**Figure 1.** Drone equipped with a multispectral camera

# Technologies for improved nutrient analysis

**By Yiannis Ampatzidis and Ute Albrecht**

Nutrient management is important for citrus production. Regular nutrient assessments should be conducted to optimize nutrient balance and prevent deficiencies or over-fertilization. Optimizing nutrition is important for tree health and can improve tolerance to stresses and diseases.

Good nutrient management requires regular field monitoring to identify problems and examine crop responses. Leaves need to be collected and sent to a specialized laboratory to get a detailed analysis of macronutrients and micronutrients, which is time-consuming and costly.

It is recommended to conduct nutrient analyses in July and August after the spring flush (see edis.ifas.ufl.edu/pdf/SS/SS53100.pdf), but more frequent analyses of leaf nutrients may be necessary to determine deficiencies associated with huanglongbing or other biotic and abiotic factors. Additional analyses may also be necessary where responses to novel management practices need to be monitored. However, it is not economically feasible to frequently collect and analyze leaves for plant nutrient status.

In addition to being time-consuming and costly, leaf nutrient analysis is prone to human error because of inconsistencies and bias during leaf sampling and the analysis process, which can compromise the interpretation and relevance of the data. Faster and cheaper alternatives to conventional nutrient analysis methods are being developed at a rapid pace.

## DRONES AND ARTIFICIAL INTELLIGENCE

New technologies like unmanned aerial vehicles (UAVs or drones) and artificial intelligence (AI) can be utilized to develop a more efficient methodology to determine leaf nutrient concentrations and improve the speed of data collection and consistency. Researchers at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Southwest Florida Research and Education Center (SWFREC) developed a non-destructive method that can be quickly and efficiently used to determine citrus leaf nutrients and create fertility maps that are compatible with variable-rate fertilizer applicators. This novel method can help overcome or complement some of the limitations of traditional leaf nutrient analysis methods.

*Faster and cheaper alternatives to conventional nutrient analysis methods are being developed at a rapid pace.*

Spectral reflectance (i.e., the energy a surface reflects at a specific wavelength) of citrus canopies in five bands of light (red, green, blue, red edge and near-infrared) were used to create an AI-based model to determine plant nutrient concentrations. The data were collected with a quadcopter UAV equipped with a multispectral camera (Figure 1, page 10).

A large dataset with good variability was developed by analyzing four large-acreage commercial field trials in two different citrus production areas (Central Ridge and Southeast Florida) with two different scions (Hamlin and Valencia orange) and a diversity of rootstocks. The differences in location, grove management and scion–rootstock combination affect nutrient uptake and distribution in the tree canopy, which made the dataset sufficiently robust to develop a precise predictive model.

The framework of this study was divided into two main phases. In the first phase (data acquisition),

# Has the Time Come for Tree Injection?

**By Rick Dantzler, CRDF chief operating officer**

I recently ran across this quote from a 2016 Citrus Industry article from Nian Wang, one of the great University of Florida scientists that the Citrus Research and Development Foundation (CRDF) funds: "Using trunk injection technology, you can probably treat the HLB-diseased trees one time per year and have good control."

This caused me to think back to something one of my industry friends said to me about whether injecting would work better than spraying. "Rick, it's the difference between smearing medicine onto your skin or injecting it into your arm," said my friend, who supports the idea of injecting bactericides into trees to control HLB.

As I thought about the analogy, I became more enthused about the idea of trunk injection for any number of things. Peptides, zinc, elements and nutritional supplements come to mind in addition to bactericides.

Peptides, especially, are a hot topic right now, and some are very expensive. Injection reduces the amount and cost of the peptide, but inevitably the issue of the affordability of the injection process itself comes up. I've often heard that if you must touch the tree, you can't afford to do it. Nevertheless, I'm convinced this is a mechanical engineering problem that can be overcome.

In fact, CRDF has established a relationship with a company in the Midwest that has two devices we are checking out. CRDF's Brandon Page has developed a trusting relationship with the leaders of this company, and they recently sent him one of each of the devices along with 44 shells loaded with oxytetracycline. I'm interested in learning how fast Brandon can move from tree to tree, injecting as he goes. My guess is that it is going to be fast and easy.

