IMPACTS OF MACRO AND MICRONUTRIENTS ON ROOT HEALTH, YIELD AND JUICE QUALITY

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Key Takeaways

- Current data suggests the need to update secondary macronutrient and micronutrient guidelines for HLB-affected trees for improved yield, improved canopy size and juice quality.

- It is good to note the lag time for nutrient applications to show effect on yield, juice quality, canopy and trunk size.

Key Takeaways (2)

- With macronutrients and micronutrients we observed reduced root dieback and increased root growth because root density was increased and the tree was more efficient in nutrient uptake.

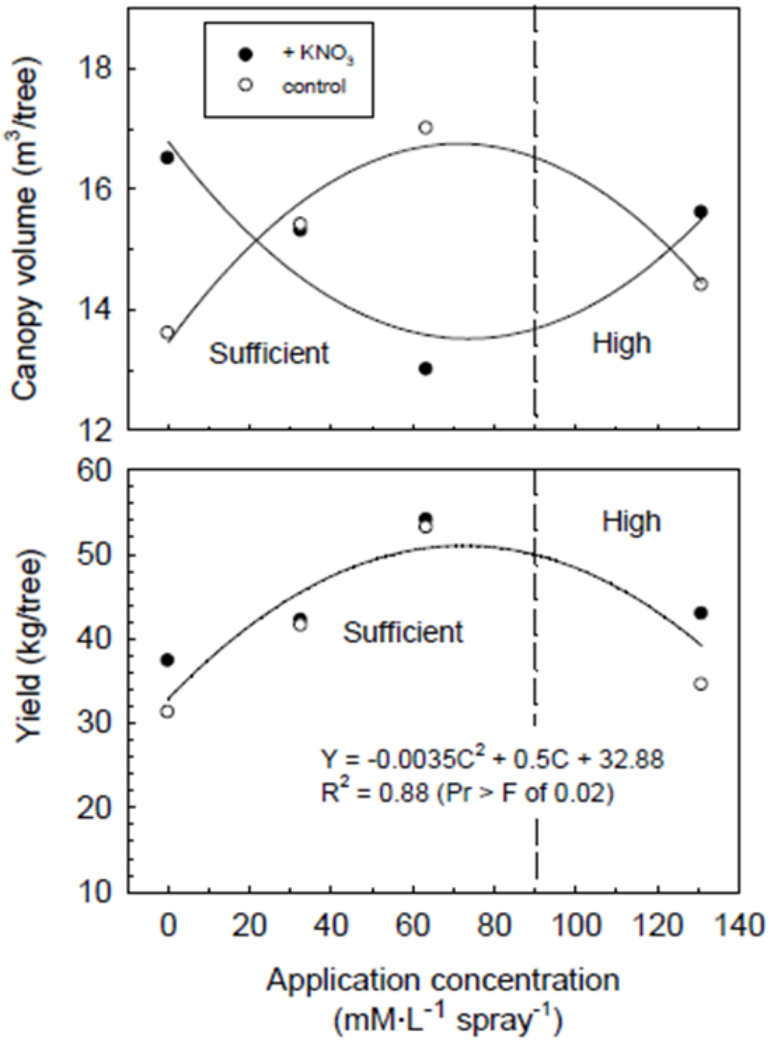
- Nutrient leaching was significantly reduced with bi-weekly fertigation and retained nitrates in the top 6 inches.

- Combined use of crop protection products and nutrition strategies appear to remediate HLB-affected trees.

Improved canopy volumes and fruit yields with foliar applications of essential nutrients on ‘Valencia’ sweet orange with 3x current recommendation.

Mn, Zn, B applied separately
(1x=5 lbs metallic per ac Mn and Zn and ¼ lbs metallic per ac B)
3x = 15 lbs Mn and Zn
0 x = control
1.5 x = IFAS Annual Recommendation
3 x = IFAS Annual Recommendation
6 x =IFAS Annual Recommendation

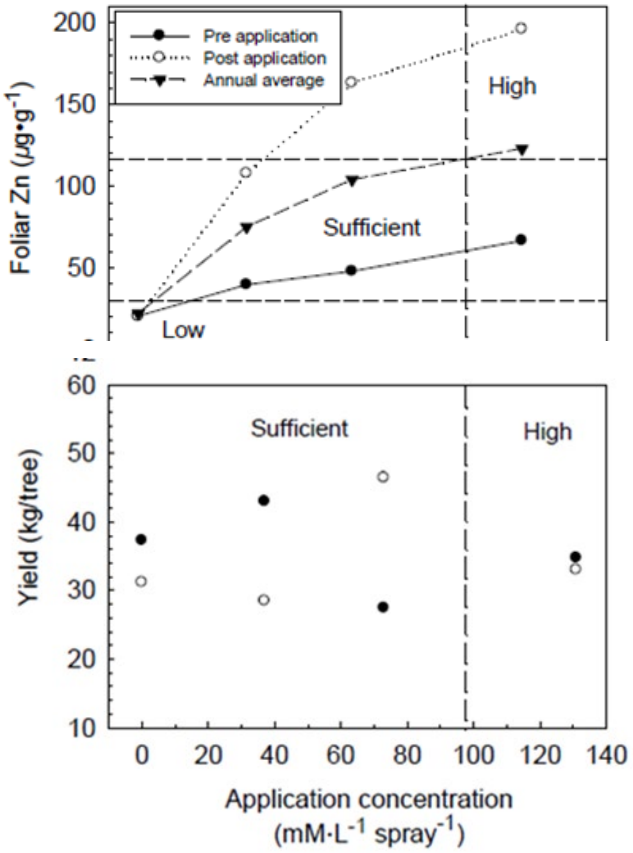
Greatest fruit yield at 3x Mn and high range of foliar Mn.
The key was to keep Mn, and Zn in the optimum or high range of leaf nutrient concentration.



Morgan, Rouse, and Ebel, 2016. Foliar Applications of Essential Nutrients on Growth and Yield of ‘Valencia’ Sweet Orange with Huanglongbing. HortScience.

Improved Growth and Yield of ‘Valencia’ Sweet Orange with Foliar Zn application up to 3x of current recommendations.

