Citrus Research and Development Foundation, Inc.

# Supplemental Citrus Nutrition Programs

## Current Status of the Research

*Citrus Research and Development Foundation, July 2013*

**Purpose of this Communication**

There is considerable interest in the role that nutritional programs may play in sustaining Florida citrus health in the presence of HLB. This area of interest includes traditional soil-applied macro-nutrients, as well as supplemental nutrients and related materials applied both to foliage and to soil. Florida citrus growers have been applying a range of nutritional materials for a number of years, and complementary research has been supported to assist in evaluation of the phenomena involved in citrus response to nutritional programs. This communication summarizes research projects that have been supported on behalf of the citrus industry by the Citrus Research and Development Foundation.

**Introduction**

From the beginning of HLB occurrence in Florida citrus, it has been apparent that cultural practices play a role in the ability of citrus trees to respond to infection. Since HLB is a disease that impairs vascular movement of nutrients and also directly affects tree roots, the overall impact of chronic infection is tree debilitation. It should be no surprise that symptoms of HLB present as nutritional deficiencies, since root injury and phloem disruption impact uptake and delivery of nutrients. It also follows that stress to trees will accentuate symptom development and injury beyond that posed by HLB and that in combination with HLB, other stresses from weather, disease, and insect damage may intensify tree decline.

With this in mind, it is natural to consider how additional nutritional inputs might interact with stress-related disease symptoms and decline of HLB-infected citrus trees. The next logical step would be to provide supplemental nutrients in an effort to offset or compensate for the symptoms observed. In the Florida experience, supplemental nutritional applications have been viewed by many as an alternative to removal of infected trees, as tree removal for inoculum management became problematic due to high incidence. There appears to be no precedent for this approach in reports from other areas where HLB has occurred. However, the widespread dissemination of *Candidatus Liberibacter asiaticus (CLas)* and relatively rapid increase in infection rates allowed this to become a popular “alternative” to tree removal. The implied intent of supplemental nutritional applications has been to overcome the limitations placed on the tree’s ability to take in nutrients through the roots. The intent of foliar application then, is to overcome this limitation and to promote nutritional therapy.

**National Academy of Science 2009 Study Perspective on Citrus Nutrition in Relation to HLB**

The National Academy of Science planning effort commissioned by the Florida citrus industry did not directly address the use of supplemental nutrition as a research priority, but rather made reference to citrus nutrition as a component of cultural practices or new approaches to growth of citrus in the

presence of HLB. They also provided reference to evaluation of systemic acquired resistance (SAR) materials for the role they may play in disrupting bacterial infection by *CLas.* Referring to Table 4.3 of the NAS report (Committee on the Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening Disease (Huanglongbing); National Research Council, 2009 http://www.nap.edu/catalog.php?record_id=12880), the following priority areas include reference to citrus nutrition (**TABLE 4-3** Near- and Near-to-Intermediate-Term Recommendations):

**Near-Intermediate (NI)-3.** Establish citrus orchard test plots for evaluation of new scouting and therapeutic methods.

**Near-Intermediate (NI)-8.** Support small-scale studies on the feasibility of alternative horticultural systems suited to endemic HLB.

**Long-term (L)-2.** Support development and testing of bactericides, therapeutics or SAR activators.

The NAS Evaluation Team reports in their discussion that supplemental levels of micronutrients have been credited with eliminating mineral deficiency symptoms associated with HLB and cite the research underway to test the effect of combinations of micronutrients and SAR inducers, with and without insecticidal psyllid control, on the spread and impact of HLB. In their report, the NAS team cites growers' hopes that the putative effect of SAR inducers and micronutrients will make removal of HLB-infected trees unnecessary. During the analysis, it was noted that even if there is such an effect, the trees will not be cured and may continue to serve as sources of inoculum.

## History of response: 2008 first cycle to present

Beginning with the organized response to HLB, research projects have included consideration of how cultural practices affect disease development and spread, and have addressed how changes in cultural practices might be used to offset the cumulative injury and tree decline due to HLB. A number of projects on nutritionals effects on HLB were originally funded by FCPRAC. Many of these projects (for example, the evaluation of intensively managed, high density plantings), fit well into the discussions and recommendations provided by the National Academy of Science team. Other projects focused on nutrition have expanded beyond the scope of the NAS priorities, as grower interest in this area has increased.

