An update on UF/IFAS–grower citrus nutrition trials

By Tripti Vashisth

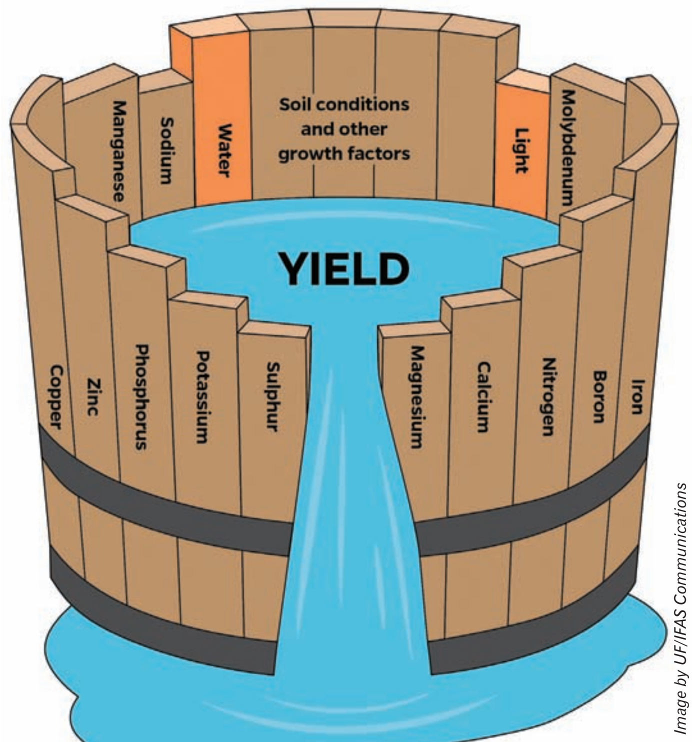

Figure 1. A leaky water barrel shows that yield is dependent on a number of factors and on Liebig's Law of the Minimum, which states that "growth is controlled not by the total amount of resources available, but by the scarcest resource."

Mineral nutrition plays an essential role in a plant's life cycle and is critical for its growth and development. Since the early 19th century, the importance of mineral nutrition for plants has been recognized, and fertilization has become an important aspect of crop production. At least 17 mineral nutrients are considered essential for plants. These include carbon, hydrogen and oxygen, which are absorbed from air and soil. The remaining mineral nutrients can be divided into macronutrients and micronutrients (Table 1, page 22). They are both equally essential, but the amount in which they are required classifies them as macronutrients or micronutrients.

Liebig's Law of the Minimum is an important concept in agricultural sciences that cannot be underestimated. According to this law (Figure 1), the growth and productivity of a plant is limited by the scarcest available nutrient, and overdosing of other nutrients cannot improve the productivity unless all the nutrients are supplied in adequate amounts. Therefore, when formulating a fertilization program, care must be taken in including all the macronutrients and micronutrients in the right proportion.

Huanglongbing (HLB) has been prevalent in Florida groves since 2007–2008. Citrus production has been declining constantly, and the April 2017 U.S. Department of Agriculture estimate was 67 million boxes of oranges for this season.

A majority of growers have been proactive with psyllid control sprays to control the spread of HLB. In addition to vigorous use of insecticides, growers are opting for enhanced fertilization programs. Preliminary studies and anecdotal evidence suggest that citrus groves on good, balanced and enhanced fertilization programs perform better, even in the presence of HLB, than the groves that are on marginal fertilization programs.

Recent research on HLB and root health suggests that up to 50 percent of fibrous root loss occurs during early infection stages of HLB. Research on root health, soil pH, bicarbonate stress and HLB indicates that in groves where soil pH is high and the irrigation water contains bicarbonates, increased HLB symptoms and severely declining trees are found. Leaf and soil nutrient analysis of such groves exhibits a reduced root uptake of calcium, magnesium, potassium and iron. It is well known in crop systems that high soil pH can interrupt nutrient uptake by roots and exacerbate plant stress. All these research and preliminary studies suggest that with the advent of HLB, plant nutrient uptake physiology and capacity is compromised. Therefore, enhanced nutrition may prolong the productivity of trees.