Mn, Zn, B applied separately
(1x=5 lbs metallic per ac Mn and Zn and ¼ lbs metallic per ac B)
3x = 15 lbs Mn and Zn
0 x = control
1.5 x = IFAS Annual Recommendation
3 x = IFAS Annual Recommendation
6 x =IFAS Annual Recommendation



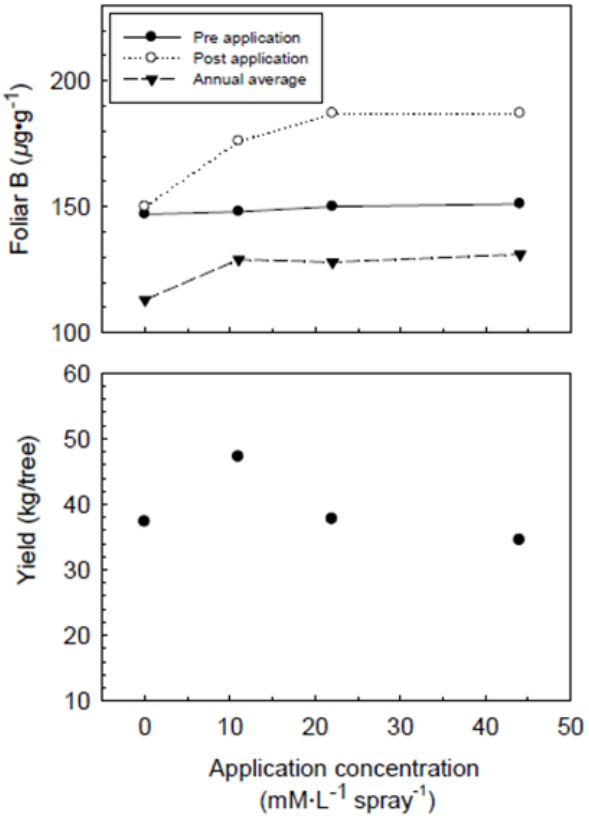
Greatest fruit yield at 3x Zn and high range of foliar Zn.
The key was to keep Zn in the optimum or high range of leaf nutrient concentration.

Morgan, Rouse, and Ebel, 2016. Foliar Applications of Essential Nutrients on Growth and Yield of ‘Valencia’ Sweet Orange with Huanglongbing

Foliar Applications of B improved fruit yield of ‘Valencia’ sweet orange

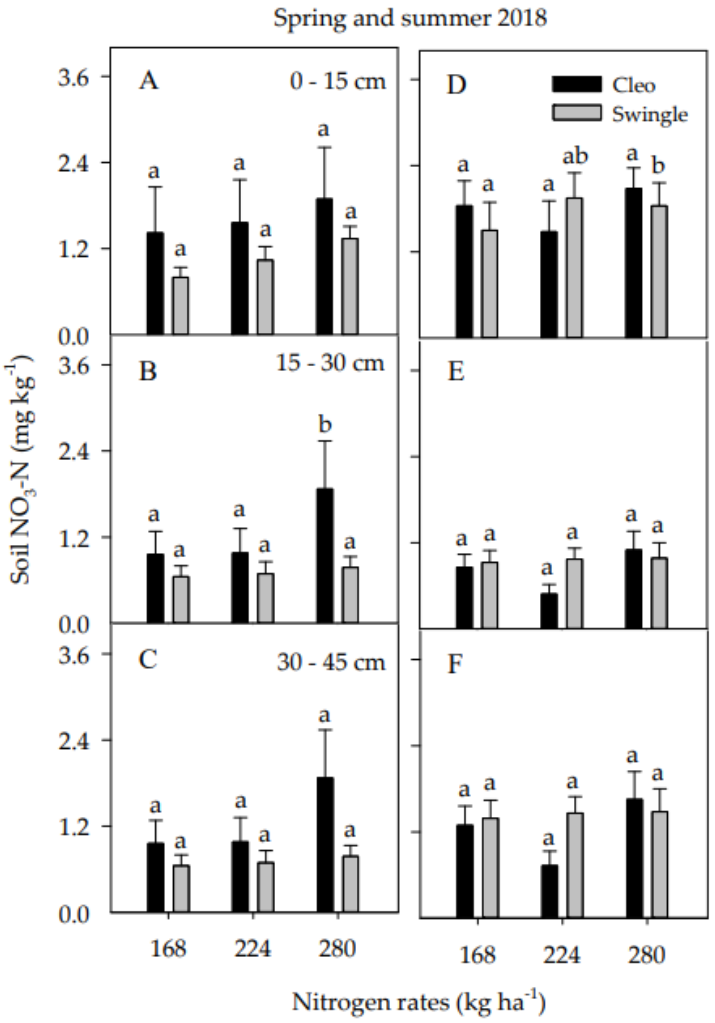
No significant difference in yield for B rates. High range of foliar B for all rates.
High canopy volumes at 3x B.

Mn, Zn, B applied separately
(1x=5 lbs metallic per ac Mn and Zn and ¼ lbs metallic per ac B)
3x = ¾ lbs metallic per ac B
0 x = control
1.5 x = IFAS Annual Recommendation
3 x = IFAS Annual Recommendation
6 x =IFAS Annual Recommendation



Morgan, Rouse, and Ebel, 2016. Foliar Applications of Essential Nutrients on Growth and Yield of ‘Valencia’ Sweet Orange with Huanglongbing HortScience.

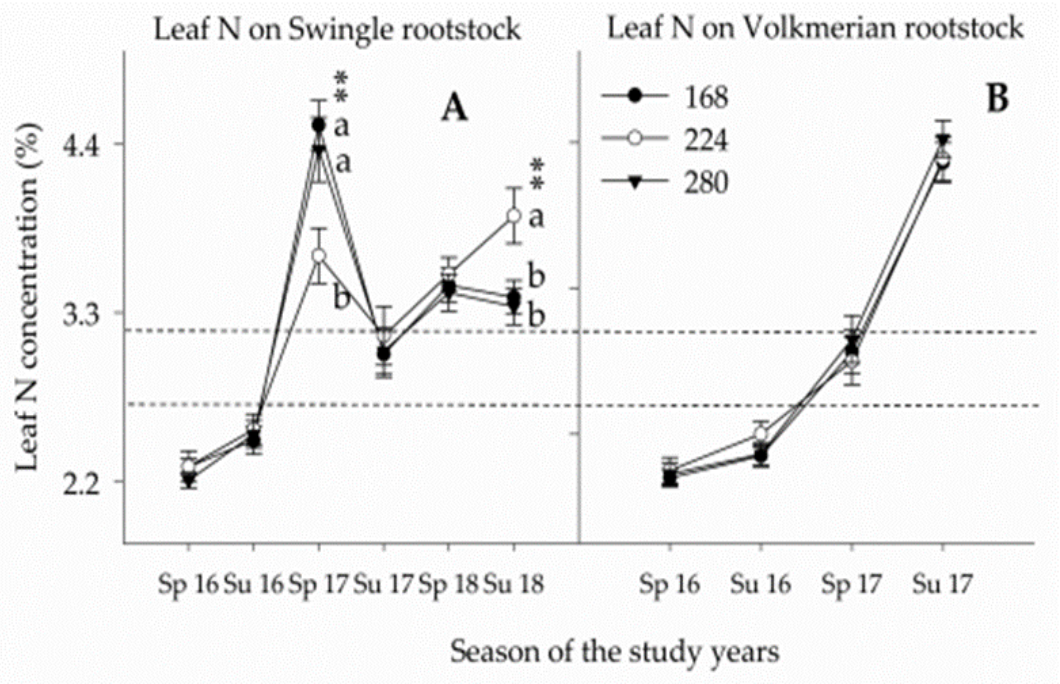
Soil NO_3 does not appear to be leaching below 15 cm (6 inches) because of the FAWN-based irrigation scheduling.



Improved N availability with fertigation at 150, 200 and 250 lbs/ac equivalent to 168, 224, 280 kg/ha, respectively.