## Overview of Project Areas: 21 projects for a total of $4,787,456

Research has been directed at HLB and nutritional interactions from a number of perspectives, and as the implications of widespread infection have materialized, additional projects have been added to address these new questions. The following is a brief summary of projects funded through CRDF that address the role of nutritional programs and SARs in responding to HLB. Like other areas of research, institutional investments (e.g., UF, IFAS and USDA, ARS) complement the nutrition projects funded by CRDF. Individual grower-sponsored trials and experiments are prevalent across the state, and it is presumed that fertilizer suppliers are investing resources in evaluating nutritional responses when HLB infection is present.

The listing of CRDF nutrition-related research projects (completed and current) includes Project Number, Principle Investigator, Project Title, Period of the Project, and Total Funding committed to the project. Additional details of each project, including progress reports, can be obtained on the website

citrusrdf.org by searching the progress reports. These projects are categorized according to their objectives, and numbers of projects and total investment is provided before each category.

**Citrus Nutrition Component Research (2 Projects) $ 233,205**

#731. James Graham. *Calcium carbonate may reduce root health and exacerbate HLB expression*. 4/1/2013 - 3/31/2016. $198,214.

#329. Arnold Schumann. *Evaluation of the mechanism and long-term management potential of boron-based suppression of HLB symptoms*. 5/1/2010 - 4/30/2012. $34,991.

**Field Evaluation of Nutritional Programs (10 Projects) $3,253,664**

#313. James Graham. *Evaluation of foliar Zinc and Manganese application for control of Huanglongbing or associated symptom development.* 5/1/2010 - 4/30/2011. $49,964.

#416. James Graham. *Evaluation of foliar Zinc and Manganese application for control of Huanglongbing or associated symptom development.* 6/1/2011 - 11/30/2013. $119,218.

#179. Robert Rouse. *Cultural practices to prolong productive life of HLB infected trees and evaluation of systemic acquired resistance inducers combined with psyllid control to manage greening.* FDOC 2009 - 6/30/2013 (extended to 12/31/13). $886,259.

#191. Arnold Schumann. *Intensively managed citrus production systems for early high yields and vegetative flush control in the presence of greening disease.* FDOC 2009 - 6/30/2012. $579,776.

#593. Arnold Schumann. *Advanced Production Systems (ACPS) for efficient, sustainable citrus groves.* 7/1/2012 - 6/30/2015. $414,039.

#203. Tim Spann. *Using physical and chemical property changes of citrus leaves as early indicators of HLB infection and effects of added plant nutrients.* 8/16/2010 - 5/31/2013. $323,323.

#00. Phil Stansly. *Development and delivery of comprehensive management plans for Asian citrus psyllid control in Florida citrus.* FDOC 2009 - 9/30/2011. $265,012.

#331. Phil Stansly. *Thresholds for vector control in young citrus treated for symptoms of HLB with a nutrient/SAR package.* 5/1/2010 - 4/30/2013. $218,360.

#447. Phil Stansly. *Role of nutritional and insecticidal treatments in mitigation of HLB in new citrus plantings.* 2/15/2012 - 2/14/2015. $199,960.

#604. Lukasz Stelinski. *Influence of plant nutrient regimes for extending the life of HLB-infected trees on Asian citrus psyllid biology and management.* 4/1/2012 - 3/31/2014. $197,753.

**Evaluation of Grower Trials of Nutritional Programs (1 Project) $95,282**

#614. Linda Young. *Enhanced nutritional application and productivity in endemic HLB grove situations in Florida - a statistical approach to determine efficacy.* 5/1/2012 - 10/31/2013. $95,282.

