Water Use for Drip-Irrigated Watermelon with Plastic Mulch in Florida[1]

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Watermelon is an important crop in Florida and accounts for a significant part of its agricultural water use. In 2010, Florida ranked first nationally in watermelon production, accounting for 19% (25,900 acres) of the national watermelon acreage (http://edis.ifas.ufl.edu/pi031). The water use of this crop can vary depending on the type of production system. Watermelon is grown in open fields and on raised plastic-mulched beds, with the latter being the predominant production system in Florida. Accurate water use estimates for this crop are needed to develop better water allocation and management plans as well as for irrigation management.

Drip irrigation under plastic mulch is a common production system used for watermelon in Florida and elsewhere in the United States. Plastic mulch affects the crop evapotranspiration (ET_c), or water use. Evapotranspiration losses from a mulched production system are different than losses from an open field production system. Compared with open field production, covering soil with impermeable plastic reduces soil evaporation and increases transpiration. The effect of plastic mulch on ET_c can also vary depending on local climate. For example, crop water use for watermelon grown with plasticulture in semi-arid California will be different than in sub-tropical Florida. These differences compel us to quantify the crop water use (ET_c) for the plastic-mulch environment of subtropical Florida. This publication summarizes the results from a crop water-use study for the drip-irrigated watermelon in south Florida.

Calculating Crop Water Use for Watermelon

For more than 40 years, ET_c or crop water use has been calculated with the "crop coefficient" method, which uses a crop-specific coefficient and reference ET (ET_0) to calculate the actual crop ET (ET_c). Reference evapotranspiration is a commonly used concept in irrigation scheduling and refers to the evapotranspiration from a well-watered grass (see http://edis.ifas.ufl.edu/ae256). Reference evapotranspiration can be calculated using commonly available weather parameters. Most modern weather stations can provide ET_0 estimates, including those stations that are part of the Florida Automated Weather Network (FAWN). The FAWN website has a tool to estimate ET_0 using the site-specific weather data (http://fawn.ifas.ufl.edu/). The primary weather parameters that influence ET_0 are temperature, humidity, wind speed, and solar radiation. For example, maximum ET_0 would occur on a sunny, dry, windy, and hot day, whereas minimum ET_0 would occur on a cloudy, humid, cold day with little wind.

1. This document is AE508, one of a series of the Agricultural and Biological Engineering Department, UF/IFAS Extension. Original publication date August 2014. Visit the EDIS website at http://edis.ifas.ufl.edu.

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Crop Coefficients

All plants do not use the same amount of water under the same climatic conditions. So, irrigation scientists have developed crop coefficients that provide a relationship between ET_0 and the amount of water (ET_c) that the crop of interest uses. Water-use studies are conducted to find the relationship between the crop's evapotranspiration and that of the reference crop (well-watered grass). These studies often involve lysimeters, which allow the scientists to actually measure the quantity of water that the crop of interest uses for daily or longer (weekly or monthly) periods. This is then related to ET_0 using the following relationship:

$$ET_c = ET_0 \times K_c$$

Where ET_c = crop evapotranspiration or crop water use

ET_0 = reference evapotranspiration

K_c = crop coefficient

Although K_c values are available for a wide variety of crops, these values may not be applicable for all situations. For example, due to Florida's unique climatic conditions (subtropical) and soil characteristics (sandy, high water table), crop coefficients developed elsewhere (e.g., arid western United States) may not provide realistic estimates for the same crop grown in Florida. Although coefficients have been developed for the few selected plasticulture crops in Florida to allow growers and water managers to accurately estimate crop water needs, they have not yet been developed for watermelon.

Watermelon ET Study

A three-year study was conducted at the UF/IFAS Southwest Florida Research and Education Center (SWFREC), Immokalee, Florida, to measure crop water use and develop K_c for drip irrigated watermelon. Four drainage lysimeters (16 ft. [width] × 12 ft. [length] × 4.5 ft. [depth]) (Figure 1) were used to estimate ET_c with the data collected for three spring seasons (2003, 2004, and 2005). Each lysimeter had two beds (length = 12 ft., width = 32 in., height = 8 in.) that contained six plants (three plants per bed). Irrigation, drainage, and runoff were measured using flowmeters. The ET_c was calculated on a biweekly basis (14-day period) as the residual of the water balance (inflow minus outflow, including the change in soil moisture). The simplified water balance can be written as follows:

$$ET_c = \text{Rainfall} + \text{Irrigation} - \text{Drainage} - \text{Runoff} + \text{Change in Soil Moisture}$$

With the known biweekly ET_c from lysimeters, K_c values were estimated by dividing ET_c by ET_0. Note that the ET_0 was calculated using the Food and Agricultural Organization (FAO) Penman-Monteith method (Allen et al., 1998). Crop coefficient values were developed for four crop stages: initial stage (0% to 10% of ground cover), development stage (10% ground cover to effective full cover), mid-season stage (effective full cover to start of maturity), and late stage (maturity to harvest).