A. Atta, K.T. Morgan, S.A. Hamido, D.M. Kadyampakeni (2020) Water and Soil Nutrient Dynamics of Huanglongbing-Affected Citrus Trees as Impacted by Ground-Applied Nutrients. Plants.

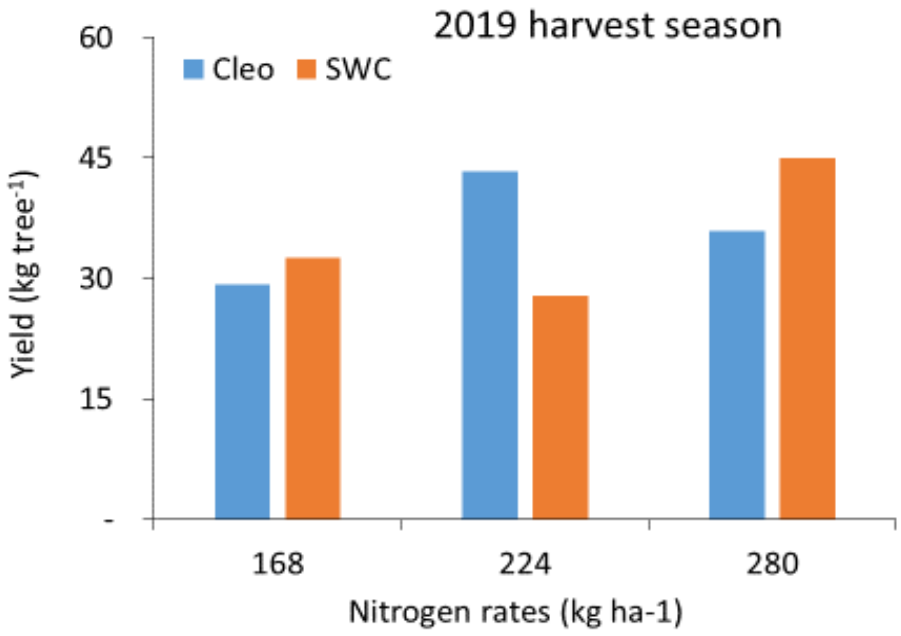
Improved leaf N with fertigation of N



Improved Leaf N with 150, 200 and 250 lbs per acre equivalent to 168, 224, 280 kg/ha, respectively.
No significant difference in leaf N among rates because they were in excess of the optimum N concentration 1 year after start of the project.

A. Atta, K.T. Morgan, S.A. Hamido, D.M. Kadyampakeni (2020) Water and Soil Nutrient Dynamics of Huanglongbing-Affected Citrus Trees as Impacted by Ground-Applied Nutrients. Plants.

Data showed significant differences, Cleo rootstock with highest yields at 200 lbs/ac and Swingle highest yields at 250 lbs N/ac.
Fruit yield varied by root stock within the same site. No size fits all.



Comparison of fruit yields between 150, 200 and 250 lbs N per acre equivalent to 168, 224, 280 kg/ha, respectively.

A.A. Atta, K.T. Morgan, D.M. Kadyampakeni and K.A. Mahmoud. 2020. The Effect of Foliar and Ground-Applied Essential Nutrients on Huanglongbing-Affected Mature Citrus Trees. Plants.

Improved fruit yield between 2018 and 2020 as a result of additional Ca and Mg at 150, 200 and 250 lbs N/ac.

	Fruit yield (boxes/acre)					
	Cleopatra			Swingle		
	2018					
	Nitrogen rates (lbs/acre)					
Macronutrients [1]	**150**	**200**	**250**	**150**	**200**	**250**
Control	86.3	77.4	77.4	82.3	78.4	111.1
Ca	98.2	68.5	78.4	81.3	73.4	135.9
Mg	95.2	89.3	96.2	82.3	75.4	98.2
Ca + Mg	109.1	77.4	107.1	92.2	83.3	117.1
	2019					
Control	97.2b	144.8	120.0	109.1	93.2	150.8
Ca	274.8a	153.8	170.6	100.2	114.1	152.8
Mg	216.3ab	165.7	208.30	148.8	109.1	110.1
Ca + Mg	256.9a	173.6	201.4	121.0	92.3	153.8
p-value	*	ns	ns	ns	ns	Ns
	2020					
Control	109.1	72.4	75.4	60.5	61.5	69.4
Ca	127.0	87.3	87.3	98.2	50.6	105.2
Mg	115.1	73.4	101.2	120.0	62.5	74.4
Ca + Mg	107.1	100.1	84.3	68.4	54.6	50.6

[1]Macros: Control (only N and other nutrients added), full calcium dose (Ca, 40 lb/ac), full magnesium dose (Mg, 40 lb/ac), and half calcium and half magnesium doses (Ca, 20 lb/ac + Mg, 20 lb/ac).

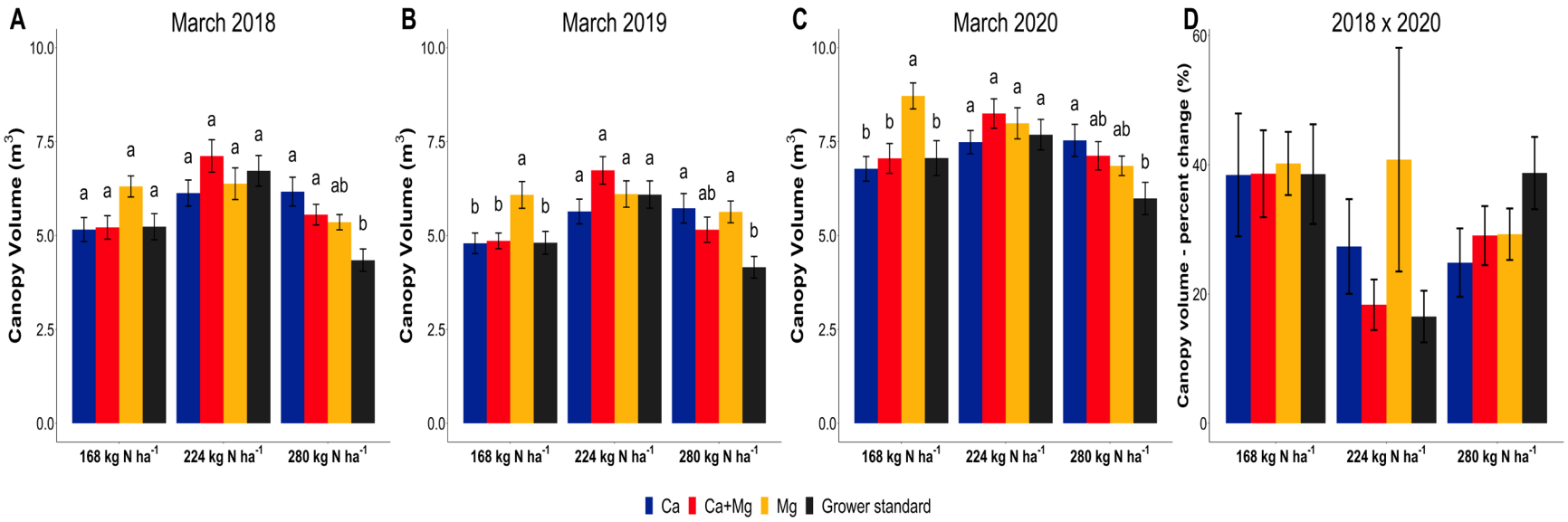
Kadyampakeni, D., E. Johnson, K. Morgan and A. Atta. 2021. Citrus Industry. September Issue, 2021.

