Irrigation scheduling methods affect water use

By Sandra M. Guzman and Rhuanito S. Ferrarezi

Irrigation scheduling has been one of the most important management practices to improve crop production. For citrus, there are multiple options to schedule irrigation, including evapotranspiration-, plant- and soil-based methods. These methods can provide different water requirement estimates based on environmental variables, plant uptake or water content in the soil.

Although each method can provide good irrigation estimates, some of them are more precise than others. The more accurately the irrigation system applies water, the more water savings are achieved. This article provides an overview of irrigation scheduling methods for micro-irrigation systems, which includes both microsprinkler and drip irrigation. The main advantages and disadvantages of each method are covered, and suggestions are provided in terms of practical solutions for field applications.

EVAPOTRANSPIRATION-BASED METHODS

The theory behind irrigation scheduling based on evapotranspiration relies on the replenishment of water evaporated from the soil surface and the water used by the tree. A crop coefficient, which is related to the water requirements based on the tree phenological stage, plus the soil and weather characteristics are used.

In order to determine the irrigation amount and frequency based on daily evapotranspiration (ET), the irrigation manager needs weather information that can be obtained from the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Florida Automated Weather Network (FAWN, https://fawn.ifas.ufl.edu) or a weather station installed in the field. Irrigation scheduling is performed using the water balance method (water in from rain, irrigation or water table rise minus water out, in this case ET). The main advantage of this method is that it can be implemented with minimal or zero investment using field weather stations or the data from FAWN.

This method could provide initial insights on the irrigation requirements, but it requires the irrigation manager to perform some initial calculations. A step-by-step guide on ET-based irrigation scheduling can be found at https://edis.ifas.ufl.edu/ae458. One of the disadvantages of the ET method is that the irrigation manager is required to collect

Figure 1. Soil moisture sensor types from different manufacturers include frequency domain reflectometry (1-4), transmission line oscillation (5-7), time domain reflectometry (8-11) and time domain transmissometry (12). (Source: Ferrarezi et al., 2020)

data from multiple sources and calculate the irrigation requirements. More information on data sources can be found at http://edis.ifas.ufl.edu/ae456.

FAWN AND CITRUS IRRIGATION APP

Both the FAWN website and the UF/IFAS citrus app are user-friendly tools to schedule irrigation. These tools make ET irrigation scheduling practical for growers without the need to collect data or make complicated calculations. Users can select the nearest weather station available and their soil type from the FAWN database to schedule irrigation. Initial information required prior to using the app includes tree row distance and emitter characteristics.

In general, the FAWN website and citrus irrigation app have similar features. However, in the citrus app, users can save their field setup for future scheduling. This means the users add the grove tree and emitter data for the initial setup, and then the app will store the setup for future schedules. The FAWN irrigation scheduler can be found at https://fawn.ifas.ufl.edu/tools/irrigation/citrus/scheduler.

The citrus irrigation app (https://smartirrigationapps.org/citrus-app) can be downloaded as Smartirrigation Citrus for both iOS and Android. The main advantage of the citrus app is that it provides ET-based irrigation schedules without the need for investment in sensors or weather stations. It also makes irrigation scheduling simple and can be used on any cell phone or computer. The main disadvantage of the app is that the nearest weather station could be located a long distance from the grove, and weather data is very variable spatially.

SOIL-BASED METHODS

Soil-based irrigation scheduling relies on measuring the amount of water available in the soil for root uptake. The most recent and accessible methodologies use soil moisture sensors (SMS). SMS readings indicate the water available in the soil at a given time.

Probes take measurements on a small but representative volume of soil, and the amount of water available in the soil is directly used for irrigation management. Sensors allow real-time and continuous measurement at

Table 1. Comparison between irrigation scheduling methods available for citrus

Characteristic/Irrigation Scheduling Method	ET-Based	Citrus App	Soil-Based
How irrigation is scheduled?	Water balance based on evapotranspiration (ET)	ET-based + irrigation system and tree configuration	Replenish water based on soil water-holding thresholds
Accuracy of method	Medium	Medium	High
User input and calculations	High	Low	Low (high if the sensor requires calibration)
Equipment needed	From none to weather station	None	Soil moisture sensors + data retrieving equipment + weather station
Initial cost	None to low	None	High

different depths with minimum alteration of the natural soil conditions.

The use of SMS for irrigation scheduling is now a common practice for citrus production. More information on sensor installation and data interpretation can be found at http://citrusindustry.net/2018/07/10/using-soil-moisture-sensors-for-citrus-irrigation/.

For irrigation scheduling, users need to determine the soil water-holding capacity, which is related to the soil type, maximum/minimum water the soil can hold and the tree root zone. SMS values below the water-holding threshold indicate the need for an irrigation event.

The main advantage is that this method provides detailed and point-based information on the soil water status in the grove. If fully automated, SMS data can be accessed online and through third-party apps. The main disadvantage of this method is the initial cost for instrumentation/installation and the need for soil-specific calibration equations to increase sensor accuracy.

There are several sensor manufacturers and models available in the market which are based on different technologies and applications (Figure 1, page 12).

A recent study tested the performance of several commercial soil

moisture sensors in Florida sandy soils (www.mdpi.com/2073-4441/12/2/358). Results indicated that factory-supplied calibration equations performed well for some sensors in sandy soils but not for others. Soil-specific calibrations resulted in accuracy ranging from 0.018 to 0.030 m^3/m^3 for 5TE, CS616, CS650, CS655, GS1, Hydra Probe, TDR310S, TDR315, TDR315L and TDT-ACC-SEN-SDI, while lower accuracies were found for 10HS (0.129 m^3/m^3) and GS3 (0.054 m^3/m^3). The study provided soil-specific calibration equations to increase the accuracy of commercial soil moisture sensors to facilitate irrigation scheduling and water management in Florida sandy soils used for citrus production.

CONCLUSIONS

Irrigation scheduling is key for nutrient uptake, higher yields and overall tree health. Adequate water supply contributes in reducing plant stress in huanglongbing-affected trees. Methods such as the UF/IFAS citrus app and the soil-based techniques have already demonstrated significant savings in water use and reductions in nutrient losses.

However, each method has different levels of accuracy, which affects the volume of water used for irrigation. Table 1 (page 14) shows a comparative summary of each irrigation scheduling method. Each method has pros and cons. The choice of which one to use depends on how comprehensive the method is to adapt to individual grove conditions, method functionality/practicality and the cost to the grower.

Sandra M. Guzman and Rhuanito S. Ferrarezi are assistant professors at the UF/IFAS Indian River Research and Education Center in Fort Pierce.

For further reading

ET-based irrigation scheduling

- https://edis.ifas.ufl.edu/ae458
- http://edis.ifas.ufl.edu/ae456

FAWN website and citrus app irrigation scheduling

- https://fawn.ifas.ufl.edu/
- https://crec.ifas.ufl.edu/extension/trade_journals/2016/2016_July_app.pdf

Soil moisture sensor irrigation scheduling

- http://citrusindustry.net/2018/07/10/using-soil-moisture-sensors-for-citrus-irrigation/
- http://citrusindustry.net/2017/07/10/understanding-soil-moisture-sensor-data/
- https://doi.org/10.3390/w12020358