And the fact that it is oxytetracycline? The fruit from the trees will need to be destroyed, of course, but it will be interesting to see how the trees do. I toured two of Wang's sites a while back and saw a visible, positive difference in tree appearance with certain dosages. He has published extensive literature on residues. Spoiler alert: The residue levels of streptomycin were below required thresholds in the United States but not for Europe. Residues of oxytetracycline were above the thresholds, even in the United States.

Is injection of bactericides, peptides, zinc, etc., good public policy? I'll leave that to those who govern and regulate the industry. Regardless of what happens with that discussion, the study of tree injection should continue. Growers have told me anecdotally they have figured out how to inject enough trees with certain devices to make it work — if only researchers could give them the right product to inject.

So, the research track should pursue two paths: 1) the development of devices that are affordable to use, and 2) finding the right things to inject that will knock the heck out of HLB.

CRDF Grower Dollars at work for you

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*Agroview converts data collected by UAV and from the ground into practical information.*

researchers acquired the spectral measurements of the canopy reflectance with a UAV-based multispectral camera. Leaf samples were collected, and nutrients were analyzed in the laboratory to generate the dataset. The second phase (model building and validation) consisted of: 1) a pre-analysis to evaluate the dataset for each nutrient and 2) model development and evaluation to ensure the repeatability of the methodology used.

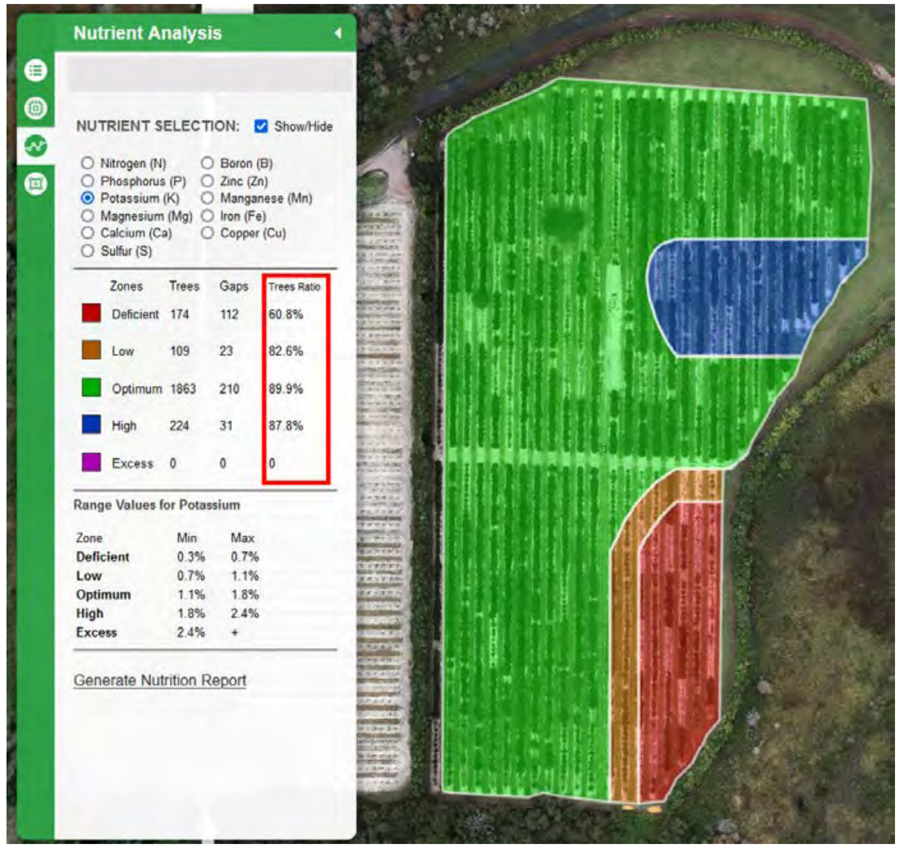


**Figure 2.** Potassium map based on University of Florida Institute of Food and Agricultural Sciences guidelines with deficient (red), low (brown), optimum (green) and high (blue) zones, developed by Agroview.

## FERTILITY MAPS

The developed AI model provides nutrient concentrations for individual trees. A novel cloud-based application, Agroview (also developed at the UF/IFAS SWFREC), was used to create fertility maps with discrete management zones to help visualize the data (plant nutrient concentrations).

An example of a fertility map for potassium can be seen in Figure 2. Five zones (deficient, low, optimum, high and excess) were determined based on UF/IFAS guidelines. Figure 2 depicts the range values for each zone.