Improved fruit yield between 2018 and 2020 as a result of improved micronutrient fertilization at 150, 200 and 250 lbs N/ac.

Treatment	Nitrogen rate, (lb/ac) 150	200	250
	Yield (boxes/ac)		
	2018		
Control	277.8 ± 1.0	262.9 ± 2.0	245.0 ± 3.0
Foliar x1	265.9 ± 3.0	240.1 ± 1.0	295.6 ± 3.0
Foliar x2	276.8 ± 1.0	251.0 ± 2.0	251.0 ± 4.0
Soil x1	237.1 ± 3.0	282.7 ± 5.0	270.8 ± 2.0
	2019		
Control	247.0 ± 1.0	212.3 ± 4.0	191.5 ± 3.0
Foliar x1	213.3 ± 3.0	201.4 ± 4.0	197.4 ± 2.0
Foliar x2	195.4 ± 2.0	180.5 ± 1.0	206.0 ± 4.0
Soil x1	197.4 ± 1.0	192.5 ± 4.0	171.6 ± 1.0
	2020		
Control	261.9 ± 2.0	291.7 ± 3.0	287.7 ± 3.0
Foliar x1	290.7 ± 0.0	283.7 ± 2.0	280.7 ± 5.0
Foliar x2	282.7 ± 4.0	300.6 ± 4.0	272.8 ± 2.0
Soil x1	278.8 ± 2.0	276.8 ± 3.0	310.5 ± 1.0

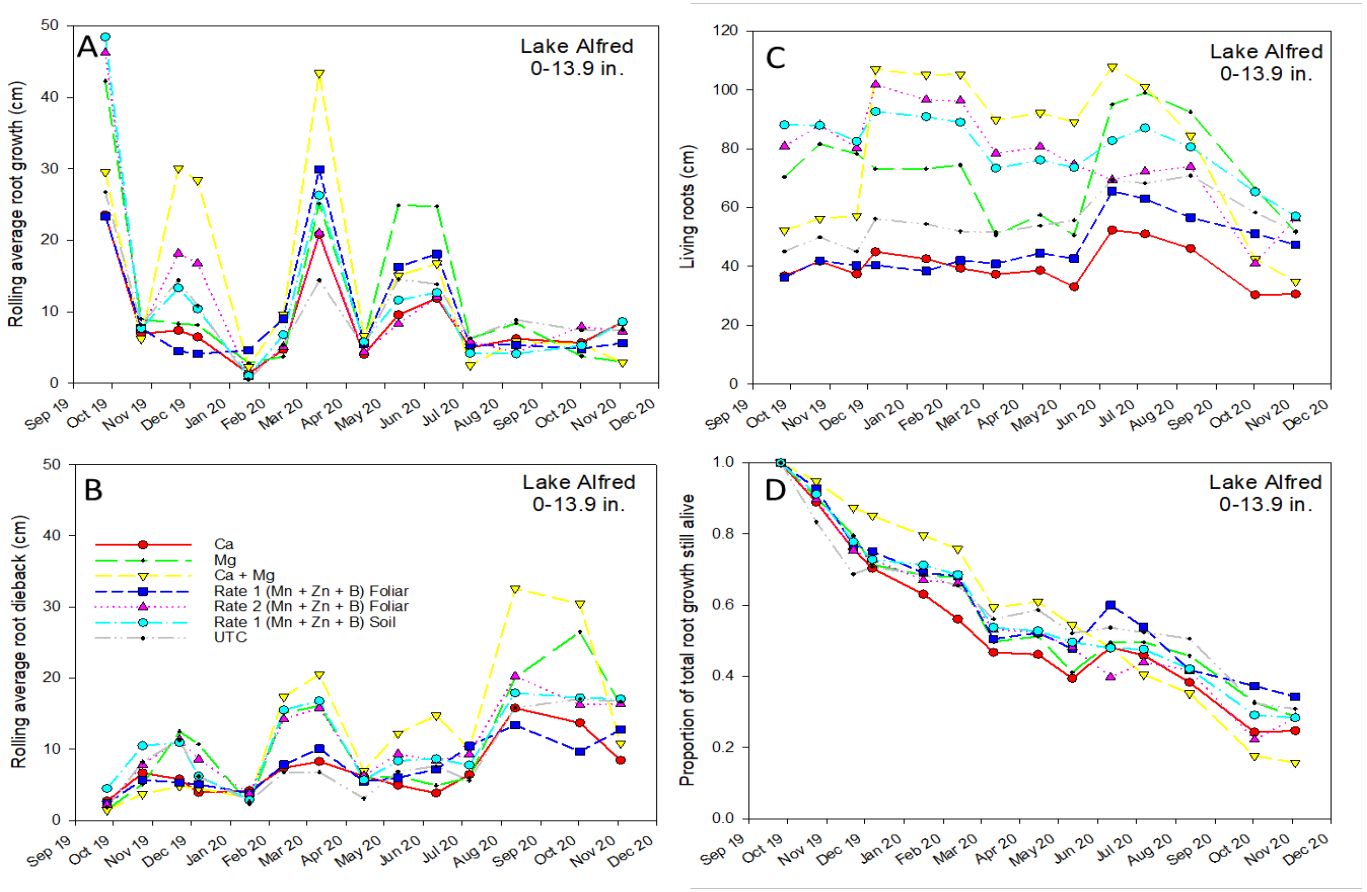
Treatments: Foliar x1 = standard soil Zn, Mn and B applied + foliar-applied Zn, Mn and B based at 1× UF/IFAS recommendations; Foliar x2= 2× foliar-applied Zn, Mn and B at UF/IFAS recommendations + standard soil Zn, Mn and B application; Soil 1x- 2× soil-applied UF/IFAS recommendations (8 lb/ac of Zn and Mn, and 1 lb/ac of B) source, Kadyampakeni et al.

Improved canopy volume between 2018, 2019 and 2020 as a result of additional Ca and Mg fertilization



E. Esteves, G. Maltais-Landry, F. Zambon, R. Ferrarezi and D. Kadyampakeni. 2021. Nitrogen, Calcium and Magnesium Inconsistently Affect Tree Growth, Fruit Yield and Juice Quality of Huanglongbing-Affected Orange Trees. HortScience

Root density is increased by foliar nutrient application because the tree is more efficient in soil nutrient applied uptake.



