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Evapotranspiration-Based Irrigation for Agriculture: Implementing Evapotranspiration-Based Irrigation Scheduling for Agriculture[1]

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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 https://ask.ifas.ufl.edu/collections/series_smart_irrigation_controllers.

Introduction

This publication is part of a series on evapotranspiration (ET)-based irrigation scheduling in agriculture and outlines step-by-step procedures for implementing a "smart" ET-based irrigation schedule and a do-it-yourself irrigation schedule. A numerical example is provided on 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*, which can be found at https://ask.ifas.ufl.edu/publication/AE457.

Criteria for Selecting Smart ET-Based 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 for 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.

Once a smart ET controller is selected as the ideal choice, another decision must be made whether to fully automate the ET controller so that real-time updates are received through an annual subscription service (signal-based technology) ($50/year) or connect the ET controller to on-site 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 USDA-National Resources Conservation Service 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 Kc (these data are available from a nearby UF/IFAS Research and Education Center, provided the center is researching your crop). If no locally developed Kc exists for your crop of interest, you could use typical average values listed in *Evapotranspiration-Based Irrigation for Agriculture: Crop Coefficients of Commercial Agricultural Crops in Florida*, which can be found at https://ask.ifas.ufl.edu/publication/AE456.
- Root depth measured on site.
- Irrigation system characteristics (e.g., irrigation rate, irrigation system efficiency, and emitter type); some of this information can be obtained from the manufacturer's catalog.

- Location-specific information, such as 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 Onsite Weather-Based ET Irrigation Controller

Step 1: Choose a brand.

Step 2: Purchase and install controller system, including mini weather station.

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

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.

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

Step 3: Seek the services of a professional, from the company where the controller was bought, to properly install the ET controller.

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

1. Obtain historical average daily ETo (inch/day) for each month and total average monthly precipitation (data is available from Florida Automated Weather Network or FAWN at https://fawn.ifas.ufl.edu/). See *Evapotranspiration-Based Irrigation for Agriculture: Sources of Evapotranspiration Data for Irrigation Scheduling in Florida* at https://ask.ifas.ufl.edu/publication/AE455.
2. Determine crop coefficient (Kc) for your crop. See *Evapotranspiration-Based Irrigation for Agriculture: Crop Coefficients for Some Commercial Crops in Florida* (https://ask.ifas.ufl.edu/publication/AE456) for steps 2 and 3.
3. Calculate crop evapotranspiration (ETc).
4. Calculate effective precipitation (P_e). More information on the variables identified in steps 4 through 7 is provided in *Evapotranspiration-Based Irrigation Scheduling for Agriculture* at https://ask.ifas.ufl.edu/publication/AE4577.
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* at https://ask.ifas.ufl.edu/publication/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 Homestead, South Florida 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 https://websoilsurvey.nrcs.usda.gov/app/.

- 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 Research and Education Center:

- 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 (https://fawn.ifas.ufl.edu/).

- Historical average daily ETo (inch/day) for each month 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 onsite measurements (assume the orchard is irrigated with micro-sprinklers).

- Flow rate 23.5 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 from 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 = 0.10 in/day.
- October ET_c = 0.10 in/day.
- November ET_c = 0.07 in/day.
- December ET_c = 0.06 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* at https://ask.ifas.ufl.edu/publication/AE457.

- September P_e = 2.8 in/month or 0.09 in/day.
- October P_e = 1.8 in/month or 0.06 in/day.
- November P_e = 0.7 in/month or 0.02 in/day.
- December P_e = 0.8 in/month or 0.03 in/day.

Step 4: Calculate the net irrigation requirement I using the following equation:

$$I = ET_c - P_e$$

Equation 1.

- September I = 0.01 in/day.
- October I = 0.04 in/day.
- November I = 0.05 in/day.
- December I = 0.03 in/day.

Step 5: Calculate the gross irrigation requirement GI using Equation 2 and assuming 80% efficiency:

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

Equation 2.

- September GI = 0.01 in/day.
- October GI = 0.05 in/day.
- November GI = 0.06 in/day.
- December GI = 0.04 in/day.

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

The SWHC is given as 1.2 inches of water per foot of soil, which is the same as 0.1 inch water per inch soil. Assuming the effective root zone is 6 inches deep, the water storage capacity is 0.6 inches.

Effective wetted area = p x $(0.5 \times 118 \text{ in})^2$

Irrigation rate = flow rate/effective wetted area:

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

Equation 3.

Assuming a 50% MAD or 0.3 inches irrigation depth:

- September irrigation schedule = run irrigation system for ((0.3 inches/0.5 inches per hour) * 60 minutes per hour) is 36 minutes every (0.3 inches/0.013 inches per day) = 22.5 days.
- Results for the remaining months are summarized below in Table 1.

Step 7: Adjust irrigation run times per month in the irrigation controller according to results in Table 1.

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.

Table 1. Summary of example irrigation scheduling results.

Month	P_m	P_e	ET_o	ET_c	P_e	I	GI	Schedule
	(inch/month)		(inch/day)					(days)
Sept	4.20	2.80	0.13	0.104	0.093	0.011	0.013	22.5
Oct	3.50	1.80	0.12	0.096	0.058	0.038	0.047	6.3
Nov	2.40	0.70	0.09	0.072	0.023	0.049	0.061	4.9
Dec	1.90	0.80	0.08	0.064	0.026	0.038	0.048	6.3

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