

# Irrigation Management of Citrus Trees<sup>1</sup>

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The chapter on irrigation management of citrus is largely taken from guidelines provided in SL253 Chapter 9 on trees prior to citrus greening <http://edis.ifas.ufl.edu/ss478>. A section has been added to cover recent findings on water use of trees affected by citrus greening and the impact this would have on the irrigation management considerations.

## WATER SUPPLY

Water is a limiting factor in Florida citrus production during the majority of the year because of the low water holding capacity of our sandy soils and the non-uniform distribution of rainfall. In Florida, the major portion of rainfall occurs from June through September but rainfall is usually scarce from February to May. This period coincides with the critical stages of leaf expansion, bloom, fruit set, and fruit enlargement, and additional irrigation is necessary to reduce the negative effects of water stress. Adequate irrigation management is key to optimize water use and increase crop yield. Several weather-, soil- and plant-based methods are available for irrigation management. The most used methods rely on weather stations to calculate evapotranspiration (ET), which is the combination of water lost by plant transpiration and removal of water from soils and wet surfaces by evaporation. Therefore, ET plays a critical role in agricultural irrigation management.

## ALLOWABLE SOIL WATER DEPLETION

As soil dries out, water becomes increasingly difficult for trees to remove, which can eventually cause water stress. Tree health and yield will suffer if the soil is allowed to get too dry. To provide adequate water for flowering, fruit set, and vegetative growth, maximum soil water depletion should not exceed 25% to 33% of available water from February to June. Once the rainy season starts, the maximum depletion can be increased to 50% to 66% of available water. This additional allowable depletion increases the capacity of the soil to hold rainfall without leaching nutrients or any applied chemicals. The same depletion in the fall and winter months will save water without reduction in yield.

## IRRIGATION SCHEDULING

Irrigation strategies must be documented and practiced to allow growers maintain or increase crop production without depletion of water resources. Increase in water use efficiency is achieved by selecting a proper irrigation scheduling method and application timing. Proper irrigation scheduling applies an appropriate volume of water to a citrus grove at the appropriate time based on tree need, soil properties and weather conditions. Successful

<sup>1</sup> This document is modified from SL253, one of a series of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date: October 2007. Modified: May 2017. Visit the EDIS website at <http://edis.ifas.ufl.edu>. For a copy of the Florida Citrus Production Guide, request information on its availability at your county extension office.

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<sup>3</sup> Figures 2 to 4 were illustrations included in SL253 chapter 9. The illustrations of water content changes in the citrus tree root zone (Figs. 3 to 4) do not represent the actual water extraction pattern. The blue shading shows 1) approximately where water extraction occurs beneath the canopy, and 2) the relative soil water content with respect to available soil water-holding capacity.

<sup>4</sup> Conventional irrigation practice for Florida citrus refers to use of microsprinkler irrigation based on replacing the citrus seasonal tree water requirements using Florida Automated Weather Network data.

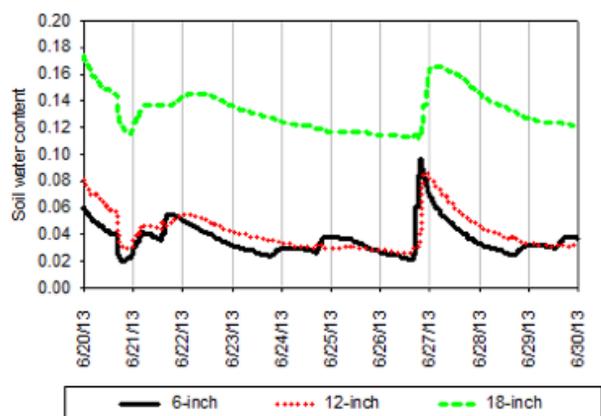
irrigation management maintains sufficient water and nutrients in the root zone to maximize plant growth and health. Growers who focus on improving water and nutrient use efficiency simultaneously will reduce nutrient losses and decrease negative environmental impacts. While some nutrient loss is unavoidable due to excess rainfall, loss due to management decisions can be minimized.

Current UF/IFAS citrus irrigation recommendations estimate citrus tree water requirements for mature tree based on data collected prior to introduction of HLB into Florida. Citrus trees affected by HLB are known to lose substantial foliage and up to 80% of the root mass depending on disease severity, thus negatively influencing water and nutrient uptake.

The commonly used methods of irrigation management include soil water measurement, water budgeting and smartphone apps.

## Soil water measurement

Experience or the calendar method can provide a reasonably good irrigation schedule, but are not accurate enough to maximize water use efficiency and prevent nutrient leaching. Using soil moisture sensors (Fig. 1) improves accuracy because they quantitatively measure changes in soil water status. These devices may be fixed in one location, portable, or hand-held. They may measure soil water at one depth or at multiple depths. General categories include time-domain reflectometry (TDR) probes and capacitance probes.



