Lessons on yield and root health from modified nutrition

By Davie Kadyampakeni, Evan Johnson, Kelly Morgan and Ali Atta

Citrus production in Florida has been decreasing over the last 15 years due to several factors, with huanglongbing (HLB) a major driver. This disease has severe effects on citrus growth and production, including stunted vegetative growth, misshapen small fruits and poor color development, root mortality, stunted branches, excessive fruit drop, severe leaf defoliation and plant mortality.

Nutrition plays an important role in plant defense mechanisms against multiple pests and diseases; well-fertilized plants are less susceptible than nutrient-deficient ones. Recent evidence suggests that HLB symptoms in citrus can be reduced with a balanced nutritional program, including improved irrigation, fertigation and nutrient management. Thus, limiting the effects of HLB by focusing on nutrient management can help keep commercial growers in production until commercially available resistant citrus varieties or long-term chemical solutions are developed. This article highlights the results of the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) research conducted on the Ridge and Flatwoods sites to evaluate the effect

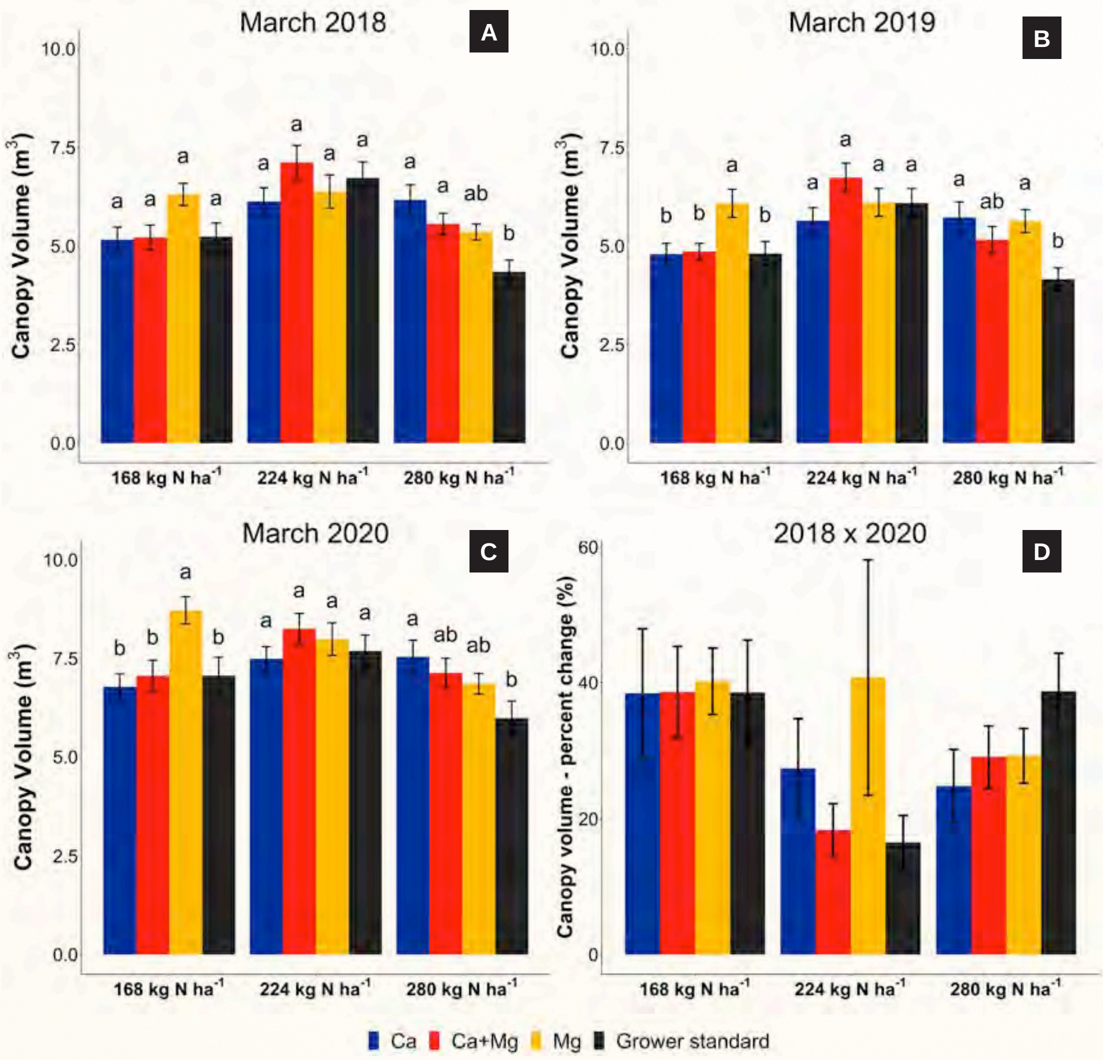

Figure 1. The effect of secondary macronutrients on yield of HLB-affected Valencia citrus tree by nitrogen rate in 2018 (A), 2019 (B) and 2020 (C). Graph D represents effect of plant nutrition on the percentage change of yield for HLB-affected trees between 2018 and 2020. Bar plots represent mean of original data, and error bars represent standard errors. Treatments sharing a given letter within each nitrogen rate are not statistically different. No letters are shown as differences among treatments that were not statistically significant. Treatments: Control = only N and other nutrients added, Ca = full calcium dose (40 pounds per acre), Mg = full magnesium dose (40 pounds per acre) and Ca + Mg = half calcium (20 pounds per acre) and half magnesium (20 pounds per acre) doses. The 168, 224 and 280 kg N/ha are equal to 150, 200 and 250 pounds N per acre, respectively.

