Using Weather Stations to Determine How Much Water Your Crop is Using? University of Tennessee, Extension Fact-Sheet

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The best method to determine crop water use is with lysimeters, large soil boxes with a crop growing inside that can be accurately weighed for differences in water use. Of course, this is not practical on-farm and is difficult for research stations. There are other methods that directly measure the potential for water use from plants such as evaporation pans (water drop in a standard size pan) and atmometers (evaporation from a water column through a porous ceramic top covered by green cloth) shown in Figure 1. The most accepted method is not a direct measurement but a relationship to weather data using energy balance and empirical equations. A strong correlation has been made between water loss from lysimeters (plant transpiration and soil surface evaporation; collectively referred to as Evapotranspiration or ET) and weather data. The factors most effecting evapotranspiration (ET) are solar radiation, air temperature, humidity, and wind speed. We find that everything from our hair to a paint job dries or loses moisture faster on a sunny, hot, dry, and windy day than on a calm and cloudy or cool day.

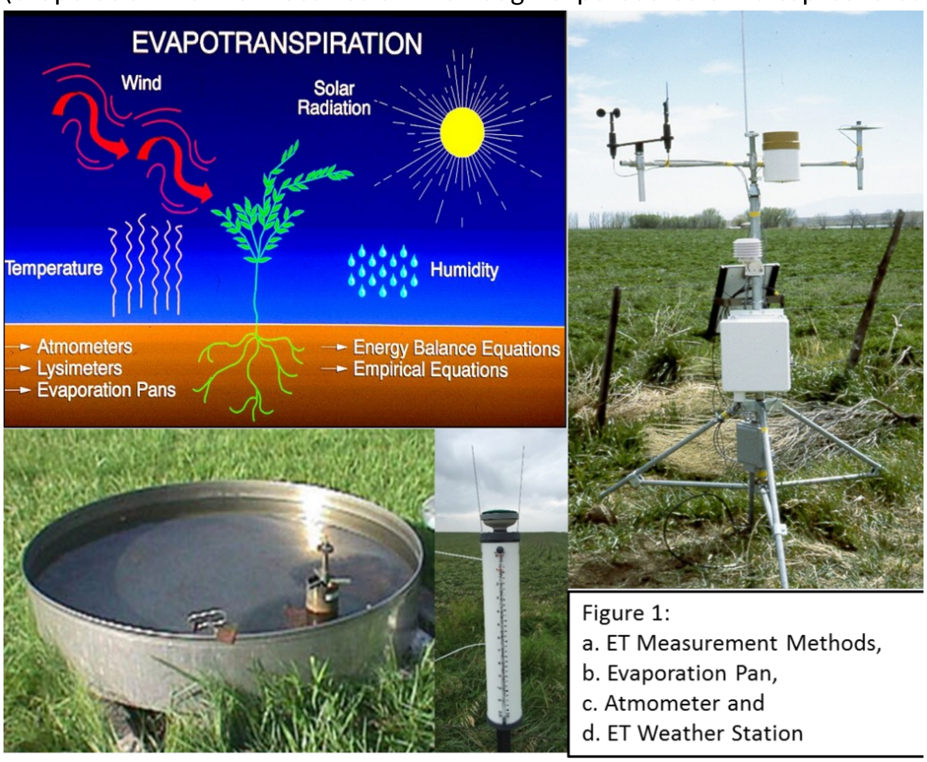
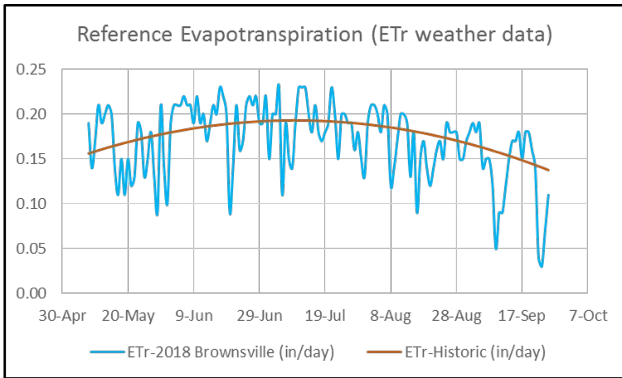
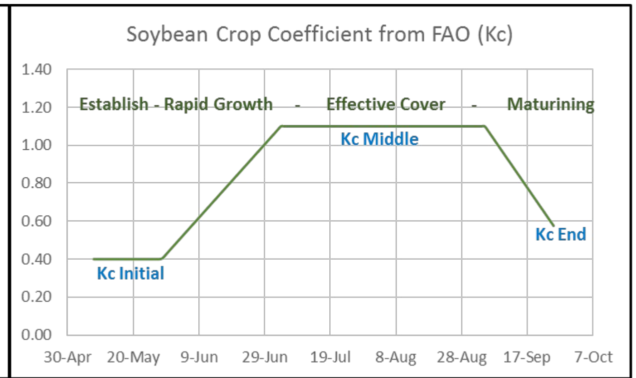
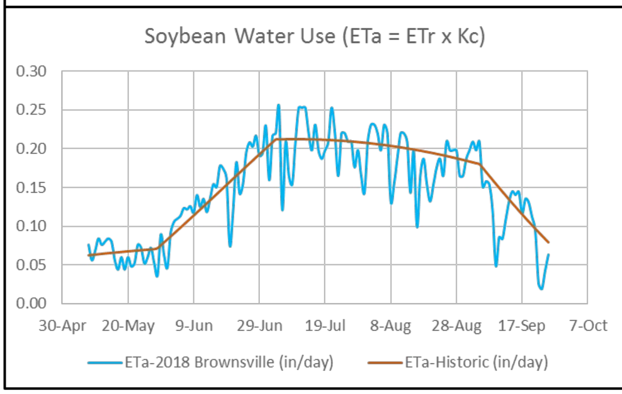