The tree ratio for each zone is the number of trees divided by the number of tree spaces (trees + gaps; a gap is a place with no tree). If the tree ratio is 100%, it means that the entire zone has zero gaps. As can be seen in Figure 2, the tree ratios for the deficient and

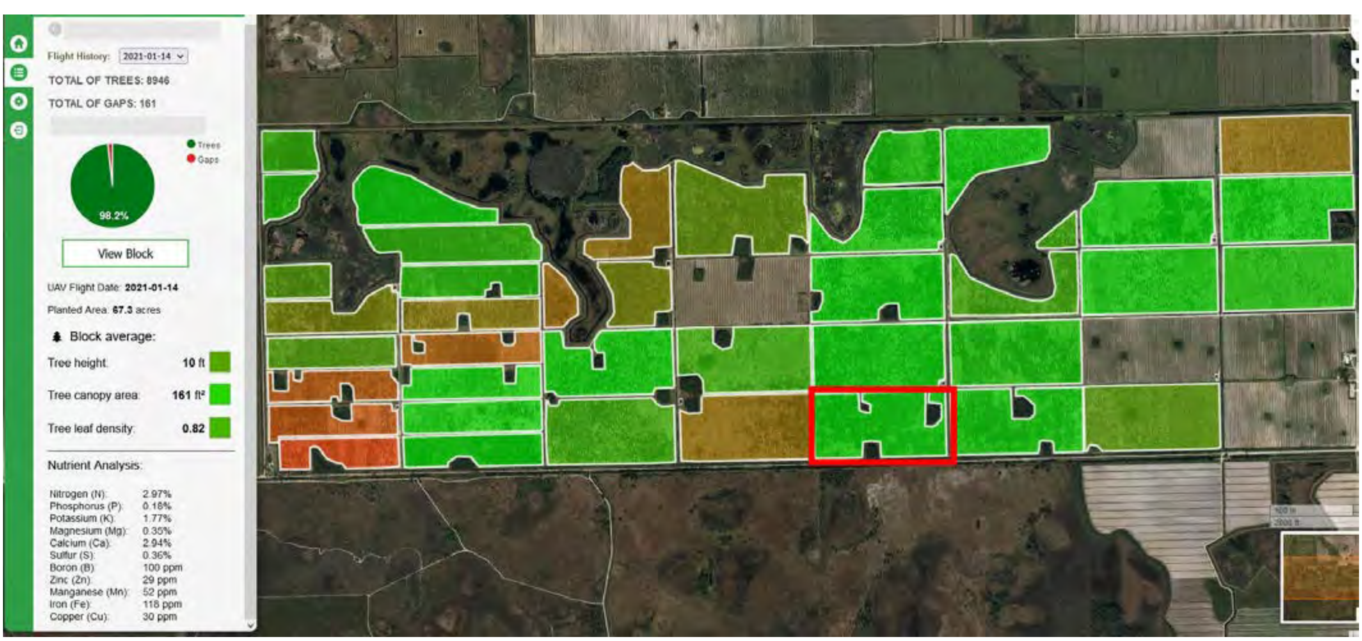


**Figure 3.** Agroview is a cloud-based application developed to convert data into practical information for growers.

low zones are lower (60.8% and 82.6%, respectively) than the optimum and high zones (89.9% and 87.8%, respectively) in this grove. Similar patterns can be observed for the nitrogen and phosphorus in this area. This indicates that this area of the grove might be problematic and require different management.

## PRACTICAL INFORMATION

Agroview (www.agroview.ai) converts data collected by UAV and from the ground into practical information. For example, Figure 3 (page 12) shows a large citrus production area with specific information for a selected area (outlined in red) displayed in the window on the left. This information includes the total number of trees and gaps, the UAV flight date, the total size of the area, average tree size and density and average plant nutrient concentrations.

The main advantage of this AI-based methodology is that large populations of citrus trees can be assessed quickly and at a low cost while reducing inaccuracies that result from sampling a small subset of plants. The AI model developed with this technology had an error of less than 15% for most of the nutrients analyzed, but the accuracy is expected to improve as evaluations continue.

This new technology generates prescription maps for variable-rate application of fertilizers based on UAV imagery. Although this model was tested in commercial citrus production systems, it can be easily adapted to other crop and production systems.

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*Yiannis Ampatzidis is an associate professor and Ute Albrecht is an assistant professor at the UF/IFAS SWFREC in Immokalee.*