Since 2008, a number of citrus growers have used enhanced foliar nutritional sprays, soil amendments, and micronutrient and macronutrient programs to supplement the ground fertilization programs. Currently, many fertilizer or nutritional products are being advertised that claim to be beneficial. These products are gaining popularity and are being applied in Florida citrus groves without close scrutiny or valid comparisons with proper controls. According to production cost analysis by Ariel Singerman, University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) Extension economist, fertilizers and foliar nutritional products constitute a significant percent of total citrus production costs (approximately 20 to 25 percent).

In 2015–2016, citrus fertilization field trials were initiated. The goal of these trials is to scrutinize the effectiveness of a few promising products (Harrell's controlled-release fertilizer, Tiger® micronutrient mix and foliar nutritional sprays) and to quantify improvements to citrus tree health and productivity. These trials are being conducted in collaboration with Florida citrus growers for a duration of three years at commercial citrus groves.

This article presents the results of year 1 for informational purposes. A minimum of 2 to 3 years of data should be considered before making any changes to a fertilization/nutrition program. It is also recommended that before making any changes to a fertilizer program, leaf and soil nutrient analysis, along with soil and irrigation water pH analysis, should be performed and taken into consideration.

Table 1. Relative essential mineral element composition of a 6-year-old Hamlin orange tree (excluding chloride and nickel). Bolded nutrients are considered macronutrients, and the rest are micronutrients.

Element	Number of atoms relative to molybdenum	Percent of total tree dry weight
Molybdenum	1	0.00003
Copper	100	0.002
Manganese	200	0.003
Zinc	300	0.006
Iron	600	0.010
Boron	800	0.002
Sulfur	11,000	0.096
Phosphorus	13,000	0.116
Magnesium	18,000	0.120
Potassium	66,000	0.728
Calcium	98,000	1.096
Nitrogen	237,000	0.932

Source: Nutrition of Florida Citrus Trees, Second Edition. Edited by Thomas A. Obreza and Kelly T .Morgan (Derived from Mattos et al., 2003).

TRIAL TYPES

UF/IFAS-grower nutrition trials were set up at two commercial grove locations in Central Florida. The trial sites included blocks of sweet orange on Swingle rootstock and were 15 to 18 years of age. The trials at both locations were started in late February and early March of 2016, and first-year harvest was done in February 2017. At each site, two subtrials were set up based on ground and foliar application.

Trial 1 is comprised of the following ground treatments:

A. **Grower's standard fertilization or grower's control** (200 pounds of nitrogen per acre). This includes ground application of dry, granular, conventional fertilizer (N-P_2O_5-K_2O-Ca-Mg-Fe) and foliar application of micronutrients [manganese (Mn), zinc (Zn), iron (Fe) and boron (B)].

B. **Controlled-release fertilizer [(CRF), Harrell's fertilizer]**. CRF can provide a slow and constant supply of nutrients to the tree root system. Harrell's CRF (N-P_2O_5-K_2O- Ca-Mg-Fe; 175 pounds of nitrogen per acre) was compared to the grower's standard, ground-applied fertilizer programs (control ground application). Foliar sprays were applied in the same form and concentration as in the grower's control to supply Mn, Zn, Fe and B.

C. **Tiger® micronutrient mix.** Preliminary studies have shown that Tiger® micronutrient mixes have been effective in improving nutrient uptake by adjusting the soil pH and providing a slow release of nutrients. For these trials, a custom blend was formulated of four minor elements: Mn, Zn, Fe and B (6-6-3-1). The Tiger® micronutrient mix was compared to the grower's standard, foliar micronutrient application, while the grower's control — ground dry, granular, conventional fertilizer (N-P_2O_5-K_2O-Ca-Mg-Fe) — was applied to this treatment to supply nitrogen, phosphorus, potassium, calcium, magnesium and iron (N-P-K-Ca-Mg-Fe).

