Nutrition: No one size fits all

By Tripti Vashisth

Constant supply and soil application of macronutrients and micronutrients can improve the health and productivity of HLB-affected citrus. A 20 to 50 percent higher than University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) recommended rate of micronutrients is beneficial for HLB-affected trees. However, the nutrition program should be customized for each grove, as no one size fits all.

Mineral nutrition plays an important role in metabolic and physiological processes such as growth and development of plants, fruit development and plant-defense response. Field observations have shown that there is a positive correlation between sulfur fertilization and enhanced resistance against fungal pathogens.

Use of elemental sulfur is also effective in bringing down soil pH. The recommended soil pH range for Florida citrus is 5.8 to 6.5. High soil pH limits nutrient availability, especially of micronutrients such as manganese (Mn), zinc (Zn) and iron (Fe), which are already reported to be deficient in HLB-affected leaves.

Moreover, at high pH, calcium and magnesium can form insoluble complexes in soil, rendering them unavailable to the plant. Field trials demonstrate that under high soil pH (greater than 6.5) conditions and bicarbonate concentrations greater than 100 parts per million in irrigation water, HLB-affected trees exhibit increased loss of feeder roots, severe decline, increased HLB symptoms and reduced yield.

On the other hand, HLB-affected trees have small root systems that limit their capacity for nutrient and water uptake. Therefore, the constant supply of balanced fertilizer seems to be promising for improving the growth and productivity of HLB-affected trees. As the majority of Florida growers are looking for strategies for a continuous supply of nutrients, controlled-release fertilizer (CRF) appears to be a promising tool.

CRF STUDY

The goal of a UF/IFAS three-year study was to evaluate the effect of CRF in combination with Tiger Sul micronutrient blend (at an elevated rate) on yield and performance of HLB-affected trees. This trial was conducted on bearing age (10- to 14-year-old) Valencia on Swingle in 10-acre blocks, replicated at two sites: Fort Meade (ridge) and Arcadia (southwest Florida). There was a total of 10 fertilizer combinations evaluated:

1. Conventional granular fertilizer + foliar (control)
2. Conventional granular fertilizer + Tiger Sul Micronutrient Mix (MM)
3. CRF + foliar
4. CRF + Tiger Sul Micro-

