Web-based irrigation scheduling

By Kelly Morgan, Edward Hanlon and Tom Obreza

A Web-based model can improve water use efficiency and reduce nutrient leaching

The competition for water supply is increasing throughout Florida. Increasing demands from residential and commercial users are often met at the expense of agricultural and environmental water supplies. One way that citrus producers can address this trend is by improving their water use efficiency. Irrigation managers can reduce grove water consumption while avoiding tree damage or fruit yield/quality loss due to insufficient irrigation. The key to improving water management is including soil characteristics and weather in irrigation scheduling decisions. A web-based, water-balance irrigation scheduling tool has been developed that is easy to use. This tool will assist growers in determining irrigation schedules that can improve water use efficiency and reduce nutrient leaching.

Grove managers may have several objectives for irrigating. Increased profit through the effective use of irrigation to produce high quality citrus is the overall goal. The use of irrigation scheduling in combination with fertilizer BMPs will provide maximum nutrient uptake efficiency, defined as the amount of fertilizer taken up by the tree divided by the amount applied. This objective attempts to hold nutrients, especially the mobile nutrients such as nitrate-nitrogen, in the root zone via measured irrigation events. Irrigation timing and duration are based upon crop need and soil-moisture content. In addition to addressing plant water needs, changes in the soil volume containing the root zone are also included, as well as irrigation delays for rainfall events.

FACTORS AFFECTING IRRIGATION SCHEDULING

Soil characteristics vary from the central "Ridge" to the flatwoods. Management techniques for irrigating commercial citrus groves must account for differences in soils and related water regimes. The water holding and drainage characteristics of these soil types greatly influence root distribution, the presence of a water table, and the need for drainage. Irrigation practices must address these characteristics to effectively irrigate the trees without leaching nutrients into surface or ground water.

Ridge soils are often well-drained, allowing citrus roots to penetrate deeply into the soil. This root distribution pattern anchors the tree and provides a large volume of soil, typically 36 inches or more deep, from which the tree may extract both nutrients and water. Flatwoods soils are often poorly drained and they flood relatively easily. Drainage and the presence of an impermeable soil layer have considerable influence on citrus root distribution in these soils. The shallow root system is restricted to the upper 12 to 18 inches of soil.

A good way to know if the irrigation water is being used correctly — avoiding too wet or too dry conditions — is to estimate the depth of wetting and the total depth of soil that will be filled to field capacity. A simple irrigation schedule can be estimated.

Irrigation duration and flow rate determine the volume of water that is added to the grove. Irrigation water applied in excess of the soil water holding capacity either continues through the soil profile below the root zone, or reaches the water table. In both cases, water above the amount required to refill the soil in the root zone is wasted and potentially contributes to nutrient leaching. This simplified model of water movement has been called "piston flow" because water entering the soil from irrigation or rainfall forces existing water in the soil deeper into the soil profile. This process also describes the flow of mobile nutrients in the sandy soils of central and south Florida, making them vulnerable to nutrient leaching. Irrigation must be scheduled to avoid or minimize loss of nutrients, especially nitrogen, from the citrus root zone.

A good way to know if the irrigation water is being used correctly — avoiding too wet or too dry conditions — is to estimate the depth of wetting and the total depth of soil that will be filled to field capacity. A simple irrigation schedule can be estimated using available information and making some assumptions. The addition of 1 inch of water will wet a Candler soil to field capacity to a depth of approximately 50 inches, given an original soil-water content of 1/3 depletion. Using the same equations, a flatwoods soil (Wabasso for example) would be wet to field capacity to a depth of about 25 inches by the same 1 inch of water at the same 1/3 depletion. Of course, a wetter soil at the beginning of the irrigation cycle would result in soil being brought to field capacity to a greater depth. Based upon grove rooting depths, the implication is that a water application in excess of 1 inch may extend field capacity conditions below the rooting depth of the citrus trees in Candler sand. A Wabasso soil will behave similarly, wetting well below the root zone.

Water budgeting and use of soil moisture sensors are two methods of irrigation scheduling that will improve the likelihood of obtaining the irrigation goals above. The remainder of this article will address the use of a water budget for irrigation scheduling.

