

Evapotranspiration-Based Irrigation for Agriculture: Implementing Evapotranspiration-Based Irrigation Scheduling for Agriculture¹

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This article is part of a series on ET-based irrigation scheduling for agriculture. The rest of the series can be found at http://edis.ifas.ufl.edu/TOPIC_SERIES_ET-based_irrigation_scheduling_for_agriculture.

Introduction

This article is part of a series on ET-based irrigation scheduling in agriculture and outlines step-by-step procedures to follow when implementing a "smart" evapotranspiration (ET)-based irrigation schedule and a do-it-yourself irrigation schedule. A numerical example is provided for how to implement a do-it-yourself ET-based irrigation schedule. General information about the equations referenced in evaluating the different parameters for do-it-yourself irrigation scheduling are listed and explained in *Evapotranspiration-Based Irrigation Scheduling for Agriculture* <http://edis.ifas.ufl.edu/AE457>.

Criteria for Selecting "Smart" ET-Based Irrigation Scheduling Controllers for Agricultural Applications

The first consideration when selecting an ET-based irrigation controller is the financial capital costs of some of the systems. Do-it-yourself ET irrigation systems require no additional up-front costs, but may require more capital with time, as effort must be given to obtaining ET data and updating the irrigation timer. Smart ET controllers, which use automated features for modifying ET, cost about \$500 to install but require less effort over time because they automatically update their irrigation schedule.

If a smart ET controller is selected as the ideal choice, another decision must be made: smart ET controllers may be fully automated such that real-time updates are received through an annual subscription service (signal based technology)

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(\$50/year) or may be connected to onsite weather sensors.

Steps to Follow in Implementing a Signal-Based ET Irrigation Controller

Step 1: Choose a brand and have a supplier test the strength of the communication signal at the installation site. If the signal is weak or poor, purchase an antenna to boost reception.

Step 2: Before programming the ET controller, collect the following data.

- Soil series name (this information can be obtained from the NRSC web soil survey at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>).
- Management allowable depletion (MAD), based on local management practices. (If no specific information is available for MAD, 50% is typically used in Florida).
- Plant type and crop coefficient K_c (these data are available from a nearby UF-IFAS REC, provided it is researching your crop). If no locally developed K_c exists for your crop of interest, you could use typical average values which have been listed in the article *Crop Coefficients of Commercial Agricultural Crops in Florida* <http://edis.ifas.ufl.edu/AE456>.
- Root depth measured on site.
- Irrigation system characteristics (e.g., precipitation rate, irrigation system efficiency and emitter type); some of this information can be obtained from the manufacturer's catalog.
- Location-specific information (e.g., slope, microclimate (shaded or sunny all day) and zip code).

Step 3: Install an on-site rain sensor.

Step 4: Seek the services of a professional to properly install the ET-based controller.

Steps to Follow in Implementing an On-Site Weather-Based ET Irrigation Controller

Step 1: Choose a brand and check with the supplier to confirm that the reference ET (ET_o) estimation equation used in the controller's irrigation scheduling algorithm is radiation-based (earlier research in Florida has demonstrated the superiority of radiation based-ET estimation equations compared with temperature-based equations).

Step 2: Purchase and install controller system, including radiation, temperature and rain sensors.

Step 3: Before programming the controller, collect data noted in step 2 for signal-based ET.

Step 4: Seek the services of a professional to properly install the ET-based controller.

Steps to Follow in Implementing a Historical Weather-Based ET Controller

Step 1: Choose a brand and purchase the ET controller. In addition, purchase and install radiation, temperature and rain sensors to improve daily ET_o estimation based on historical climatic data.

Step 2: Before programming the controller, collect data noted in step 2 for signal-based ET controllers.

Step 3: Seek the services of a professional to properly install the ET controller.

Step-by-Step Guide for Implementing Do-it-Yourself ET-Based Irrigation Scheduling

1. Obtain historical average monthly daily ET_o and total average monthly precipitation (data from Florida Automated Weather Network, FAWN, <http://fawn.ifas.ufl.edu/>). See *Sources of Evapotranspiration Data for Irrigation Scheduling in Florida* <http://edis.ifas.ufl.edu/AE455>.
2. Determine crop coefficient (K_c) for your crop. See *Crop Coefficients for Some Commercial*

Crops in Florida <http://edis.ifas.ufl.edu/AE456>. for steps 2 and 3.