Table 1. Three years of fruit yield of huanglongbing-affected Valencia sweet orange grove in Lake Alfred, Florida

	Nitrogen Rate (pounds per acre)		
Treatment	150	200	250
	Yield (boxes per acre)		
	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 1x UF/IFAS recommendations
Foliar x2 = 2x foliar-applied Zn, Mn and B at UF/IFAS recommendations + standard soil Zn, Mn and B application
Soil x1 = 2x soil-applied UF/IFAS recommendations (8 pounds per acre of Zn and Mn, and 1 pound per acre of B).

of macronutrient and micronutrient fertilization on fruit yield, juice quality and root health.

RIDGE SITE

Effects on Fruit Yield

Nitrogen (N) rates and secondary macronutrient treatments did not significantly influence fruit yields, although yields increased with time (Figure 1, page 22). Nitrogen rates did not have a significant effect when yields were analyzed by year.

Secondary macronutrient effects on yield were not statistically significant when tested within each N rate in March 2018 and 2019. Percent yield change was similar to current recommendations among secondary macronutrient treatments.

Yield showed an inconsistent pattern in response to zinc, manganese and boron rates, application methods and N rates in all three years of data collection (Table 1). There were no significant differences in various treatments applied, but the fruit weight pattern for 2018 and 2020 was 1.5 times greater than that of 2019, which may be largely due to the alternate bearing observed in Valencia orange trees. The various levels of N and micronutrient application rates and methods had no significant effect on the percentage total soluble solids (TSS/Brix), acid and TSS/acid ratio. This finding serves as a reminder that quality is often lost with increased yield.

Effects on Root Health

During much of the 2020 growing season, the calcium (Ca) + magnesium (Mg) treatment appeared to have the most beneficial effects on root growth and longevity at all N rates (Figure 2A and Figure 2D, page 24). However, the poor initial live root length and the rapid dieback in the fall of 2020 suggest this response may be related to alternate bearing (Figure 2B and Figure 2C, page 24). The Ca and foliar 1x rates had the lowest healthy root length throughout the experiment, with the Ca treatment having consistently poor root longevity.

In contrast, the currently recommended rate of soil micronutrients provided the most consistent healthy root length and moderate to good root longevity. The double rate of foliar micronutrients improved the living root length through increased root growth but had moderate to poor root longevity depending on season and year.

Surprisingly, all treatments monitored had a very poor fall root flush in 2020. This will continue to be monitored to determine if this is related to alternate bearing or other effects.

FLATWOODS SITE

Effects on Fruit Yield

The first fruit harvest of this experiment was performed immediately after the trees lost all their fruit following Hurricane Irma in September 2017 (Table 2). There was a significant rootstock effect but no treatment effect on the fruit yield. In 2018, there was 11%, 64%, 56% and 57% greater fruit yield for trees budded on Cleopatra than Swingle rootstocks attributed to the control trees, Ca or Mg, or Ca and Mg combined treated trees, respectively. In 2020, there was 47%, 56%, 46% and 55% greater fruit yield for trees budded on Cleopatra than Swingle rootstocks attributed to the control trees, Ca, Mg,