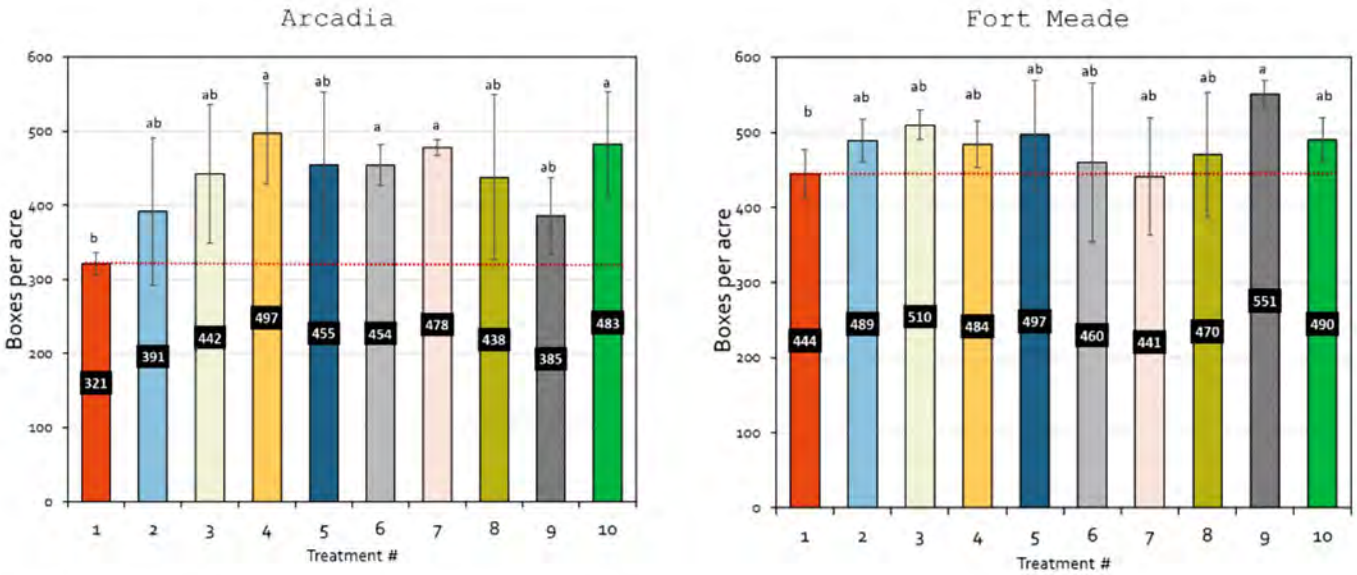

Figure 1. 2019 yield in boxes per acre for all treatments at both sites

nutrient Mix
5. CRF + Tiger Sul Micronutrient Mix + Tiger Sul Mn elevated by 20 percent
6. CRF + Tiger Sul Micronutrient Mix + Tiger Sul Zn elevated by 20 percent
7. CRF + Tiger Sul Micronutrient Mix + Tiger Sul Fe elevated by 20 percent
8. CRF + Tiger Sul Micronutrient Mix + Tiger Sul boron (B) elevated by 20 percent
9. CRF + Tiger Sul Micronutrient Mix + Tiger Sul Mn and B elevated by 20 percent
10. CRF + Tiger Sul Micronutrient Mix + Tiger Sul Mn and B elevated by 50 percent

The amount of nitrogen applied in treatments 1 and 2 was 180 pounds/acre; in CRF (treatments 3 through 10), it was 150 pounds/acre. Both conventional and CRF blends had

the same amount of phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). However, with reduction in the amount of nitrogen in CRF, the amount of P, K, Ca and Mg applied was reduced. The foliar micronutrients were applied based on UF/IFAS recommendations.

The base Tiger Sul Micronutrient Mix was a Mn-Zn-Fe-B: 6-6-3-1 blend and was applied at 1.5 pounds/tree. The elevated rates were calculated from the base Tiger Sul Micronutrient Mix. For example, Mn applied in treatment 2 and 4 was 12 pounds/acre whereas in treatment 5 and 9, it was 14.4 pounds/acre.

RESEARCH RESULTS

After three years of trials at both sites, many striking differences were observed. Usually, the differences observed for various parameters were not in agreement at both sites. However, it is interesting to note that for all the parameters measured, including yield, canopy volume and fruit quality, treatment 1 (the control) was always the worst performing treatment regardless of the best performing treatment and the site of experiment.

If soil pH adjustments are made, regular soil pH monitoring should be done to ensure that soil pH does not drop below the recommended range.

With the use of the Tiger Sul product, a gradual decrease in pH was observed. The decrease in pH was slow, and on average, the pH dropped by 0.5 or less per year. Therefore, it is advised that if soil pH adjustments are made, regular soil pH monitoring should be done to ensure that soil pH does not drop below the recommended range.

Figure 1 shows the yield in boxes per acre for the final year of study for the two sites. At the ridge site, only treatment 9 performed better than the control. At the southwest Florida site, treatments 4, 6, 7 and 10

Bayer Project Update

By Rick Dantzler, CRDF chief operating officer

It's been a while since this column addressed the project the Citrus Research and Development Foundation (CRDF) and its private-sector funding partners, PepsiCo and Coca-Cola, have underway with Bayer Crop Science. It is the most expensive in CRDF's history at $12,610,000, so the fiscal impact alone makes it worthy of discussion.

Started in early 2017, the project has two objectives: 1) to develop a plant defense modulator (PDM) to cause the plant's natural defenses to fight HLB, and 2) to develop an antibacterial microbe to kill liberibacter, the bacteria that causes citrus greening.

Because of the project's size and scope, a committee was formed to oversee it. The committee meets at least twice a year. Work on the project is taking place in Bayer labs in France, Germany and California, and there are three field trials in Florida to test the products that show promise.

To date, Bayer has developed a PDM that is quite promising. Referred to as its "H Class," the product has survived all of Bayer's internal milestones on the way to commercialization. Unfortunately, development is expected to take 10 to 12 years, so it isn't going to provide help soon. Nevertheless, it is a product that Bayer is very excited about, especially since it has shown efficacy against phloem-living bacteria in several vegetables, something that is necessary for product development since the citrus market alone is not large enough to support the amount of investment Bayer would have to make ($200 to $250 million) to bring a product to market.

The development of an antibacterial microbe is not as mature, even though Bayer has several compounds it is testing with many more in the pipeline. With the project's funding, Bayer has built a high-throughput system to test 500 compounds per calendar quarter. So far, approximately 3,000 of 55,000 compounds Bayer has identified as good possibilities for efficacy against liberibacter have been tested. While the time to develop a product of this nature is less than the PDM, it is still five to seven years out once Bayer decides to bring it to market.

Here's where we are on the money: The project is fully paid through June 30, 2020. However, at a burn rate of nearly $5 million last year (when the project was up and operating at maximum scale), CRDF simply can't continue funding the project at such a level. Bayer has provided a scaled-back work program, primarily by eliminating one of the three field trials, but even that costs $3,400,700 per year, which is still beyond CRDF's means.