**Figure 1.** Continuous monitoring of soil moisture at 6, 12, and 18-inch depths in the soil by a multi-level capacitance probe installed in the root zone of a mature citrus tree.

Considerations when using soil moisture sensors to schedule irrigation include:

- Knowing the soil water-holding capacity and tree root zone depth.
- Placing sensors where the majority of roots are located (typically in the top 12 inches), such as at the dripline of the tree.

- Use multiple sensors, both across the grove and with depth, to fully characterize the tree root zone.
- Moving sensors to follow root growth as the tree canopy expands in developing groves.
- Base irrigation on the soil depth containing the greatest root density.
- Manage root zone soil moisture between field capacity and the maximum allowable water depletion (one-fourth to two-thirds depletion, depending on time of the year).

## Water budgeting

An alternative method to schedule irrigation uses a computer program that estimates tree water consumption (evapotranspiration, or ET) from weather data. Reference ET and convenient irrigation scheduling management tools for all Florida citrus production regions can be found on the Florida Automated Weather Network (FAWN) website at <http://fawn.ifas.ufl.edu> and [http://www.crec.ifas.ufl.edu/extension/trade\\_journals/2015/2015\\_March\\_grower\\_tools.pdf](http://www.crec.ifas.ufl.edu/extension/trade_journals/2015/2015_March_grower_tools.pdf).

## Smartphone apps

Mobile smart devices (e.g., smartphones, tablets) have become popular because of convenience and ease of use, making them ideal for disseminating information on a regular basis with real-time data. Tools developed for use on mobile smart devices are typically called “apps” and are available for a variety of functions. Due to the increasing popularity of smartphones and apps, FAWN developed an app for the iPhone and Android platforms that allows users to view data from grower-owned weather stations provided as a cost share from the Florida Department of Agriculture and Consumer Services on their smartphones in much the same way that the data can be viewed on the FAWN webpage. UF/IFAS has also developed smartphone apps for crop irrigation scheduling using FAWN weather data. The FAWN and irrigation scheduling apps are available to download in the App Store and Play Store at no cost. A simple description of how to use the app is available at: [www.crec.ifas.ufl.edu/extension/trade\\_journals/.../2016\\_July\\_app.pdf](http://www.crec.ifas.ufl.edu/extension/trade_journals/.../2016_July_app.pdf). The goal is to provide users with an easy-to-use mobile app to access information to improve irrigation scheduling for a wide range of crops, including citrus. By using the app instead of a set time-based schedule for irrigation, accurate irrigation is achieved. The irrigation scheduling app has the potential of reducing water and fertilizer use, resulting in reduced irrigation and fertilizer costs and the possibility of reducing nutrient leaching.

# IRRIGATION STRATEGIES TO IMPROVE NUTRIENT UPTAKE AND REDUCE LEACHING

Developing an irrigation strategy to reduce nutrient leaching has the objective of not applying more water than the root zone can hold. Considering the low water-holding capacity of citrus grove soils, this objective is very difficult to accomplish even for the most experienced and diligent irrigation managers. The major questions to be answered in this procedure are:

- How much water can the root zone hold?
- What is the maximum irrigation system run time before leaching occurs?

## Example

We have a central ridge citrus grove with the following characteristics:

- Tree spacing – 12½ ft in-row x 25 ft between rows.
- Tree canopy diameter – 17½ ft.
- Root zone depth – 3 ft.
- One 16 gal/hr micro-sprinkler per tree with a 16-ft diameter wetted pattern.
- The citrus root zone is continuous from tree to tree, existing both inside and outside of the wetted pattern.
- The irrigated system wets approximately 60% of the total root zone (Fig. 2a).
- Nutrient leaching risk in this grove is higher within the wetted pattern due to potential over-irrigation, plus the fact that most fertilizers are applied to that zone (Fig. 2b). A good irrigation manager will control this risk with careful water management.

This example starts with the entire grove at field capacity moisture content following a heavy rain (Fig. 2b). The citrus trees begin to remove water from the soil in response to the atmospheric ET demand. After several days have passed (depending on time of year), the water content in the root zone decreases to 50% of available water capacity (Fig. 3a).

At this point, the grove manager turns on the irrigation system and operates it long

enough to return the soil in the wetted pattern back to field capacity (Fig. 3b). From this point until the next significant rainfall, the manager can only influence the soil water content in the irrigated zone. The water content in the non-irrigated zone rapidly decreases to the point where little to no soil water can be extracted by the trees.

