Water Use for Seepage-Irrigated Pepper with Plastic Mulch in Florida

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Bell pepper (*Capsicum annuum*) is an important crop for Florida and accounts for a significant fraction of its agricultural water use. In 2004, Florida ranked second nationally in bell pepper production, accounting for 34% of the national acreage (18,000 acres) (Mossler et al., 2012). Most of it is produced in south Florida, where the water table is shallow. Seepage irrigation is one of the most common systems used in south Florida for growing plastic-mulched vegetable crops, including bell pepper. Compared with an open field production, covering the soil with impermeable plastic reduces soil evaporation and increases transpiration.

Due to its low capital cost and ease of management, seepage irrigation in Florida is used on nearly 52% of the irrigated land (Marella, 1999). The seepage irrigation system involves applying large volumes of water to the narrow irrigation ditches to artificially raise the water table within 18–24 in. of the ground surface for supplying water to the crop root zone. The high water table in a seepage irrigation system results in conditions that are different from those of a drip irrigation system, because of near-saturation soil moisture in the row-middles between the raised mulched beds. For an erect crop such as bell pepper (referred to as “pepper” throughout), this near-saturation soil moisture results in high evaporation from the row-middles, affecting crop water use considerably throughout the growing season. These differences compel us to quantify the actual crop water use ($\text{ET}_c$) for seepage-irrigated pepper grown on plastic mulch in a subtropical Florida. This publication summarizes the results from a crop water use study for the seepage-irrigated pepper in south Florida.

**Crop Coefficient and Water Use**

The crop coefficient approach has been a common method for calculating $\text{ET}_c$ for several decades. In this method, $\text{ET}_c$ is calculated by multiplying a crop-specific coefficient ($K_c$) with the reference ET ($\text{ET}_0$). The $\text{ET}_0$ is evapotranspiration from a well-watered grass and can be calculated using commonly available weather parameters such as temperature, humidity, wind speed, and solar radiation. While a variety of methods exist, the Food and Agricultural Organization (FAO) Penman-Monteith (FAO-PM) method (Allen et al., 1998) is widely used worldwide as a standard for estimating $\text{ET}_0$. Most modern weather stations used by vegetable growers have built-in estimation procedures to provide $\text{ET}_0$ (FAO-PM) that reflects the prevailing climatic conditions at their farms. The reference ET can also be obtained online from weather stations that are part of the Florida Automated Weather Network (FAWN) at [http://fawn.ifas.ufl.edu/](http://fawn.ifas.ufl.edu/).

The amount of water used by plants under the same climatic conditions differs with crop type. Crop water use of an erect crop such as pepper is different from a vine crop (e.g., watermelon), because of the differences in evaporation as

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well as transpiration. For the crop of interest, scientists have developed $K_c$ values that relate $ET_0$ with the crop water use ($ET_c$). Such studies usually involve lysimeters to measure the quantity of water that the specific crop uses ($ET_c$) and to develop $K_c$ as a ratio of $ET_c$ to $ET_0$ ($K_c = ET_c/ET_0$).

The $K_c$ values for most crops, including pepper, can be obtained from FAO-56 (Allen et al., 1998), a publication that is used worldwide as reference for $K_c$. However, the $K_c$ may vary from one place to another depending on climate, soil, and irrigation methods. The errors in water use estimates further increase when $K_c$ for an open-field pepper is applied for the plastic-mulch production system. Use of literature $K_c$ values (e.g., FAO-56) for seepage-irrigated pepper in Florida may result in erroneous estimates of $ET_c$. Although $K_c$ values 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 pepper.

**Pepper ET Study**

An experiment was conducted for five crop seasons at the UF/IFAS Southwest Florida Research and Education Center, Immokalee, Florida, to measure crop water use and develop $K_c$ for seepage-irrigated pepper. Two large drainage lysimeters ($16 \times 12 \times 4.5$ ft.) (Figure 1) were used to quantify pepper $ET_c$ using the data collected for fall seasons (September–December) of 2003, 2004, 2006, 2007, and 2008. Each lysimeter had two beds (length = 12 ft., width = 32 in., height = 8 in.) that contained 40 plants (two rows with 20 plants per bed). The water volumes for irrigation, drainage, and runoff were measured using flowmeters. Crop water use ($ET_c$) was calculated on bi-weekly basis as a residual of the water balance (inflow minus outflow, including the change in moisture) written as follows:

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

With the known value of biweekly (14-day period) $ET_c$ from lysimeters, $K_c$ values were estimated by the ratio of $ET_c$ to $ET_0$, where $ET_0$ used here was calculated using the FAO-PM method. The crop coefficient values are developed for four stages based on crop cover: 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).

The $K_c$ values in Table 1 are shown graphically in Figure 2. The crop coefficient values from Figure 2 together with site-specific $ET_0$ can be used to calculate $ET_c$ for seepage-irrigated pepper in Florida for any day during the growing period. In absence of nearby weather station, the nearest weather station that is a part of the Florida Automated Weather Network (FAWN) (http://fawn.ifas.ufl.edu/) can be used to obtain the local $ET_0$ values. Alternatively, reference $ET_0$ can also be obtained from the long-term monthly data summarized 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 seepage-irrigated pepper $ET_c$.

**Situation:** Pepper was planted on plastic mulched bed on September 10, 2013, at a farm in Immokalee, Florida. The
crop was irrigated using seepage system. What is the ETc for October 30, 2013, which was 50 days after the transplant (DAT)?

**Step 1.** Obtain daily ET₀ in Immokalee using the FAWN weather station (visit [http://fawn.ifas.ufl.edu/](http://fawn.ifas.ufl.edu/)) in Immokalee, Florida. The ET₀ obtained from the FAWN weather station for October 30, 2013 is 0.11 in./day.

**Step 2.** Read Kc from Figure 2 for 50 days after transplant (DAT) as 1.2.

**Step 3.** Calculate the crop evapotranspiration (ETc) for October 30, 2013 as follows:

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ET_c = Kc \times ET_0 = 1.2 \times 0.11 = 0.13 \text{ in./day}
\]

Use of Kc values from Table 1 or Figure 2 provides ETc values for seepage-irrigated pepper under plastic-mulch production system with shallow water-table environments. The initial Kc was high due to high evaporation from the wet row-middles. Although the Kc values presented here represent an average of five-year data, year-to-year variations in weather and crop parameters may result in Kc values being different than those presented in Table 1. Pepper ETc from this study can be used for a variety of applications, from constructing the farm’s water budgets to its water allocations. The crop water use obtained from the use of Kc shown above does not include application and subsurface losses. To estimate the water needed for irrigation, the ETc needs to be divided by the irrigation efficiency (http://edis.ifas.ufl.edu/ch153). Due to water loss, the irrigation efficiency is always less than 100%. Seepage irrigation system typically has water use efficiency of 20%–50%. Use of Kc values presented in this study can help improve the accuracy of ETc estimates for seepage-irrigated pepper grown on mulched beds for water management–related applications in subtropical Florida.

### References


