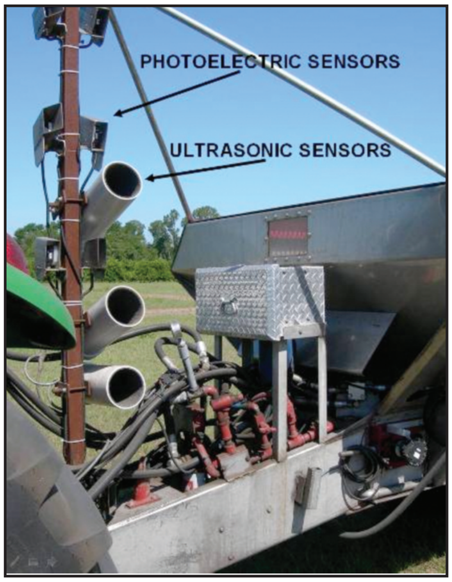
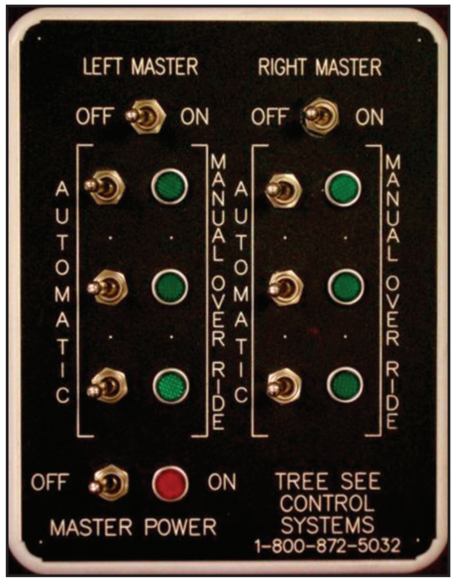
# Tips for fine-tuning variable rate fertilization



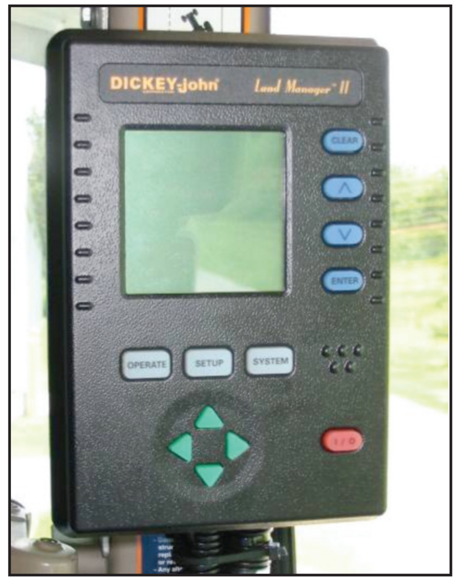




***Figure 1.*** *Left to right: Canopy sensors, sensor control box, VRF computer controller.*

**By A.W. Schumann and H.K. Hostler**

How can variable rate fertilization (VRF) for Florida citrus save one money and how can it be fine-tuned? Crude oil prices recently reached new highs so fertilizer prices will continue to increase. VRF is a precision agricultural tool capable of immediately reducing citrus fertilizer costs in increasingly non-uniform blocks of trees, conserving non-renewable resources and protecting the environment.

## WHAT AFFECTS VRF SPREADER PERFORMANCE?

The previous article (January 2008 *Citrus Industry* magazine) emphasized that when purchasing a variable rate spreader, one should insist on rapid response times and "look-ahead" sensing using well-matched components. This is important because tree spacing in the row of modern groves may be 15 feet or less. At a typical ground speed of 6 mph, one tree space passes by in just 1.7 seconds. In UF/IFAS tests, a well-matched and tuned VRF system such as the DICKEY-john Land Manager II computer controller with Hydraforce proportional valves was able to change fertilizer rates in less than 0.30 seconds. So the DICKEY controller is well-suited for this type of fertilization.

A different VRF system with slower servo valves and the manufacturer's own brand of controller took up to 3.1 seconds to change rates. Thus, wrong rates were applied to the wrong trees and bare ground was fertilized. Slow VRF systems may show apparent fertilizer savings, but the tree nutrition could be incorrect and misplaced. There are five important components for fine-tuning VRF response times and accurate performance:

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**1. The hydraulic valves which control the chain speed**

Fast valve choices include proportional and dump valves, but a system configured with dump valves has limited flexibility for customizing the different fertilizer rates for different tree sizes. Dump valves are arranged in banks to simply split the hydraulic oil flow, so two valves would permit only fixed 0, 50, and 100 percent fertilizer rates. A single proportional valve permits infinitely variable oil flow between 0 and 100 percent, and therefore can achieve any fertilizer rate. For example, a grower may require four fertilizer rates of 0, 50, 75, and 100 percent. Dump valves typically do not provide feedback to the controller and therefore do not permit in-cab diagnostics to monitor performance or failures. A separate dump valve is needed for each canopy sensor, so the system can get complicated and expensive when using multiple sensors. For these reasons, proportional hydraulic valves are the best choice for VRF spreaders.

**2. The type of computer controller and its features**

There are many variable rate computer controllers on the market, including products from DICKEY-john, Midwest Technologies and Raven Industries. The DICKEY-john Land Manager II controller is an excellent match for the fast Hydraforce proportional valves. The DICKEYcontroller is economically priced and ideal for single-tree VRF using canopy sensors. The other two brands are more expensive, but include mapping functions and are useful if prescription maps will be used. A unique feature of the Land Manager II controller is that it includes an "autogain" function, which calibrates and optimizes the performance of the complete valve-controller-spreader system instead of using default or guessed settings.