**Nutritional Programs and New Plantings (1 Project) $152,952**

#598. Tim Spann. *Bringing young citrus trees infected with Candidatus Liberibacter asiaticus into production using intensive horticultural management strategies.* 7/1/2012 - 6/30/2015. $152,952

**Improved Sampling and Detection (1 Project) $85,732**

#526. Reza Ehsani. *Precision foliar nutrient management using real time leaf analysis and a variable rate application technique.* 7/1/2012 - 6/30/2013. $85,732.

**Nutrition Interaction with Other Stresses (5 Projects) $856,621**

#308. Meghan Dewdney. *Does Huanglongbing (HLB) or associated nutrient deficiencies change Asian citrus psyllid (ACP) feeding patterns?* 5/1/2010 - 6/30/2013. $80,816.

#545. James Graham. *Phytophthora damage to roots: a potential contributor to reduced nutrient uptake and decline of HLB-affected citrus trees.* 7/1/2012 - 6/30/2015. $336,714.

#548. Jude Grosser. *Understanding and manipulating the interaction of complex rootstock genetics and constant nutrition to enhance the establishment, longevity and profitability of new citrus plantings in HLB-endemic areas.* 4/1/2012 - 3/31/2015. $303,984.

#176. Michael Rogers. *Effects of nutrition and host plant on biology and behavior of the Asian citrus psyllid and implications for managing psyllid populations.* FDOC 2009 - 3/31/2011. $87,607.

#594. Arnold Schumann. *Improving the uptake efficiency of nutrients applied to citrus foliage.* 7/1/2012 - 6/30/2013. $47,500.

**Impacts of Nutritional Programs on Fruit/Juice Quality (1 Project) $110,000**

#702. Elizabeth Baldwin. *Investigate effect of nutritional sprays on healthy and HLB-diseased orange fruit and resulting juice quality.* 5/1/2013 - 4/30/2015. $110,000.

CRDF has approved funding of 21 projects that include nutritional aspects, for a total investment of $4,787,456 since 2009. Several of these project areas have been in place since the initial funding cycle on HLB research overseen by the Florida Department of Citrus, and in some cases, the second phase of this research is ongoing, providing continuous research support for 5 years.

## August 2011 Industry/Research Workshop to Discuss Citrus Nutrition and HLB

With increased use of supplemental nutritional programs by citrus growers, the interest in coordinating ongoing experimental research with grower trials of various nutritional strategies rapidly increased. In response, CRDF conducted a Research Management Committee Workshop at UF, IFAS, CREC, Lake Alfred on Aug. 24th, 2011. The purpose of the workshop was to share research results and grower observations and to discuss opportunities to coordinate efforts with Florida citrus growers.

At the workshop, brief presentations were provided which focused as much as possible on experimental designs and data. This put the emphasis on the collection and analysis of data from all the trials rather than any one particular experiment. The approach allows for group interpretations of data. The presentations at the workshop illustrated the inherent uncertainty involved in these types of experiments and the length of time required to build confidence in the experimental results.

Two categories of “open research questions,” related to nutrition research were outlined as a result of the presentations and discussions, as follows:

1) Questions with important implications for immediate grower practices

- What is the basis for adjusting nutritional elements? How much is too much of a supplement? How will we know?
- How can infected trees be accurately scouted and rogued when symptoms are masked with enhanced nutrition?

- Should other measures of tree health be considered to correlate with yield of pounds solids and juice quality, such as a phloem function assay or tree girth measurements?
- At the grove level, have yield increases attributed to HLB-infected or uninfected trees been separated to understand their individual contribution?
- What return can be expected with incremental use of sprays both for psyllid control and supplemental nutritionals?

2) Questions that are research priorities for now but that may lead to applications

- Is there evidence for a disease-specific nutritional effect?

## Current Status of Understanding the Role of Supplemental Nutritional Programs

There will be a great deal of risk and continued uncertainty for growers in making decisions on how best to maintain grove health in the presence of HLB. There is enormous variability in yield that is both site- and season-dependent. Additionally, the rate of decline of HLB-infected groves is highly dependent upon the age of infection and overall condition of the grove, including genotype, environmental interactions, soil, salinity, root disease and the overall level of abiotic and biotic stress already imposed on a specific site. It has been demonstrated by many growers that groves were not at an optimal level of nutritional support as HLB spread in the state. Under such conditions, supplemental foliar applications are recommended. Interpretation of response from these applications has proven a challenge across the industry.

