UF IFAS Extension UNIVERSITY of FLORIDA

AE509

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

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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 (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 ET_c for several decades. In this method, ET_c is calculated by multiplying a crop-specific coefficient (K_c) with the reference ET (ET_0). The 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 ET_0. Most modern weather stations used by vegetable growers have built-in estimation procedures to provide 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/.

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

1. This document is AE509, 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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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 × 12 × 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 = Rainfall + Irrigation – Drainage – Runoff – 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).

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

Pepper ET_c and K_c

The five-year average seasonal ET_c calculated from the lysimeter measurements was 267 mm (10.5 in.), almost 60% higher than the estimate from the FAO-56. The K_c and ET_c values for four crop stages from this study is shown in Table 1. Compared to FAO-56, the initial stage K_c from this study was considerably high, due to high evaporation from the wet row-middles as a result of wetting the field to make the soil workable for bedding. This wetting is achieved by raising the water table to less than 18 inches. The difference in K_c (and ET_c) between this study and FAO-56 is relatively small during mid-season stage. As the crop progresses towards effective full growth, the transpiration overtakes evaporation during mid-season stage, and becomes a dominant part of crop water use till the crop is harvested.

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

Table 1. Stage-based crop coefficient (K_c), crop water use (ET_c), and reference ET (ET_0) for pepper for this study

Crop Stage	K_c	ET_c (mm)	ET_0 (mm)
Initial	0.86	83	97
Development	1.05	44	42
Mid-season	1.21	110	91
Late	1.28	33	26
Total/Average	1.10	271	257

crop was irrigated using seepage system. What is the ET_c for October 30, 2013, which was 50 days after the transplant (DAT)?

Step 1. Obtain 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 October 30, 2013 is 0.11 in./day.

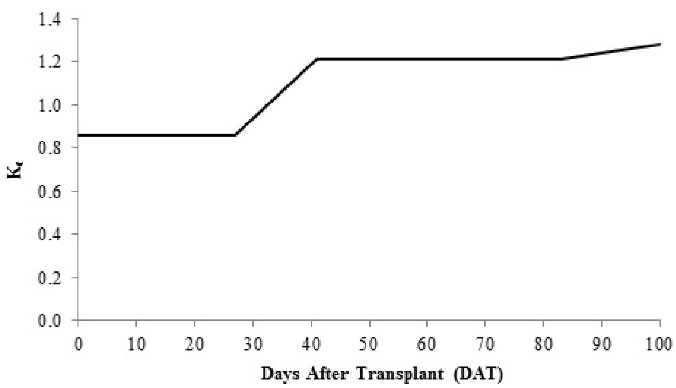

Figure 2. Crop coefficient (K_c) values for seepage-irrigated pepper for days after transplant (DAT)
Credits: Shukla et al. (2012)

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

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

$$ET_c = K_c \times ET_0 = 1.2 \times 0.11 = 0.13 \text{ in./day}$$

Use of K_c values from Table 1 or Figure 2 provides ET_c values for seepage-irrigated pepper under plastic-mulch production system with shallow water-table environments. The initial K_c was high due to high evaporation from the wet row-middles. Although the K_c values presented here represent an average of five-year data, year-to-year variations in weather and crop parameters may result in K_c values being different than those presented in Table 1. Pepper ET_c 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 K_c shown above does not include application and subsurface losses. To estimate the water needed for irrigation, the ET_c 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 K_c values presented in this study can help improve the accuracy of ET_c estimates for seepage-irrigated pepper grown on mulched beds for water management–related applications in subtropical Florida.

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