If the grove manager operates the irrigation system too long and applies more water than the soil can hold, water will move beneath citrus tree roots. If water soluble nutrients like nitrate or potassium are present in the irrigated zone during the irrigation period, a portion will leach (Fig. 4a).

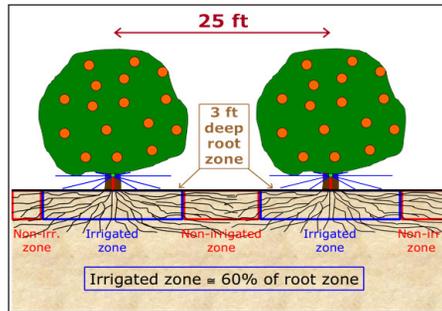


Figure 2a. Scaled diagram of example citrus grove described above (left).

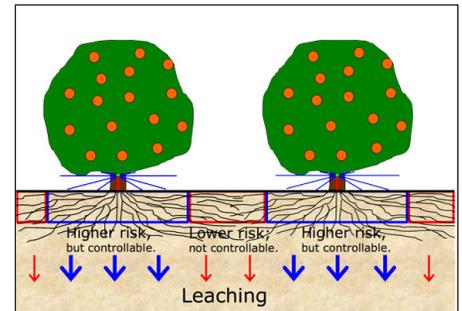


Figure 2b. Irrigated and non-irrigated zones in a citrus grove have different leaching potentials that depend on irrigation scheduling and fertilizer placement (right)

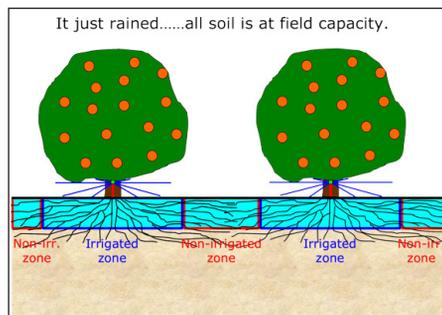


Figure 3a. The citrus grove at field capacity soil water content (time = 0) (left).

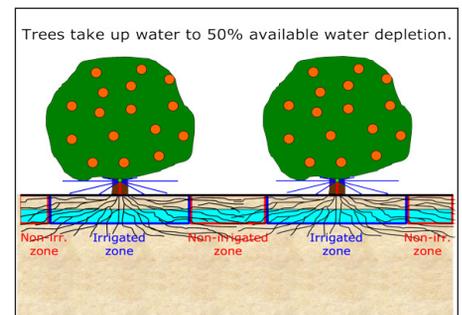


Figure 3b. The citrus grove several days later, after half of the available water has been removed from the root zone. Note that water extraction has occurred from both the irrigated and non-irrigated zones (right)

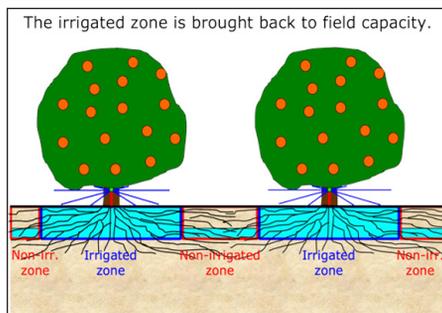


Figure 4a. The citrus grove after irrigation returns the wetted zone to field capacity. Note that the non-irrigated zone contains very little available water (left).

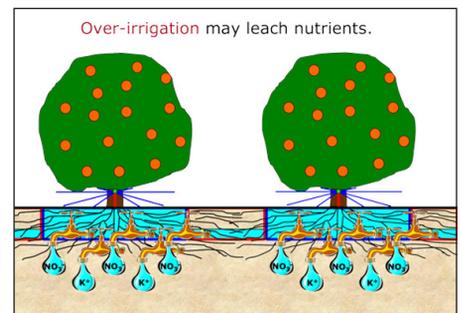


Figure 4b. Excessive irrigation leaches mobile nutrients like nitrate or potassium (right)

## HOW MUCH WATER CAN THE ROOT ZONE HOLD?

- Central ridge soils – 0.3 to 0.7 inches/ft
- Flatwoods soils – 0.3 to 1.2 inches/ft

## WHAT IS THE MAXIMUM SYSTEM RUN TIME BEFORE LEACHING OCCURS?

Information needed:	In this example:
Soil water-holding capacity	0.6 inches/ft
Maximum allowable depletion	50%
Root zone depth	3 ft
Surface area wetted by micro-sprinklers	60%
Micro-sprinkler flow rate	16 gal/hr
Tree spacing	12½ ft x 25 ft