D. **Harrell's CRF + Tiger micronutrient mix.** This treatment is a combination of treatments B and C. It did not receive any component of the grower's control fertilization and was compared to the grower's control fertilization program (including ground and foliar treatments). In this treatment, all the nutrients were supplied from Harrell's (N-P-K-Ca-Mg-Fe) or Tiger micronutrient blend (Mn, Zn, Fe and B).

Trial 2: Foliar micronutrient – sulfate vs. nitrate vs. glucoheptonate (chelate) form. This trial targets a comparison among different chemical forms of micronutrients to determine differences in uptake efficiency and growth enhancement. For this trial, the concentration of all the nutrient (Mg, Mn, Zn and Fe) active ingredients was kept constant to establish a fair comparison among different formulations of the micronutrients.

FIRST YEAR RESULTS

Trial 1 (ground-applied fertilizer). Figure 2 (page 24) shows the average yield in pounds for both the locations for trial 1. There were no statistical differences among the grower's control, Harrell's CRF, Tiger micronutrient mix and the Harrell's + Tiger micronutrient combination treatments. There was a

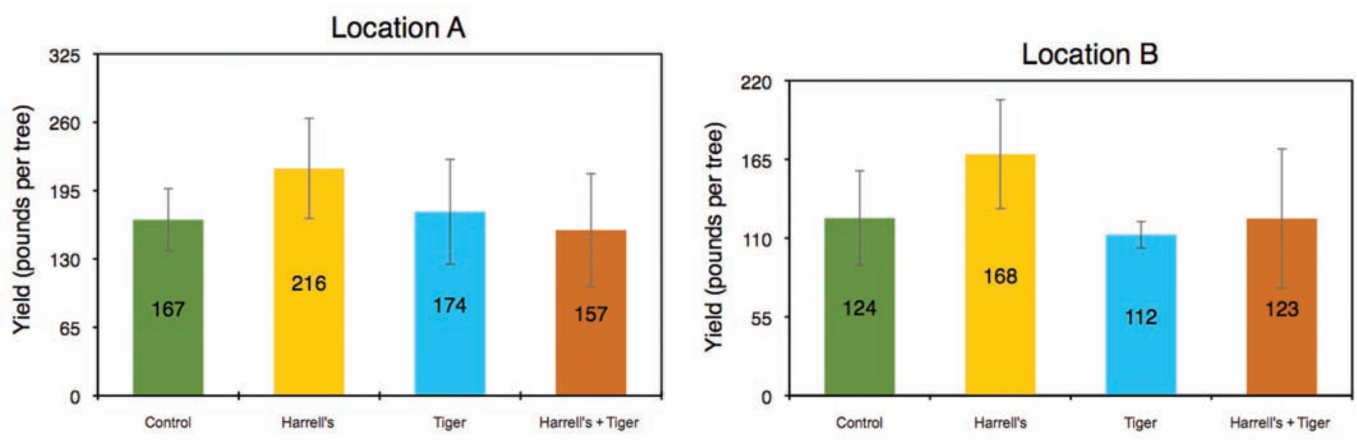

Figure 2. Average yield in pounds for trial 1 (ground treatments). The four treatments were: grower's control (grower's dry, conventional fertilizer + grower's foliar spray), Harrell's CRF (+ grower's foliar spray), Tiger micronutrient blend (+ grower's dry, conventional fertilizer) and Harrell's CRF + Tiger micronutrient.

