Eduardo Esteves, Tanyaradzwa Chinyukwi, Samuel Kwakye
- **Sponsors**: UF/IFAS Citrus Initiative, USDA NIFA, CRDF

QUESTIONS/COMMENTS?