**3. The quality and type of ground speed sensor**

Ground speed sensors are crucial for the VRF controller to achieve the appropriate chain speed so that the fertilizer rate per acre is correct at any ground speed. The main types of speed sensors include Doppler radar, GPS and wheel rotation sensors. The radar sensor is accurate when properly calibrated, but reliability can be compromised by changes in the ground texture, such as from tall grass or weeds. A GPS speed sensor, such as the DICKEY-john iSPEED, is a specialized GPS receiver with dedicated speed output. The GPS sensor requires no calibration, is unaffected by ground condition, but must have an unobstructed view of the sky that could be blocked by large trees. Wheel rotation sensors detect the speed of a VRF spreader with a stationary metal detector mounted behind one wheel. They are the most rugged and cost-effective sensors and need calibration only after installation. However, wheel sensor accuracy can be affected by ground condition, wheel slip and tire distortion.

**4. The type of canopy sensor and the inclusion of a "look-ahead" function**

Ultrasonic and optical canopy sensors may both be used on VRF spreaders. They are sensitive to interferences from tall weeds, which may be mistaken for a low tree canopy by the computer controller. Thus proper weed control is required for correct operation of these sensors. The optical sensor system is sensitive to airborne dust thrown up by the tractor wheels. Dust triggers the system like a tree canopy. Mounting the sensor mast in front of the tractor solves this problem. The ultrasonic sensors (e.g., TreeSee) are sensitive to moisture so they must be protected from rain and dew. The tubular PVC housing of each sensor excludes rain during normal use, but when not in use, the ultrasonic sensor housing should be covered with an end cap.

A canopy sensor system includes a control box, featuring control switches and sensor status indicator lamps. Choose a sensor control box which implements an automatic "look ahead" feature (e.g. TreeSee). Look-ahead is a type of precompensation which uses the continuous stream of tree size information being collected by canopy sensors. This information allows the computer to predict, so that the valve response time, fertilizer particle drop time and other mechanical delays can effectively be subtracted ahead of the fertilizer placement point. If look-ahead is not implemented, the fertilizer placement may be inaccurate due to poor synchronization of rates with trees, especially at varying ground speeds. In our study, look-ahead sensing was able to double the accuracy of a DICKEY-john VRF system.

**5. Correct calibration of the VRF spreader and adjustment of sensor angles**

Since the hydraulic motors driving the two conveyor chains have a limited maximum and minimum speed (in rpm), the other components in the system must be adjusted so that the motors can operate in their allowed range. Gate height, ground speed, fertilizer bulk density, application rate and tree-row spacing all affect the required motor speed. A Windows PC program or spreadsheet is the best way to combine all the interacting factors so that they can be optimized in a single calculation. The fertilizer density, row spacing, maximum rate and maximum ground speed are entered into the program, which then calculates the correct gate height to use. A second program was developed for calculating the required angles to aim the sensors in order to detect the targeted tree height. The program calculates the sensor angle from the geometry of the sensor height, row spacing and targeted tree height, and the resulting angle in degrees can then be adjusted on each sensor using a digital protractor. Software for handheld computers has been developed and is available on the CREC Precision Agriculture Web site's software page at http://www.crec.ifas.ufl.edu.

## AN EXAMPLE OF VRF IN YOUNG TREES

In this example, a 24-acre grove of uniformly-sized young Hamlin trees with non-overlapping canopies was fertilized with a 3-ton fertilizer spreader fitted with four optical sensors per side (Figure 1). Due to the small canopy size, only the lowest sensors, aimed at a 3-foot canopy height, were utilized and the left-hand side of the DICKEY-john controller was programmed to apply the full 500 lb./acre rate of 10-0-12 fertilizer (50 lb./acre N) where canopy was detected, and 0 lb./acre in the absence of canopy. For comparison, the right-hand side applied the constant full rate of 500 lb./acre. Tree spacing was 22 x 11 feet, average tree diameters were about 6 to 7 feet so trees occupied about two thirds of their allocated row space.

At a ground speed of 4.5 mph, each tree space took 1.7 seconds to pass and the tree canopy took about 1.1 seconds. Rapid rate changes were accomplished with the Hydraforce valves. The controller's fertilizer accumulators showed that the citrus rows receiving variable rates used 31 percent less fertilizer than the rows receiving a fixed rate. Fertilizer was mainly saved by not spreading material between non-overlapping canopies of young trees since this grove did not have any missing tree spaces. This comparison was repeated for each of the four split annual applications.

In July, the leaf N concentration measured in the VRF rows was 2.84 percent, which was the same as 2.86 percent measured in the fixed-rate rows. Therefore, the fertilizer saved by VRF was not detrimental to tree nutrition. The

*Figure 2. The VRF spreader fertilizing young solid-set Hamlin trees.*

fertilizer saving corresponded approximately with the proportion of rows not filled by canopies (33 percent).

There are many choices of components for VRF spreaders which can affect the quality of fertilizer applications in citrus groves. The buyer can choose to customize the components and options when ordering the spreader and this article should help both manufacturers and growers to find the right combination. These large-scale field tests have confirmed the advantages of VRF in Florida citrus without detrimental effects on tree nutrition.

*Arnold Schumann and Kevin Hostler are at the UF/IFAS CREC in Lake Alfred.* *Thanks are due for the help and support from Gapway Grove Corp., Mosaic, DICKEY-john, Roper Growers Cooperative and FDACS.* *Email schumaw@ufl.edu for more information.*