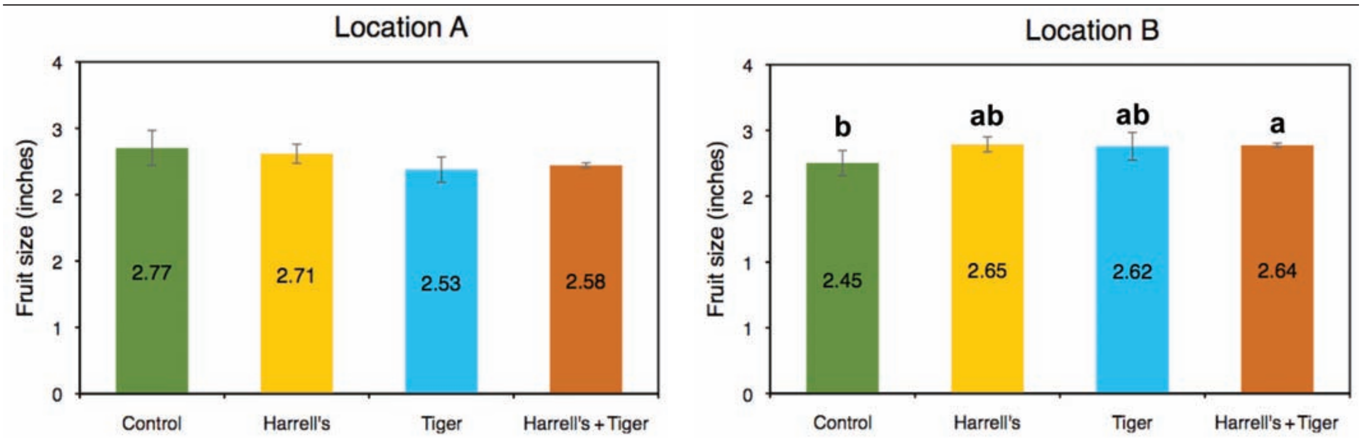

Figure 3. Average fruit size in inches for trial 1 (ground treatments). The four treatments were: grower's control (grower's dry, conventional fertilizer + grower's foliar spray), Harrell's CRF (+ grower's foliar spray), Tiger micronutrient blend (+ grower's dry, conventional fertilizer) and Harrell's CRF + Tiger micronutrient. Average yield for location A was significantly higher than average yield for location B.

**Sets of bars with different letters indicate statistically significant differences between treatments within a location.*

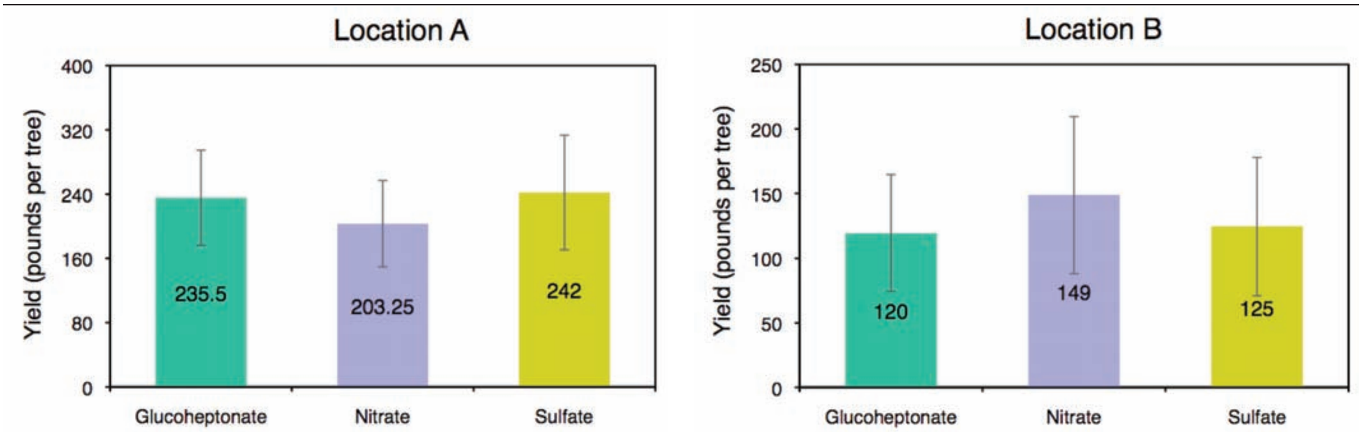

Figure 4. Average yield in pounds for trial 2 (foliar micronutrient treatments). The three treatments were: glucoheptonate, nitrate and sulfate of magnesium, manganese, zinc and iron. The ground N, P, K, Ca and Mg treatments were the same for the three treatments.

significant difference among the yield at the two locations. Location A produced about an average of two boxes of fruit per tree; location B produced approximately 1.25 to 1.5 boxes per tree. Interestingly, at both locations, a trend of Harrell's CRF performing slightly better average yield (not statistically different) than the grower's control fertilizer was observed.