3. Calculate crop evapotranspiration (ET_c).
4. Calculate effective precipitation (P_e). More information on the variables identified in steps 4 through 7 are provided in *Evapotranspiration-Based Irrigation Scheduling for Agriculture* <http://edis.ifas.ufl.edu/AE457>
5. Calculate the net irrigation requirement (I).
6. Calculate gross irrigation requirement (GI).
7. Calculate the precipitation rate (PR) of the irrigation system by determining the flow rate and dividing it by the wetted area, soil water holding capacity (SWHC), and root depth. (Typical SWHC values for some common soils in Florida can be found in *Irrigation Scheduling for Tropical Fruit Groves in South Florida* <http://edis.ifas.ufl.edu/TR001>).
8. Estimate irrigation run time per cycle or event, and adjust run times accordingly in the timer.

Example Do-it-Yourself ET-Based Irrigation Schedule

Consider an avocado orchard in south Florida (Homestead) with the following soil, plant type, weather data, irrigation system and local management characteristics.

Soil characteristics: The soil series was obtained from the NRSC web soil survey at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>.

- Krome gravely loam with a SWHC of 1.2 inches of water per foot of soil.

Plant characteristics: Plant data were obtained from UF-IFAS Tropical REC):

- Crop development stage: Assume mid stage (September to December).
- Crop coefficient $K_c = 0.80$.

- Root depth: Effective root depth, assume 6 inches.

Weather data: These data were obtained from the closest FAWN weather station: <http://fawn.ifas.ufl.edu/>.

- Historical monthly ET_o averages (in/day) for Homestead FAWN station.
- Historical average total monthly rainfall P_m (in/month).

Irrigation system characteristics: These data were obtained from a manufacturer's catalog and on-site measurements (assume the orchard is irrigated with micro-sprinklers).

- Flow rate 24 gal/h (this should be measured on site).
- Assume effective wetted diameter of 118 in (this should be measured on site).
- Irrigation system efficiency, assume 80%.

Local management practices:

- Assume a management allowable depletion (MAD) of 50%.

Step-by-step calculation

Step 1: Calculate historical average monthly and daily ET_o and total average monthly precipitation (assume a 10-year data record 1998 to 2008).

- September $ET_o = 0.13$ in/day and $P_m = 4.2$ in.
- October $ET_o = 0.12$ in/day and $P_m = 3.5$ in.
- November $ET_o = 0.09$ in/day and $P_m = 2.4$ in.
- December $ET_o = 0.08$ in/day and $P_m = 1.9$ in.

Step 2: Calculate crop evapotranspiration using Equation $ET_c = ET_o * K_c$

- September $ET_c = 0.11$ in/day.
- October $ET_c = 0.1$ in/day.
- November $ET_c = 0.09$ in/day.

- December $ET_c = 0.07$ in/day.

Step 3: Calculate effective precipitation (P_e).
General information on estimating P_e can be found in *Evapotranspiration-Based Irrigation Scheduling for Agriculture* <http://edis.ifas.ufl.edu/AE457>

- September $P_e = 2.8$ in/month or 0.09 in/day.
- October $P_e = 1.8$ in/month or 0.04 in/day.
- November $P_e = 0.7$ in/month or 0.02 in/day.
- December $P_e = 0.83$ in/month or 0.03 in/day.

Step 4: Calculate the net irrigation requirement I using

$$I = ET_c - P_e$$

- October $I = 0.08$ in/day.
- November $I = 0.08$ in/day.
- December $I = 0.04$ in/day.

Step 5: Calculate the gross irrigation requirement GI using the following equation and assuming 80% efficiency.

$$GI = \frac{I}{E}$$

- October $GI = 0.1$ in/day.
- November $GI = 0.1$ in/day.
- December $GI = 0.05$ in/day.

Step 6: Calculate irrigation run time per cycle/event.

Assuming the effective root zone is 6 inches deep and a 0.1 inch per inch soil water holding capacity, the water storage capacity is 0.6 inches.

Irrigation precipitation rate = flow rate/effective wetted area:

$$\frac{23.5 \frac{\text{gallon}}{\text{hour}} \times 231 \frac{\text{inches}^3}{\text{gallon}}}{\pi(0.5 \times 118 \text{ inches})^2} = 0.5 \text{ inches/hour}$$

- September irrigation schedule = run irrigation system for $((0.3 \text{ inches}/0.5 \text{ inches per hour}) * 60 \text{ minutes per hour})$ is 36 minutes every $(0.3 \text{ inches}/0.05 \text{ inches per day}) = 6$ days

- October irrigation schedule = run irrigation system for 36 minutes every 3 days.
- November irrigation schedule = run irrigation system for 36 minutes every 3 days.
- December irrigation schedule = run irrigation system for 36 minutes every 6 days.

Step 7: Adjust irrigation run times per month in the irrigation controller accordingly.

Conclusion

Based on the overall production goal and availability of resources (equipment and funds), either of the above approaches can optimize irrigation water use in agriculture. However, smart ET-based irrigation scheduling controllers minimize both labor and maintenance requirements.