Figure 1:
a. ET Measurement Methods,
b. Evaporation Pan,
c. Atmometer and
d. ET Weather Station

Research and field data shows that the actual rate of crop ET can be approximated by multiplying the rate of ET from a well-watered reference crop (like grass or alfalfa, ETr) by a crop-specific parameter called a crop coefficient (Kc). The reference ET (ETr) can be calculated using various equations depending on the availability of weather data. Also, there are plenty of sources of crop coefficient (Kc) values, including a collection published by the Food and Agriculture Organization of the United Nations (1) that adjusts for the crop type and stage of development to determine the actual crop ET (ETa) or crop water use, such that ETa = ETr x Kc. Figure 2 shows ETr that has been calculated from weather data over an entire growing season and how a crop coefficient is used to estimate crop water use (ETa).







Crop	Kc initial	Kc Middle	Kc End
Cotton	0.35	1.15	0.6
Corn	0.3	1.15	0.45
Soybean	0.4	1.1	0.5

Figure 2: Seasonal example of calculating crop water use (ETa) from weather data, ETr equations and crop coefficients

The Biosystems Engineering & Soil Science (BESS) Department of the University of Tennessee maintains a network of weather stations that measures and records the data necessary to calculate Reference ET. This network can be accessed from the BESS Homepage (2). The weather stations record solar radiation, temperature, humidity, wind speed, and precipitation. The network calculates and automatically publishes ETr on a grass basis from weather data using the Turc or Modified Penman Equations. A sample of weather data and the calculated ETr using the Haywood County station is shown in the Table 1.

Table 1: Haywood County Weather Data and Calculated Reference Evaporation

Date	Solar Radiation MJ/day	Temperature Max °F	Temperature Min °F	Humidity Max	Humidity Min	Wind Speed mi/hr	Precipitation inches	Reference ET inches
7-28-18	18.8	86	64	99	54	1	0	0.16
7-29-18	22.0	88	64	97	49	2	0	0.18
7-30-18	17.1	84	68	98	64	3	0	0.15
7-31-18	15.7	84	66	99	56	2	0	0.13
8-1-18	23.5	82	61	100	55	2	0	0.19
8-2-18	26.2	88	63	100	44	2	0	0.21
8-3-18	25.8	90	63	100	43	1	0	0.21
8-4-18	23.6	90	66	99	51	2	0	0.20

Actual crop ET (ETa = ETr x Kc) is used for irrigation scheduling in a water balance approaches which takes crop, soil (3), rainfall and irrigation into account. Historic crop water use (ETa) and historic rainfall for West Tennessee can be found in the Water Balance Tables for cotton, corn and soybean. Historical averages can provide a general understanding of your need to irrigate but weather and rainfall patterns tend to be much more variable than historic averages in any given year.

There are several real-time water balance programs available like MOIST (Management Of Irrigation Systems in Tennessee) by the University of Tennessee (4). MOIST spreadsheets keep a water balance of soil water depletion by subtracting actual crop ET and manually adding rainfall & irrigation. The water balance has been automated and soil sensor have been added to UT's latest irrigation scheduling product, MOIST+ (Management Of Irrigation Plus Soil Tension), but this version requires the purchase and installation of a data logger, rain gauge and sensors for your field (5).

Weather data, ETr calculation and crop coefficients provide an estimate of crop water use (ETa) and thus knowledge of how much irrigation is required to maintain soil moisture at a level that can optimize yield. Tennessee specific recommendations for irrigating cotton (6) and soybean (7) are available using a Managed Depletion Irrigation (MDI) approach.

Links

1. FAO Irrigation and Drainage Paper #56 – Chapter 8 – Soil Water Depletion Fraction or MAD.
2. Weather Station Data from BESS Homepage
3. How Soil Holds Water, a Home Experiment
4. Using a Water Balance to Make Irrigation Decisions: MOIST.
5. Automating and Combining Water Balance and Sensor Based Irrigation Scheduling: MOIST+.
6. The Basics of Cotton Irrigation in Tennessee.
7. The Basics of Soybean Irrigation in Tennessee.