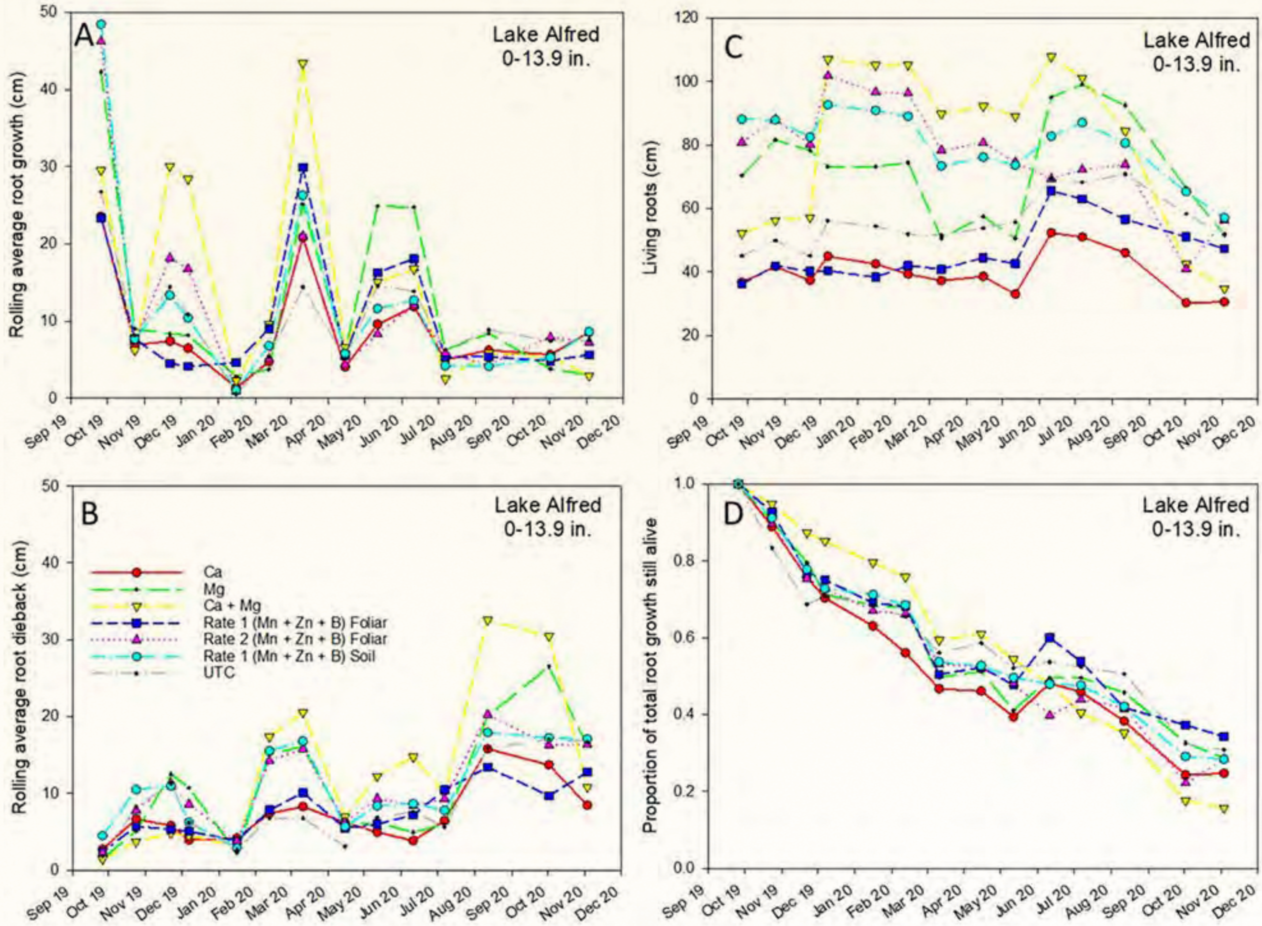

Figure 2. Root dynamics from the Lake Alfred site show differences in seasonal (A) root growth and (B) root dieback that can be used to determine the (C) length of living roots at each scan time and (D) the proportion of root growth that is still alive at each scan date. A shallower curve represents longer root longevity, and a steeper curve represents shorter root lifespan.

Table 2. Three years of fruit yield of huanglongbing-affected Hamlin sweet orange grove in Immokalee, Florida

	Fruit Yield (boxes per acre)					
	Cleopatra			**Swingle**		
	2018					
	Nitrogen Rates (pounds per 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
	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]Macronutrients:
Control = only N and other nutrients added
Ca = full calcium dose (40 pounds per acre)
Mg = full magnesium dose (40 pounds per acre)
Ca + Mg = half calcium (20 pounds per acre) and half magnesium (20 pounds per acre) doses

or Ca and Mg combined treated trees, respectively.

There was severe fruit drop in the 2020–2021 harvest season. On three years' fruit yield average, there were 1.7x, 1.5x and 1.6x under 150 pounds per acre N rate; 1.1x, 1.1x and 1.2x under 200 pounds per acre N rate; and 1.2x, 1.5x and 1.4x under 250 pounds per acre N rate greater fruit yield on the Ca, Mg or Ca + Mg treated trees than the control trees for trees budded on Cleopatra rootstocks, respectively. Similarly, there were 1.1x, 1.4x and 1.1x greater yield under 150 pounds per acre N rate; 1.0x, 1.1x and 1.0x under 200 pounds per acre N rate; and 1.2x, 0.8x and 1.0x under 250 pounds per acre N rate on the Ca, Mg or Ca + Mg treated trees than the control trees for trees budded on Swingle rootstock, respectively.

Effects on Root Health

The total fibrous root length density (FRLD) of Hamlin citrus trees budded on Cleopatra and Swingle rootstocks was significantly lower in spring than in the summer and fall seasons of 2018. The peak root growth was observed in April/May and August/September.

Thus, the Ca nutrition generated significantly greater FRLD of the secondary macronutrients for trees budded on Cleopatra rootstocks and the Ca and Mg combined nutrition for trees budded on Swingle rootstocks. This result contributed the highest portion of the FRLD and was significantly higher during the summer and fall than the spring season. The FRLD dynamics and distribution resumed during the second year with a slight decrease in the fall cold season. Similarly, the FRLD of Hamlin citrus trees budded on Cleopatra was continuously influenced by Ca nutrition and on Swingle rootstocks for trees treated with Ca and Mg combined nutrition.

SUMMARY

Results showed yield increments over time and significant improvement in root health. Combined use of macronutrients and micronutrients appears to improve root growth and fruit yield, thereby helping citrus trees stay productive.

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