Figure 1. The drainage lysimeter for watermelon experiment
Credits: Sanjay Shukla

Watermelon ET_c and K_c

The three-year average ET_c for watermelon was 279 mm (11 in.). The K_c and ET_c for different crop stages are shown in Table 1. The initial K_c for watermelon was considerably high due to wet row-middles at the beginning of the growing season, which resulted in high evaporation. For a plasticulture production system, making beds requires soil to be sufficiently wet. In Florida, water gun or V-ditches are used to wet the soil for making beds. Use of V-ditches is quite common in south Florida and involves applying water through the ditches to raise the naturally shallow water table to less than 18 in. Depending on the farm needs and grower preferences, the shallow water table at the beginning of the crop is either allowed to drop naturally or maintained at a lower level.

For ease of use, the stage-based K_c values in Table 1 are shown graphically in Figure 2. Crop coefficient values from Figure 2 can be combined with site-specific ET_0 to calculate ET_c for any day during the growing period. Most modern weather stations that are used by growers can provide ET_0 estimates for the specific farm. Alternatively, you can locate

Table 1. Stage-based crop coefficient (K_c), crop ET (ET_c), and reference ET (ET_0) for watermelon

Crop Stage	K_c	ET_c (mm)	ET_0 (mm)
Initial	0.65	34.7	53.43
Development	0.71	107.1	150.85
Mid-season	1.01	95.5	94.51
Late-season	0.71	42.1	59.36
1 in. = 25.4 mm			

the nearest weather station that is a part of the Florida Automated Weather Network (FAWN) (http://fawn.ifas.ufl.edu/) and obtain the local ET_0 values. Reference ET_0 can also be obtained from the monthly values summarized online at https://edis.ifas.ufl.edu/ae481 for major cities in Florida. The following example shows the use of K_c values from the lysimeter study for calculating watermelon ET_c.

Situation: Watermelon was planted on March 1, 2014, at a farm in Immokalee, Florida. The watermelon was grown on raised plastic mulched beds and was irrigated using drip system. What will be the ET_c for April 20, 2014, which was 50 days after the transplant (DAT)?

Step 1. Determine daily ET_0 in Immokalee using the FAWN weather station (visit http://fawn.ifas.ufl.edu/) in Immokalee, Florida. The ET_0 obtained from the FAWN weather station for April 20, 2014 was 0.19 in./day.

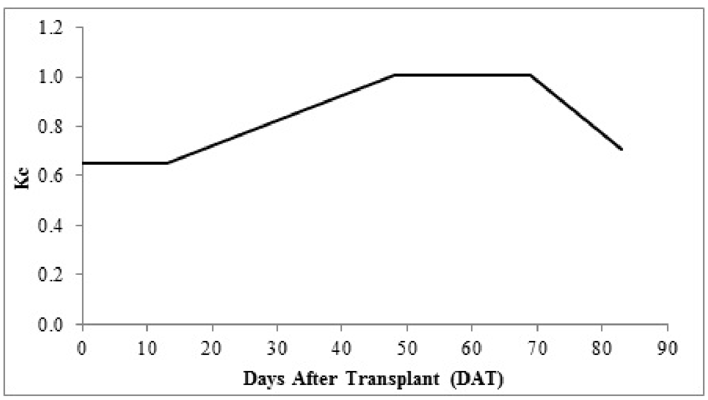

Figure 2. Crop coefficient (K_c) values for drip-irrigated watermelon for days after transplant (DAT)
Credits: Shukla et al. (2014)

Step 2. Read K_c from Figure 2 for 50 days after transplant (DAT) as 1.0.

Step 3. Calculate the crop evapotranspiration (ET_c) for April 20 as follows:

$$ET_c = K_c \times ET_0 = 1.0 \times 0.19 = 0.19 \text{ in./day}$$

Use of K_c values from Table 1 or Figures 2 provides ET_c values for drip-irrigated watermelon under plastic-mulch production system with shallow water table conditions at the beginning of the season. The initial high K_c value due to shallow water table condition results in high unproductive losses of water because of high soil evaporation from wet row-middles. It should be noted that these K_c values represent an average of a three-year period. Year-to-year variations in weather and crop parameters may result in K_c values being different than those in Table 1. The watermelon ET_c obtained can be used for a variety of applications, ranging from constructing the farm's water budgets to its water allocations. Note that the crop water use obtained from the use of K_c shown above does not include application losses. To obtain water that needs to be pumped for irrigation, divide the ET_c by the irrigation efficiency (visit http://edis.ifas.ufl.edu/ch153). Irrigation efficiency is always lower than 100%. Typically drip irrigation system will have efficiency of 80%. Use of K_c values shown here can help improve the accuracy of ET_c estimates for drip-irrigated watermelon in subtropical Florida.

References

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