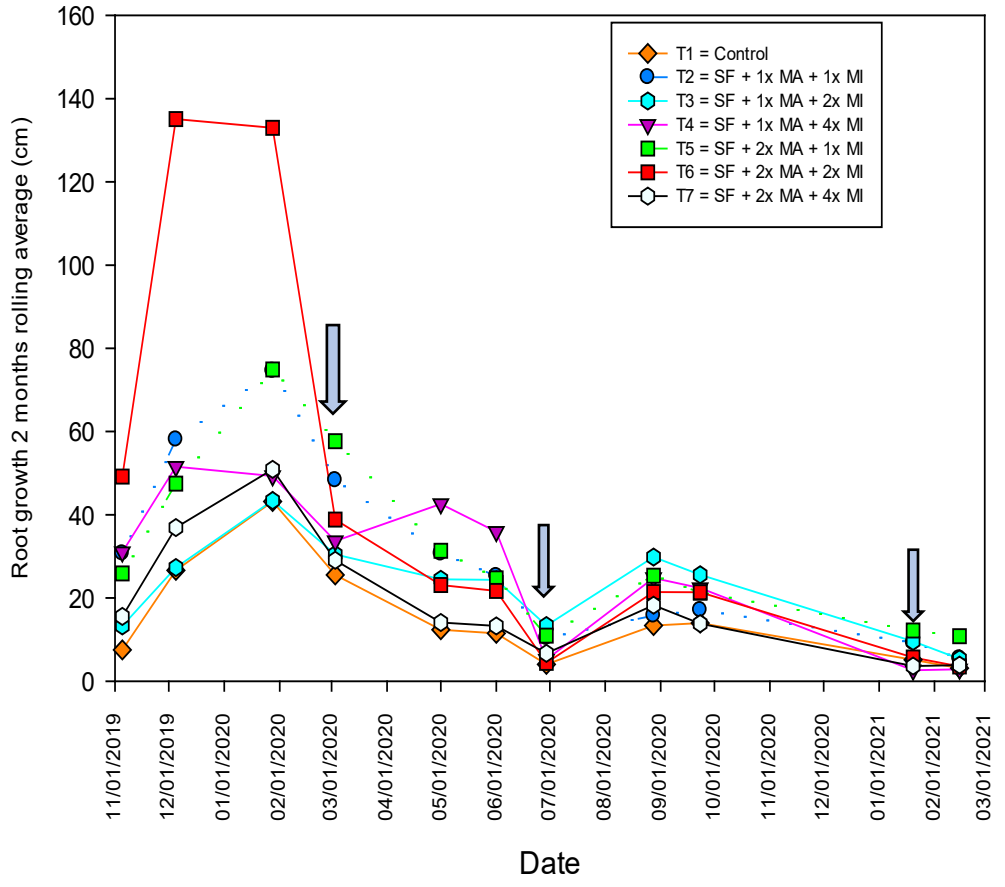
Kadyampakeni, D., E. Johnson, K. Morgan, A. Atta. 2021. Lessons on macronutrients and micronutrients on root health. Citrus Industry

Update on Root Nutrition and Fertilization Guidelines Project (3-year study)

Treatment number	Treatment
1	control with standard fertilization via fertigation of N, P, S, Mo, Cu fertilization according to UF/IFAS guidelines. No extra K, Mg, Ca, Mn, Fe, B, and Zn.
2	standard fertilization + 1X MA + 1x MI
3	standard fertilization + 1X MA + 2x MI
4	standard fertilization + 1X MA + 4x MI
5	standard fertilization + 2x MA + 1x MI
6	standard fertilization + 2x MA + 2x MI
7	standard fertilization + 2x MA + 4x MI

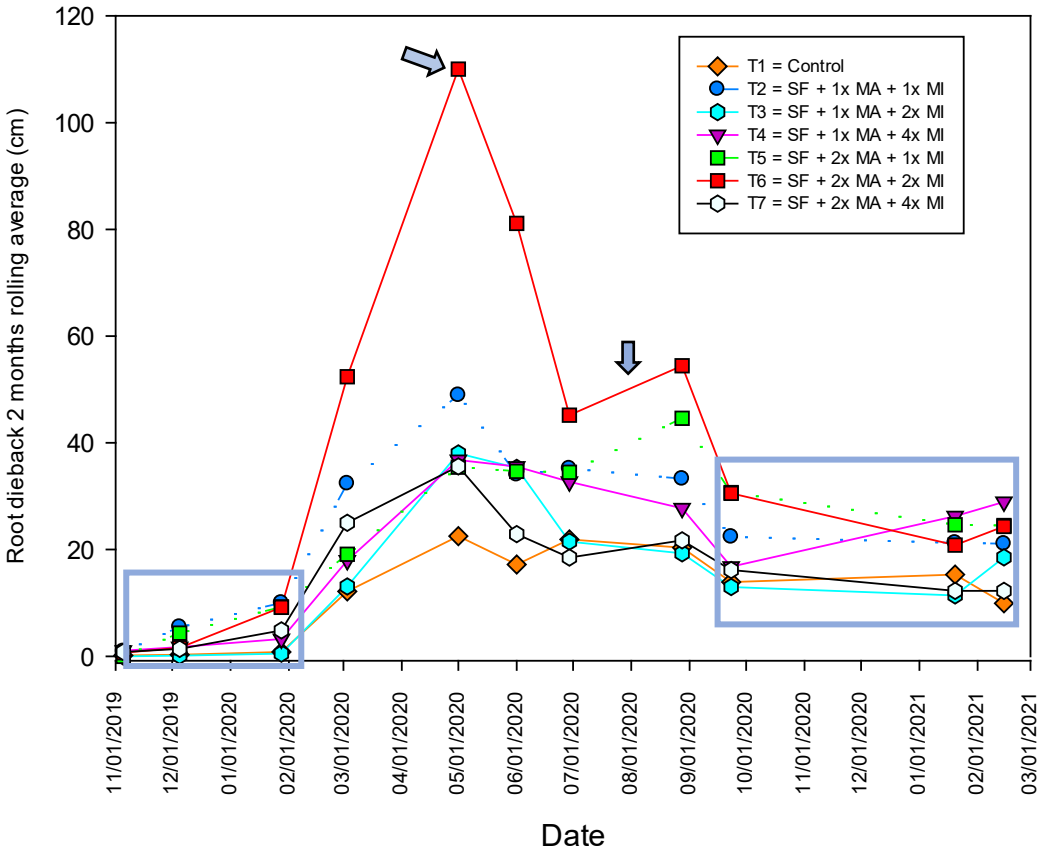
1x MA = 40 lbs./ac Ca and 220 lbs./ac K per year; 1x MI = 5 lbs./ac Fe and Zn per year.