## CALCULATIONS

1. Volume of water the root zone can hold:  
0.6 inches/ft × 3 ft deep root zone = 1.8 inches
2. Volume of water to refill at maximum depletion:  
1.8 inches × 50% = 0.9 inches
3. Volume of water this represents per tree space:  
0.9 inches/tree × 1 ft/12 in × (25 ft × 12½ ft) × 7.5 gal/ft<sup>3</sup> × 60% coverage = 105 gal/tree
4. Maximum system run time:  
105 gal ÷ 16 gal/hr emitter flow rate = 6.6 hr
5. Adjust for system irrigation efficiency of 90%:  
6.6 hr × 0.9 = 7.3 hr

Therefore the irrigation system should never be run longer than about 7 hours for any single cycle provided that the available soil water is at least 50% depleted when the irrigation begins.

## IRRIGATION MANAGEMENT CONSIDERATIONS FOR HLB AFFECTED TREES

With citrus greening (HLB), irrigation scheduling is becoming more important than ever as water stress can negatively affect tree growth and crop production.

Canopy size is reduced as is the number of fruit and fruit size, and premature fruit drop is increased. In addition, extension growth of shoots, leaves, and roots is negatively impacted. Other benefits of proper irrigation scheduling include reduced loss of nutrients through leaching due to excess water applications and reduced pollution of groundwater or surface waters. Three studies were conducted in Florida from 2011 to 2015 with the objective of determining 1) the effectiveness of ET-based irrigation scheduling on reduced water use in citrus, 2) irrigation requirements of HLB affected citrus trees compared with healthy trees, and 3) effect of irrigation scheduling on productivity of citrus trees affected with HLB.

Results from the first field study indicate water use with soil moisture sensors and ET based models reduced average monthly water use by approximately 14% of the conventional irrigation

practice without reducing yields. Results from a second study under greenhouse conditions indicated that healthy trees consumed approximately 25% more water than HLB affected trees (Table 1). Reduced water uptake by HLB affected trees resulted in significantly greater soil water content. The relationship between leaf area and water uptake indicated that diseased trees with lower canopy density and corresponding lower leaf area index take up less water and consequently less nutrients from the soil. The elevated soil water content may partially explain higher rates of root infection with *Phytophthora spp.* observed in some HLB-affected trees. The third experiment was conducted in three commercial groves on Ridge and Flatwoods soils. Irrigation schedules consisted of current UF/IFAS ET based recommendation, daily irrigation, and an intermediate schedule, all using the same amount of water on an annual basis. The UF/IFAS schedule was determined weekly using the Citrus Irrigation Scheduler found at the Florida Automated Weather Network (FAWN) website (<http://fawn.ifas.ufl.edu/tools/irrigation/citrus/scheduler/>), and resulted in irrigation schedules ranging from daily in May to every 10-14 days in the winter months from November to February. Daily irrigation schedules were determined by dividing the UF/IFAS irrigation duration by the number of days between irrigations. “Intermediate” irrigation was half the UF/IFAS interval for half the time. Daily irrigation increased tree water uptake and soil water content compared with Intermediate and UF/IFAS schedules. Daily and Intermediate irrigation increased canopy density as measured by leaf area index compared with UF/IFAS schedule. Fruit drop per square foot of under canopy area was lower for daily irrigation schedules in the second year of the study, but yields were similar among all irrigation schedules.

This shows that for HLB-affected trees, irrigation frequency needs to be increased and amounts of irrigation water decreased to minimize water stress from drought or excess water, while ensuring optimal water availability in the rootzone at all times. It is recommended that growers maintain soil moisture in the root zone (top 3 feet for ridge and 18 inches for flatwoods soils) using soil moisture sensors or irrigation apps. The FAWN and SmartIrrigation app provides the option of daily irrigation schedules. As noted above, HLB affected trees with lower canopies use less water than do healthy trees. Therefore, if the irrigation scheduling app is used the irrigation time should be reduced by 10% to 20%. For example, if the app suggests an irrigation time of 1 hour, this time could be reduced by 6 to 12 minutes for HLB affected trees.

**TABLE 1. Water use of HLB affected trees in southwest Florida under greenhouse conditions**

Month - Year	Potential evapo-transpiration (inches/day)	Crop evapo-transpiration (inches/day)			
		Hamin		Valencia	
		without HLB	affected with HLB	without HLB	affected with HLB
Jan to Jun 2014	0.14	0.12	0.09	0.11	0.09
Jul to Dec 2014	0.17	0.16	0.10	0.16	0.11
Jan to Jun 2015	0.13	0.16	0.11	0.15	0.11
Jun to Oct 2015	0.15	0.19	0.13	0.19	0.14
Overall Average	0.15	0.16	0.11	0.15	0.11