Consequently, we have asked the California Citrus Research Board to assist, and its research committee has recommended approval. If the board ratifies the recommendation, our plan would be to jointly apply for a U.S. Department of Agriculture National Institute of Food and Agriculture grant, and co-fund, along with PepsiCo and Coca-Cola, bridge funding until Uncle Sam makes up his mind, which we believe will happen before the end of this year. Keep your fingers crossed that federal funding comes through, because that is most likely the only way the project can continue beyond this calendar year.

CRDF Grower Dollars at work for you

Column sponsored by the Citrus Research and Development Foundation

Table 1. Treatments were ranked (high to low) based on cumulative yield (boxes per acre) over the three-year trial period. The green color shows the best performing treatment at the Arcadia site, and the red color shows the best performing treatment at the Fort Meade site.

Arcadia Site			Fort Meade Site		
	Treatment Number and Description	Total Three-Year Yield (Boxes per Acre)		Treatment Number and Description	Total Three-Year Yield (Boxes per Acre)
7	CRF + Tiger MM + Fe (20 percent)	1,310	9	CRF + Tiger MM + Mn + B (20 percent)	1,130
4	CRF + Tiger MM	1,263	4	CRF + Tiger MM	1,076
8	CRF + Tiger MM + B (20 percent)	1,259	2	Conventional + Tiger MM	1,063
10	CRF + Tiger MM + Mn + B (50 percent)	1,233	3	CRF + foliar	1,047
5	CRF + Tiger MM + Mn (20 percent)	1,136	5	CRF + Tiger MM + Mn (20 percent)	1,039
6	CRF + Tiger MM + Zn (20 percent)	1,118	10	CRF + Tiger MM + Mn + B (50 percent)	1,034
2	Conventional + Tiger MM	1,095	6	CRF + Tiger MM + Zn (20 percent)	1,027
3	CRF + foliar	1,088	8	CRF + Tiger MM + B (20 percent)	981
9	CRF + Tiger MM + Mn + B (20 percent)	1,048	7	CRF + Tiger MM + Fe (20 percent)	913
1	Control	908	1	Control	893

performed better than the control, with an approximate increase of 100 to 150 boxes per acre. In addition, an improvement in fruit size and consumer preference was also observed with elevated micronutrients (treatments 9 and 10).

During the trial, both the sites had unique natural disaster issues. The Fort Meade site suffered a significant outbreak of post bloom fruit drop in 2016, and the Arcadia site was dealt a direct hit from Hurricane Irma. Therefore, we calculated the cumulative yield for both sites over the three-year

trial period (Table 1, page 12). It was mind-boggling to note that the cumulative ranks for the top-performing treatment at either site was the lowest-performing treatment at the other site, although the control was ranked lowest for both sites.

IMPLICATIONS FOR GROWERS

Overall, the data suggests the continuous supply of soil-applied nutrients through CRF and 20 to 50 percent elevated levels of micronutrients in addition to soil pH acidification improved yield and fruit quality. However, these results are not consistent across sites and therefore, a nutrition program should be site specific and customized to fulfill the nutritional needs of the trees.

Frequent leaf nutrient analysis is essential for an effective nutrition program as it helps in ensuring that the fertilizer program is meeting tree requirements.

Regular leaf sampling can be helpful in customizing a nutrition program. Leaf nutrient concentration should be maintained at the high end of the optimal range, as per the UF/IFAS nutrient concentration recommendation for healthy citrus. For a successful nutrition program, the following tips should be considered:

- The goal of a nutrition program should be a continuous availability of all nutrients to the tree year-round.
- Right source, right rate, right time and right place are key for fertilizer application.
- A nutrition program should be a combination of soil- and foliar-applied nutrients. Do not rely solely on foliar application for any nutrient.
- Soil-applied nutrients are taken up by the plant with the water uptake; therefore, irrigation scheduling is important.
- The placement of fertilizer (right place) is critical. It should be placed in the wetted zone since the uptake of nutrients occurs in a solution form.
- Frequent leaf nutrient analysis is essential for an effective nutrition program as it helps in ensuring that the fertilizer program is meeting tree requirements.
- The focus of a nutrition program should be on leaf nutrient levels and not on the rate of nutrient applied.
- Optimal soil pH is critical for making nutrients available to the tree; the soil pH needs to be in the right range at the time of nutrient application.
- If soil pH adjustments are made periodically, the fertilizer application should be coordinated to occur after the pH adjustment.

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