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

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In Florida, watermelon is an important crop that accounts for a significant part of the state's agricultural water use. Florida ranked first nationally in watermelon production area in 2010, accounting for 19% (10,500 hectares [ha]) of the national watermelon acreage (http://edis.ifas.ufl.edu/pi031). Depending on the type of production system and climate, the water use of this crop can vary. In Florida, watermelon is predominantly grown on raised plastic-mulched beds. To develop improved water management and allocation plans, accurate water use estimates for watermelon are needed.

Seepage irrigation under plastic mulch is a common production system used to produce watermelon in south and northeast Florida where the water table is shallow. Seepage irrigation involves artificially raising the water table to within 18–24 inches, in order to supply water to the crop root zone. This requires applying large volumes of water to the narrow irrigation ditches (between every two to six raised mulched beds). Such shallow water tables for seepage irrigation result in wet row-middles. In seepage-irrigated farms, water tables rise quickly after a rainfall; for south Florida, the water table has been shown to rise a height of 16 times more than the rainfall depth (Jaber et al., 2006). Such conditions cause near-saturation to full saturation of soil in the row-middles' bare soil area on seepage-irrigated farms. A wet row-middle causes high evaporation from the row-middle and, therefore, higher ET_c compared to drier row-middles for drip irrigation.

Plastic mulch alters the rainfall entry and soil temperature of the raised beds and can significantly affect ET_c. Evapotranspiration from a mulched production system is different from an open field production system. Covering soil with impermeable plastic reduces soil evaporation and increases transpiration, compared with open field production. The effect of plastic mulch on ET_c can also vary depending on climate. For example, crop water use for watermelon grown with plasticulture in drier semi-arid region will be different than a subtropical region with higher humidity. The difference also arises with the irrigation method. There can be large differences in ET_c between drip and seepage irrigation systems that are used to grow watermelon in Florida. While ET_c for drip-irrigated watermelon has been quantified (see EDIS publication AE 506, *Water Use for Drip-Irrigated Watermelon with Plastic Mulch in Florida*), there is no information on seepage-irrigated watermelon grown on plastic mulch for subtropical Florida. This publication summarizes the results from a crop water use study for the seepage-irrigated watermelon in south Florida.

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Calculating Crop Water Use for Watermelon

For more than 40 years, crop water use or ET_c has been calculated with the "crop coefficient" method, which uses a crop-specific coefficient (K_c) and reference ET (ET_0) to calculate the actual crop ET (ET_c). Reference ET refers to the evapotranspiration (evapotranspiration + transpiration) from a well-watered grass, which can be calculated using commonly available weather parameters. The Florida Automated Weather Network (FAWN) can provide ET_0 estimates. This weather station website has a tool to estimate ET_0 using the site specific weather data (visit http://fawn.ifas.ufl.edu/). Temperature, humidity, wind speed, and solar radiation are the primary weather parameters that influence ET_0. For example, high ET_0 occurs on a sunny, dry, windy, and hot day, whereas low ET_0 occurs on a cloudy, humid, cold day with little wind.

Crop Coefficients

Different plants use different amount of water under the same climatic conditions. Crop water use for a vine crop such as watermelon will be different than an erect crop (e.g., pepper) because of differences in evaporation and, to an extent, transpiration. Scientists have developed K_c values that relate ET_0 with actual crop water use (ET_c) for a specific crop of interest. Several studies have been conducted throughout the world to estimate local K_c values, which are then used to translate ET_0 (well watered grass) to ET_c 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

A lysimeter is the most commonly used method for measuring water use for agricultural crops for daily or longer time periods (weekly or monthly). Literature K_c values are available for a wide variety of crops; however, they may not be applicable for all situations. Although crop 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 are not available for seepage-irrigated watermelon. Crop water use for drip-irrigated watermelon has been provided in another EDIS publication (Shukla et al., 2014). The wet row-middles of seepage-irrigated fields result in significantly higher ET_c compared to drip systems that have drier row-middles. Therefore, despite the use of local (Florida) K_c for drip-irrigated watermelon, it will lead to erroneous estimates of field-scale crop water use for seepage-irrigated watermelon. The large potential for errors in quantifying ET_c for seepage-irrigated crop requires the development of K_c values specifically for seepage-irrigated watermelon grown on mulched beds.

Watermelon ET Study

A three-year study was conducted at the UF/IFAS Southwest Florida Research and Education Center, Immokalee, Florida, to measure crop water use and develop K_c for seepage-irrigated watermelon. Two drainage lysimeters (16 × 12 × 4.5 ft.) (Figure 1) were used to estimate ET_c using 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). Using flowmeters, the irrigation, drainage, and runoff were measured. The water balance equation can be written as follows:

ET_c = Rainfall + Irrigation – Drainage – Runoff – Change in Soil Moisture Storage

All inflow and outflow from lysimeters are used in the above water balance to calculate ETc as residual of the water balance (inflow minus outflow, including the change in moisture). Using measurements from the lysimeter for three years, ET_c was calculated on a biweekly basis (every two weeks). With the known value of biweekly ET_c from lysimeters, K_c values were estimated by ratio ET_c to ET_0, where ET_0 was calculated using the FAO Penman-Monteith method (Allen et al., 1998). Based on crop cover, crop coefficient values were developed for four 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).