WATER BUDGET APPROACH

When water is lost from the soil by evaporation and the citrus tree loses water through transpiration, water must be supplied to replace evapotranspiration (ET). A reference evapotranspiration (ETo) can be used as a basis for estimating the citrus grove ET or irrigation demand. Reference ET is calculated on a daily basis using weather data or is available for the nearest FAWN site at (http://fawn.ifas.ufl.edu).

Two factors (Kc and Ks) must be used to convert the reference ET to one that addresses citrus growing in specific soils found in the grove of interest. The equation: $ETc = ETo*Kc*Ks$ uses these components to estimate the crop ET (ETc). The crop coefficient (Kc) for citrus changes throughout the year. The coefficient is low during the cooler months when water use is low and higher in the warm summer months when water use by the citrus trees is high. The soil-water extraction factor (Ks) is an estimate of the trees' ability to remove water throughout a range of water contents. As soils dry out, the Ks is reduced. Tree roots must expend more and more energy to take up water from the soil — thus the trees remove less water and the Ks gets smaller. When soil water is depleted by as little as 50 percent, tree water uptake can be reduced as much as 40 percent. Reduced water uptake by the tree can result in lower tree growth and yield.

Thus, growers are advised to keep their soil above the recommended maximum allowable soil water depletion for the given time of the year so that Ks remains as high as possible. The UF/IFAS recommendation is to allow 25 to 33 percent soil-water depletion during February through May, and 50 to 66 percent depletion during June through January. These allowable depletions provide increased soil water in the spring of the year for blooming, fruit set and growth flushes. The increased allowable soil water depletion in the summer and fall allows for more effective use of rainfall during our rainy season and sufficient water for fruit expansion.

THE CITRUS IRRIGATION SCHEDULER

A powerful irrigation scheduling method is available through the Florida Automated Weather Network (FAWN) weather system (www.fawn.ifas.ufl.edu/citrus irrigation scheduler). This model is described below.

To aid citrus growers in water management decision-making, a computer-based decision support system to facilitate more efficient water use for site-specific soil characteristics and local weather data was developed. Grove in-row and between-row tree distances are used to estimate the canopy volume, which in turn is used to calculate the root distribution. Irrigation system characteristics provided by the user are spray diameter, shape of wetting pattern and flow rate. These factors are used to determine irrigation delivery rate and application time. Soil characteristics for a given site can be specified from a list of soil types. The current ET is automatically provided from a selected FAWN site near the grove and appropriate Kc and allowable depletion are used based on the current date. A schedule of days between irrigation and hours of irrigation duration are provided. Suggested irrigation application delays for rainfalls of up to 1 inch are also provided.

FIELD TESTING

A field test of the Citrus Irrigation Scheduler was conducted in six groves for a period of three years. Weather stations were placed in the groves, irrigation schedules were provided to the cooperators and soil moisture measurements were taken every half-hour. Evapotranspiration at these sites was compared with ET estimated at the closest FAWN site. Soil moisture sensor data were also compared with estimated values from the model. A conclusion was reached that a Web-based tool using the model described would provide the accuracy needed for grower irrigation decisions. Also concluded was that FAWN stations provided reliable ET data for these grower irrigation schedules. Thus growers would not be required to maintain their own stations.

CONCLUSIONS

We have discussed the importance of soil characteristics and rooting depth on irrigation scheduling. Understanding the depth of your root zone is key to determining the depth to which soil moisture must be managed by irrigation. Growers can then use generic tables, soil water balance, or soil water sensors to determine when the next irrigation should occur. However, the grower needs to further understand that these irrigation schedules vary by time of year due to irrigation demand (ET) and allowable depletions. The use of a computer tool like the one available at the FAWN Web site can simplify the calculations required for proper irrigation scheduling. The proper scheduling of irrigation can provide sufficient water for tree growth and fruit development, protect the environment through reduced leaching of fertilizer nutrients, and improve the grower's bottom line by reducing costs of both water and fertilizer.

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