Florida soils are low in nutrient holding and cation exchange capacity, and it is well understood that HLB causes a significant amount of fibrous root loss. Therefore, a constant supply of nutrients by using CRF seems to be beneficial for the trees. A significant difference in fruit size among the grower's control and Harrell's + Tiger treatment was observed at location B, but no such difference occurred at location A (Figure 3). No significant differences were

Table 2. Average total soluble solids (°Brix) and pre-harvest fruit drop (%) for trial 1 (ground treatments) at locations A and B. The four treatments were: grower's control (grower's dry, conventional fertilizer + grower's foliar spray), Harrell's CRF (+ grower's foliar spray), Tiger micronutrient blend (+ grower's dry, conventional fertilizer) and Harrell's CRF + Tiger micronutrient.

Treatments	Pre-harvest Fruit Drop (%)		Total Soluble Solids (°Brix)	
	Location A	Location B	Location A	Location B
Control	10.1	32.6	11.6	9.3
Harrell's	9.6	15.4	11.5	10.5
Tiger	7.9	29.2	12.6	10.1
Harrell's + Tiger	11.9	22.0	12.4	9.5

Table 3. Average total soluble solids (°Brix), fruit size (inches) and pre-harvest fruit drop (%) for trial 2 (foliar treatments) at locations A and B. The three treatments were: glucoheptonate, nitrate and sulfate of magnesium, manganese, zinc and iron. The ground N, P, K, Ca and Mg treatments were the same for the three treatments.

Treatments	Pre-harvest Fruit Drop (%)		Fruit Size (inches)		Total Soluble Solids (°Brix)	
	Location A	Location B	Location A	Location B	Location A	Location B
Glucoheptonate	12.1a*	24.8	2.7	2.5	11.8	9.9
Nitrate	9.4b	20.9	2.8	2.5	12.0	10.3
Sulfate	12.8a	25.3	2.7	2.6	12.0	10.2

*Means followed by different lowercase letters indicate statistically significant differences between treatments within a location.

observed in the pre-harvest fruit drop percentage between any treatments. However, on average, location B seemed to have more pre-harvest fruit drop (16 to 33 percent) while location A displayed 8 to 11 percent fruit drop (Table 2). Total soluble solids (°Brix) were unaffected by the treatment at either location (Table 2).

Trial 2 (Foliar micronutrient – sulfate vs. nitrate vs. glucoheptonate (chelate) form). Figure 4 (page 24) shows the average yield in pounds per tree for trial 2 at both locations. No significant differences were observed among yields of treatments at either location. Overall, location A had higher yield (pound per tree) than location B. Location A produced, on average, more than two boxes per tree, whereas location B produced less than 1.5 boxes per tree. Moreover, no obvious/consistent trend for yield was observed for different treatments between the two locations.

No significant differences or trends were observed in fruit size or total soluble solids in fruit from different foliar treatments (Table 3, page 26). Nitrate treatment was found to have, on average, less pre-harvest fruit drop than sulfate and glucoheptonate treatments at both locations, but was statistically significant only at location A (Table 3, page 26).

SUMMARY

Overall, first-year harvest results for both the locations have been as expected. We did not see any significant differences between the different treatments in year 1. These trials are being conducted on mature trees with large root and shoot systems. It can take up to three years for any nutritional/fertilizer program to impact health and productivity of a mature citrus tree. Year 1 data from these trials suggests that a good fertilization program can positively affect the yield and quality of fruit.

Controlled-release fertilizer seems to be beneficial for HLB-affected trees because it provides a constant supply of nutrients. When applying CRF, the nitrogen rate can be reduced by 10 to 20 percent as CRF has minimal leaching of nutrients. It is evident from the results that the pre-existing condition of trees, groves and grove location make a significant difference in the yield and productivity of the trees. Therefore, fertilization programs should be grove-specific, as there can be location and treatment interactions.

The results presented in this article are for informational purposes only. At minimum, three years of data should be scrutinized before making any recommendations for changing fertilizer/nutritional programs.

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