Watermelon ETc and Kc

A three-year average ET_c for seepage-irrigated watermelon was 373 mm (14.7 in.), and this value was 34% higher than drip-irrigated watermelon grown at the same farm for the same period (Shukla et al., 2014). The difference in ET_c between drip- and seepage-irrigation systems was low during the initial stage. The practice of wetting the fields to make the soil workable for bedding and maintaining high moisture levels for root establishment of the transplants resulted in similar row-middle soil moisture in drip- and

Figure 1. The drainage lysimeter for the watermelon crop water-use experiment

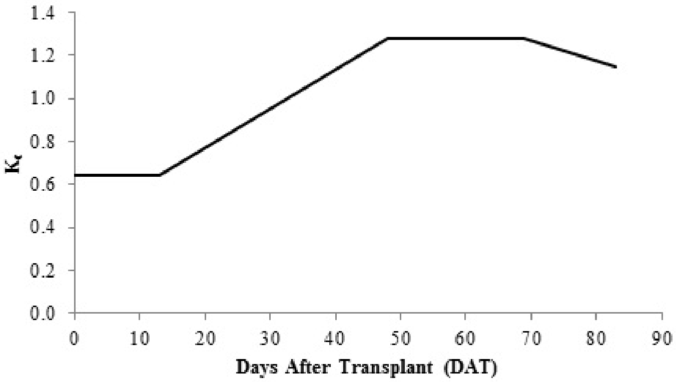

Figure 2. Crop coefficient (K_c) values for seepage-irrigated watermelon for days after transplant (DAT)
Credits: Shukla et al. (2014)

seepage-irrigated watermelon and, therefore, similar ET_c during the initial stage. The difference in ET_c between the drip and seepage irrigation systems was highest during the development stage. This difference was because the vine cover during this stage was less than effective full cover. This lack of vine cover resulted in higher evaporation from the uncovered soil surface and, therefore, ET_c for the seepage-irrigated watermelon because of wetter row-middles (compared to drier row-middles of the drip-irrigated watermelons). The three-year average K_c and ET_c for different crop stages are shown in Table 1. The initial K_c for watermelon was considerably higher than reported in the literature for agricultural crops due to wet soils in the row-middles during the initial stage.

The stage-based K_c values in Table 1 are shown graphically in Figure 2 for ease of use. Crop coefficient values from Figure 2 and site-specific ET_0 can be used to calculate ET_c for a given day during the growing period. Most modern weather stations can provide ET_0 estimates for their farms. In the absence of a nearby weather station, you can locate the nearest weather station that is part of the Florida Automated Weather Network (FAWN) (visit http://fawn.ifas.ufl.edu/) and obtain the local ET_0 values. Monthly values of reference ET can also be obtained online at https://edis.ifas.ufl.edu/ae481 for major cities in Florida. The example below shows the use of K_c values from the lysimeter study for calculating ET_c for seepage-irrigated watermelon.

Situation: Watermelon was planted on plastic mulched bed on March 1, 2014, at a farm in Immokalee, Florida. The watermelon was irrigated using seepage system. What will be the ET_c for April 30, 2014, which was 60 days after the transplant (DAT)?

Step 1. Obtain daily ET_0 in Immokalee using the FAWN weather station (visit http://fawn.ifas.ufl.edu/) at Immokalee, Florida. The ET_0 obtained from the FAWN weather station for April 30, 2014, was 0.15 in./day.

Step 2. Read K_c from Figure 2 for 60 days after transplant (DAT) as 1.3.

Step 3. Calculate the crop evapotranspiration (ET_c) for April 30 as follows:

$$ET_c = K_c \times ET_0 = 1.3 \times 0.15 = 0.20 \text{ in./day}$$

Use of K_c values from Table 1 or Figures 2 provides ET_c values for seepage-irrigated watermelon under plastic-mulch production systems with shallow water table conditions. The initial high K_c value was due to shallow water

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	0.64	34.2	53.43
Development	1.00	151.3	150.85
Mid-season	1.28	121.7	94.51
Late-season	1.15	68.3	59.36
1 in. = 25.4 mm			

table conditions that resulted in high unproductive losses of water from wet row-middles. Compared to literature (i.e., FAO-56 [Allen et al., 1998], a publication used worldwide as reference for K_c values), a proportional increase in K_c was not observed during the later stages, because the area shaded by the leaves increased with the plant growth to the extent that at effective full growth, almost the entire row middle was covered, which reduced the evaporation (Figure 1). It should be noted that the K_c values presented here represent an average of 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. Watermelon ET_c obtained can be used for a variety of applications ranging from constructing water budgets for the farm or watersheds to water allocations. Note that the crop water-use obtained from the use of K_c shown above does not include application and subsurface 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, seepage irrigation system will have efficiency of 40% (Stanley and Clark, 1991). Use of K_c values shown here can help improve the accuracy of ET_c estimates for seepage-irrigated watermelon in subtropical Florida.

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