However, there is no evidence that supplemental nutritional effects are disease specific. It is likely that, in the presence of HLB, the range of nutritional requirements for optimal yield is narrowed and/or shifted by HLB infection and the general susceptibility to stress, possibly including the stress of psyllid feeding, is exacerbated. Additional risk factors that are now being assessed are the possible increased susceptibility of HLB infected groves to other infectious disease such as *Phytophthora* and root weevils.

Randomized, controlled nutritional trials are valuable because statistically significant effects can often be obtained if large effects are observed. The disadvantage is the expense required to adequately test any significant portion of the relevant variables and multiple years that are required for nutritional treatments to take full effect and be measured. A more practical alternative that emerged from the workshop was to develop a system to aggregate data from grower experience that is based on large acreage commercial operations, data mining and meta-analysis. This is possible because many growers have adopted nutritional supplement programs and are comparing different options under commercial scale. UF, IFAS and grower leaders volunteered to collaborate on this approach first recommended by the Foundation Scientific Advisory Board (SAB), and use the data set presented at this meeting as an initial look at database structure and results. The Research Management Committee acted on this opportunity by approving funding to support the collection and interpretation of data from grower trials. This two-year project was broadly supported by those present at the workshop.

Other actions included extending a current project (#179 Rouse) to incorporate measurements of phloem health in HLB symptomatic versus asymptomatic trees and with/without supplemental nutritional treatments. A new project (#477 Stansly) was approved to continue the evaluation of ACP and nutritional treatments on growth and productivity in field plots.

There is a wide range of yield potential in the varied Florida groves and soils types. Three-fold variation from 250 to 750 boxes/acre in well-managed groves is observed. Growers in high production areas have the economic advantage to spend luxuriously to realize an economic and horticultural gain. The minutia of which component may or may not be contributing to an effect is not relevant to their economics. This is not the case as yields decline and groves remain chronically infected.

The workshop included discussion that it is time for manufacturers and distributors of supplemental nutritional products to take some of the responsibility for sponsoring field research at the grower level. Many nutritional manufacturers have the resources to provide grower supported research that could bring useful information to the grower community in a more timely fashion. Ongoing efforts with more products and responsible grower participation could quickly prove or dismiss claims and give growers quick feedback on how to make decisions on nutritional supplements.

With more than 4 years of field research having been completed, there remain a number of unanswered questions. As pointed out earlier, the complex interaction of nutritional mixes with citrus tree health is complicated by variable growing conditions and exposure to biotic and abiotic stresses. Adding to that, the specific stress on the health and productivity imposed by HLB only compounds an already difficult situation.

Component research may be the approach most likely to answer the questions surrounding which parts of a nutritional mix are important in bolstering infected trees' productivity. This research can be accomplished either by building and testing a nutritional program one element at a time, or using the alternative strategy of deconstruction: removing one element at a time from a mix to determine which components are contributing. The timetable to fully understand the most useful components using either approach is many years or decades.

Alternatively, Florida citrus growers are conducting trials of a wide range of nutritional programs under an array of growing conditions. The results of these trials are reported anecdotally, and as expected, vary widely, and generally have not been reproducible. Collectively, these trials perhaps represent the best means by which some order can be derived from the approaches and products available to supplement citrus nutrition. CRDF funded a 2-year project in 2011 to assist in interpreting the results of these grower trials. It is unfortunate that only 5 growers of the many who pledged to provide their information followed through on the commitment to provide information from their trials. Thus, many of the questions remain unanswered and the pathway forward is not any clearer.

CRDF will continue to evaluate research proposals which are submitted to address solutions to HLB as they are received, and to work with the industry via CRDF committees to encourage growers to share the data associated with their successful as well as less successful field trials. With hundreds of such trials spread across the state, there is much we can learn through interpreting the common features that lead to success, or which are lacking from trials where the goals are not achieved. These are greatly underutilized resources that could lead to a better understanding of the role of supplemental nutrition in citrus management.