Effect of varied fertilization rates on root growth at Flatwoods Site



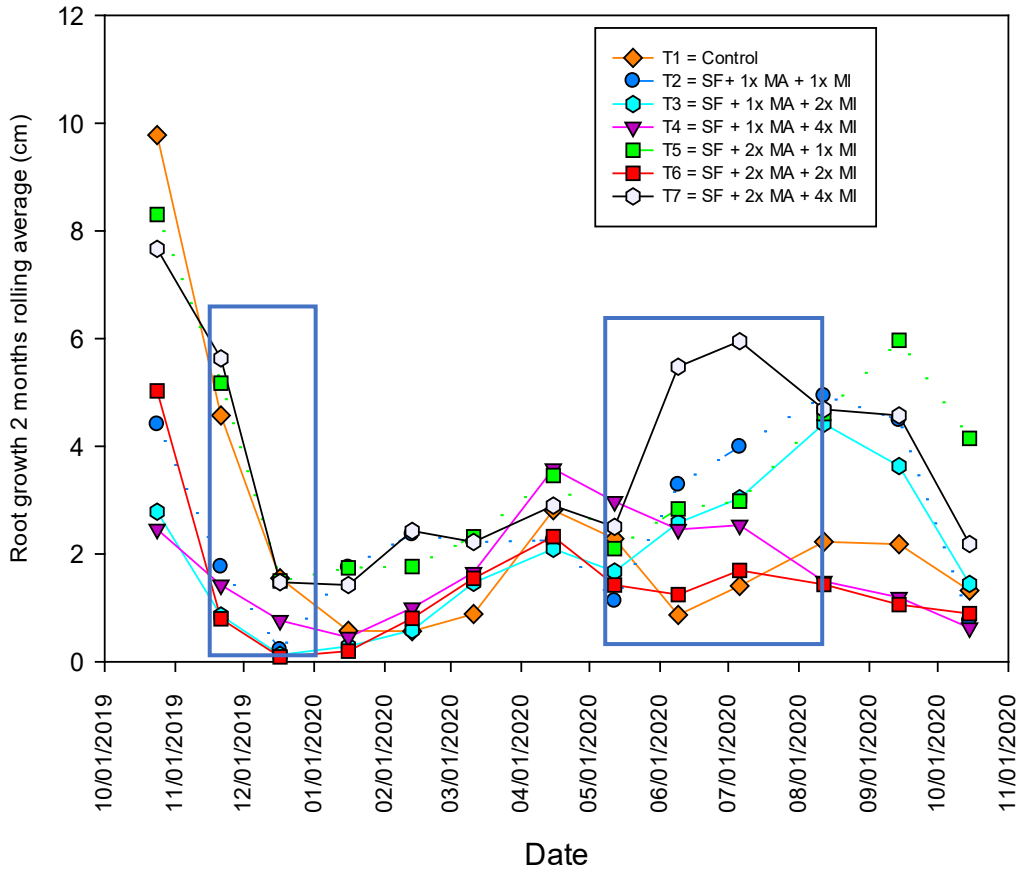
- Root growth increased from November 2019 till February 2020 (fall / winter season).
- Root growth decreased sharply at the beginning of the spring season (March 2020).
- By July 2020, root growth for all treatments had decreased.
- At the end of study (winter season), root growth had decreased again, and Treatment 5 had the greatest root growth.

EFFECT OF VARIED FERTILIZATION RATES ON ROOT GROWTH AT FLATWOODS SITE



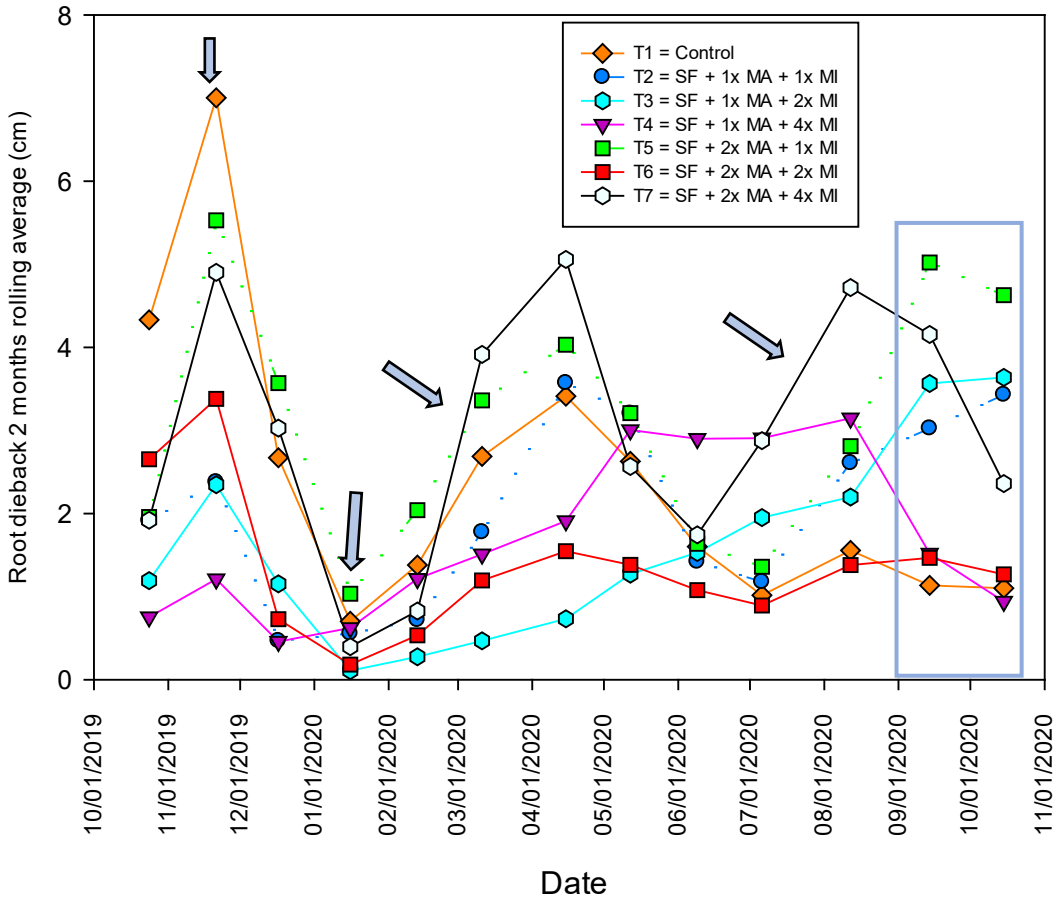
- Root dieback was reduced during the fall/winter season and during spring season.
- Root dieback increased sharply, with Treatment 6 having the greatest root dieback until summer 2020.
- Fall season prompted another increase in root dieback.
- Root dieback continued to decrease from mid-fall season of 2020 until the end of the study.

Effect of varied fertilization rates on root growth at Ridge Site



- Root growth decreased sharply from November 2019 to January 2020.
- Root growth increased during winter season until towards the end of spring season (April 2020) when decrease in root growth was observed.
- Throughout summer 2020, root growth at Ridge site increased for all treatments. However, root growth decreased once fall season had started.

EFFECT OF VARIED FERTILIZATION RATES ON ROOT DIEBACK AT RIDGE SITE



- Root dieback increased from November 2019 to December 2019.
- A sharp decrease in root dieback was observed during the winter season.
- Root dieback increased once spring season started.
- At the beginning of fall season 2020, root dieback began to decrease. Treatment 5 had the greatest root dieback.

Update on improved fertilizer blends and crop protection products (4-year study)

1	Program 1	Psyllid Control only
2	Program 2	Psyllid Control only
3	Program 1	Psyllid Control, Aliette soil
4	Program 2	Psyllid Control, Aliette soil
5	Program 1	Psyllid Control, Velum Prime soil
6	Program 2	Psyllid Control, Velum Prime soil
7	Program 1	Psyllid Control, Aliette and Velum
8	Program 2	Psyllid Control, Aliette and Velum

Update on improved fertilizer blends and crop protection products (4-year study)

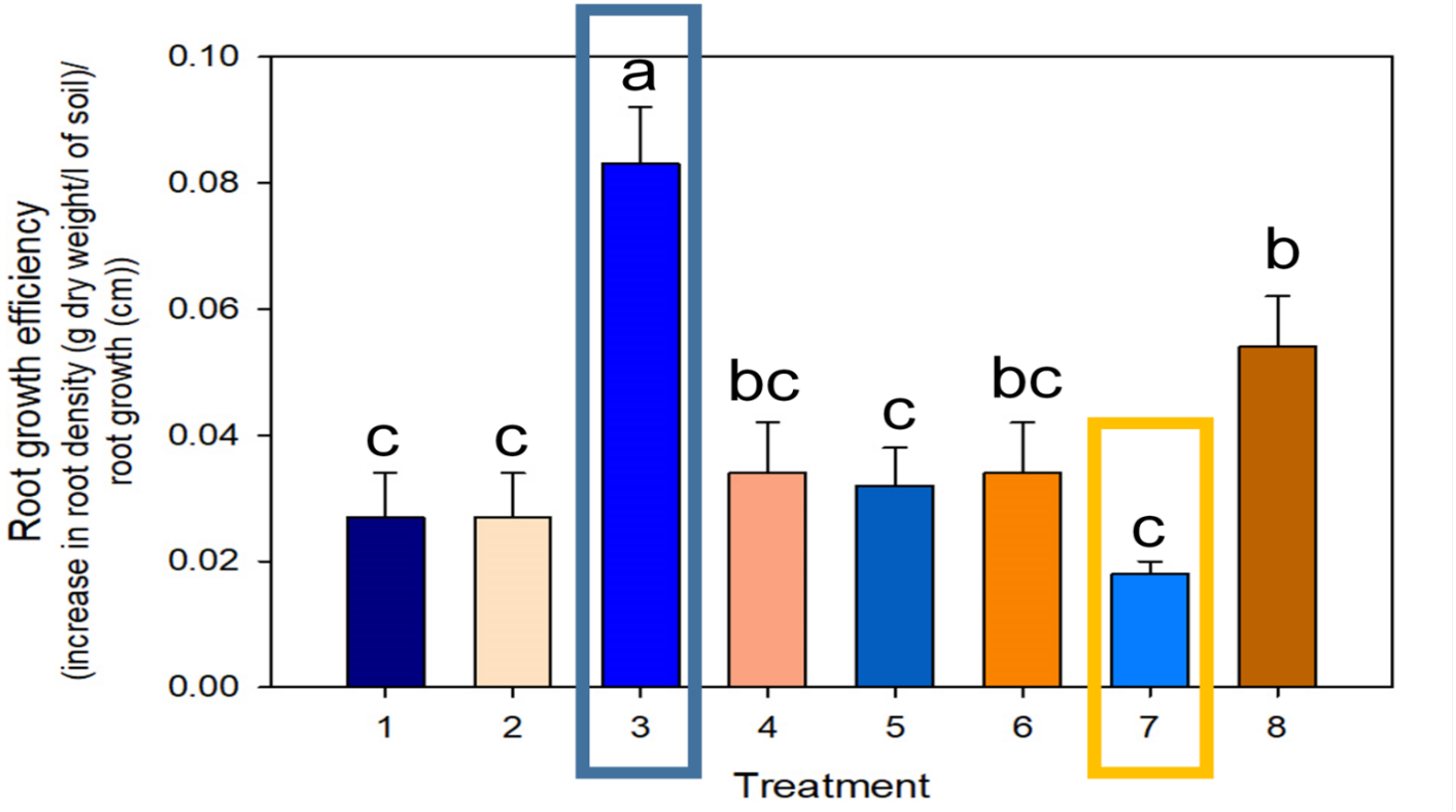
Program 1: 9-1-14 11Ca 7.6S 2Mg 0.08Zn, 0.04Mn 0.025B applied at 180 lbs N/a/yr applied in 4 splits.

Program 2: 16-2-16 composed of NH_4NO_3, diammonium phosphate and KCl. It is also applied at 180 lbs N/a/year. S, Mn, B and Zn are supplemented in 4 splits at equivalent rates supplied, but Ca and Mg are omitted.

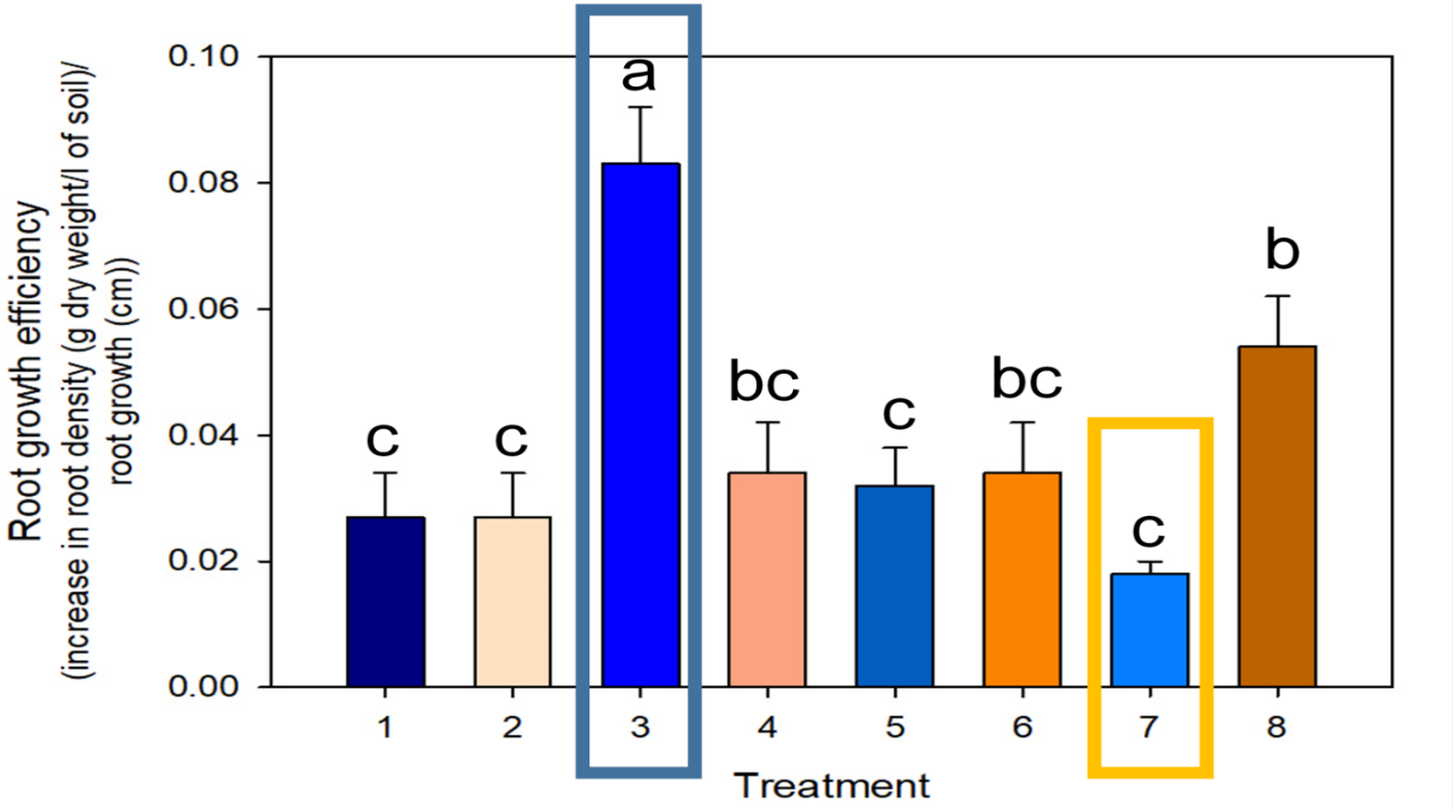
Aliette applied in 4 splits in May, June, July and August yearly at 5lbs/acre via microjet

Velum applied twice yearly between Feb/March and 6 weeks later at 6.8 fl oz/acre

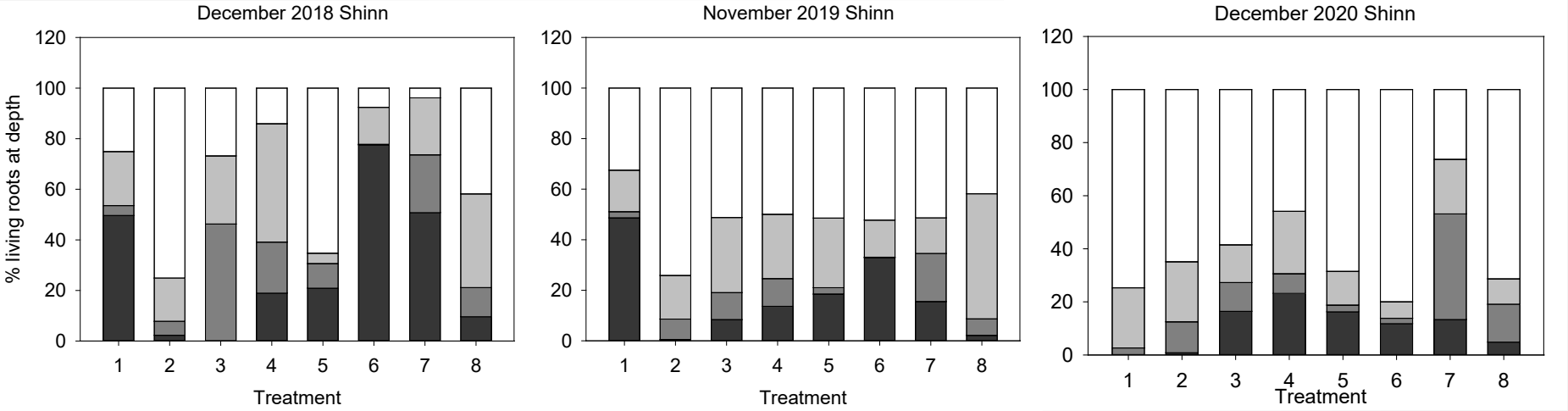
Improvements in root growth efficiency as a result of combined use of improved fertilizer blends and crop protection products



Improvements in root growth efficiency as a result of combined use of improved fertilizer blends and crop protection products



Percent of living roots at depth, roots increased with either 9:1:14 alone, or either blend with either Aliette or Velum and not a combination of Aliette and Velum.



- Odd = Program 1
- Even=Program 2
- 5-8 = Velum
- 3,4,7,8 = Aliette

- Treatments with Velum an/or Aliette have consistent portion of deep roots
- Program 1 fertilizer alone had strong deep roots until 2020 winter

Improvements in juice quality as a result of combined use of improved fertilizer blends and crop protection products. Brix at about >10.5 in some of the treatments with crop protection products.

Treat.	March 2019				April 2021			
	Lbs solids/ box	Brix	Acid	Ratio	Lbs solids/ box	Brix	Acid	Ratio
1	4.90	8.98	0.74	12.25	5.28	9.95	0.56	17.94
2	5.54	10.20	0.74	13.85	5.31	9.97	0.61	16.78
3	4.93	9.17	0.70	13.11	5.62	**10.56**	0.58	18.20
4	5.58	10.20	0.77	13.21	5.60	**10.53**	0.54	19.59
5	4.98	9.25	0.73	12.70	5.54	**10.49**	0.53	20.06
6	5.40	10.06	0.74	13.72	5.63	**10.57**	0.59	17.99
7	5.01	9.27	0.77	12.07	5.48	10.33	0.60	17.38
8	4.76	8.92	0.77	12.17	5.30	10.19	0.52	19.51
Sign.	ns	ns	ns	ns	ns	ns	ns	ns

Improvements in yield as a result of combined use of improved fertilizer blends and crop protection products. Yields between 180 to 293 boxes per acre and yield per tree: 0.63 to 1.01 boxes.

Treatment	Mar-19		Apr-20	Apr-21	
	Fruit yield per tree (boxes)	Fruit yield (boxes/acre)	Fruit yield (boxes/acre)	Fruit yield per tree (boxes)	Fruit yield (boxes/acre)
1	0.95a	274.2	115.7	1.01a	292.4
2	0.94a	272.1	107	0.63c	183.2
3	0.75b	217.9	115.9	0.90ab	259.9
4	0.84ab	243.8	127.2	0.74bc	215.8
5	0.97a	279.4	119	0.83ab	241
6	0.98a	284.1	117	0.89ab	257
7	0.95a	274.1	120.9	0.78bc	225.2
8	0.91ab	263.4	115.7	0.85ab	244.5
Sign.	***	ns	ns	***	ns

Summary

- Current data suggests the need to update secondary macronutrient and micronutrient guidelines for HLB-affected trees for improved yield, improved canopy size and juice quality.

- It is good to note the lag time for nutrient applications to show effect on yield, juice quality, canopy and trunk size.

Summary (2)

It good to note the lag time for nutrient applications to show effect in yield, canopy and trunk size.

Use of bi-weekly fertigation kept soil nitrate in the top 6-inches.

Aim to keep leaf macronutrients and micronutrients at optimum to high ranges.

Consider using a combination of improved fertilizer blends and crop protection products for improved juice quality and root density.

Acknowledgments

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- Drs. E. Johnson (CREC)
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- Soil and Water Sciences Labs in Immokalee and Lake Alfred; Root Pathology Lab in Lake Alfred.