Original Research Article

Estimation of Actual Crop Evapotranspiration of Green Chilli in Semi-Arid Region under Different Atmospheric Condition

L. Aiswarya¹*, K. Arunadevi², R. Lalitha² and S. Vallalkannan³

¹Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu, India
²Department of Soil and Water Conservation Engineering, ³Department of Irrigation and Drainage Engineering, AEC & RI, Kumulur, Tamil Nadu, India

*Corresponding author

A B S T R A C T

In order to give precise amount of irrigation through drip irrigation system, it is important to estimate the reference evapotranspiration (ET₀) and crop evapotranspiration (ETc) for any crops. In this study, crop evapotranspiration (ETc) was determined for the Green chilli cultivated in the polyhouse and open field for the semi-arid climatic condition in Kumulur, Tamil Nadu, as it changes with the crop characteristics, climatic conditions and management practices. The chilli variety chosen was TNAU Hybrid CO1. The ET₀ value was determined by the Penman Mondeith method mentioned in the FAO-56 using ET₀ calculator. The ETc value was calculated by the soil water balance method as the change in soil moisture. The soil moisture data was obtained from the tensiometer readings. From the study, the ETc (mm/day) value of green chilli obtained was 2.2, 3.1, 3.2, 1.4 in polyhouse and 2.6, 3.5, 3.6, 1.6 in open field condition for the initial, developmental, middle and end season stages respectively.

Keywords
Green chilli, Crop Coefficient, Drip Irrigation, ET₀ Calculator, Soil Water Balance Method

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Introduction

Green chilli belongs to Solanaceae family is introduced by Portuguese to India from Brazil in the sixteenth century. In India, chilli cultivation is more concentrated in the southern states like Andhra Pradesh, Karnataka, Orissa, Maharashtra and Tamil Nadu. This is one of the most susceptible crops to water stress. Most of the farmers cultivate the chilli by providing surface irrigation without any kind of scientific basis. Thus an appreciable amount of water loss occurring. In semi-arid regions, where water scarcity and high evapotranspiration rates exist, drip irrigation placed an important role (Devika et al., 2016). Water loss from a given cropped plot can be determined from the knowledge of reference evapotranspiration ET₀, crop evapotranspiration ETc and crop coefficient Kc of that particular crop. Miranda et al., 2006 found out the ET and Kc values of pepper seedling variety Tobasco Maclhenny using a precision weighing lysimeter [1.5m x
1.5m x 1m] by following the soil water balance method. The crop ET value ranges 1 to 5.6 mm/d. The Kc value so obtained is 0.3, 1.22, 0.65 for the initial, mid-season and end season stages respectively. Asante et al., 2010 found out that by providing irrigation of four days interval the ETc value of hot pepper were 32.95, 115.84, 343.78, and 94.91mm/day under full water supply for each growth stages, during the period of October 2009 to February 2010. Sam-Amoah et al., 2013 found out that by providing irrigation of four days interval the ETc value of hot pepper were 32.95, 115.84, 343.78, and 94.91mm/day under full water supply for each growth stages, during the period of October 2009 to February 2010. Sam-Amoah et al., 2013 found out that the ETc value of hot pepper were 32.95, 115.84, 343.78, and 94.91mm/day under full water supply for each growth stages, during the period of October 2009 to February 2010. Sam-Amoah et al., 2013 found out that the ETc value of hot pepper were 32.95, 115.84, 343.78, and 94.91mm/day under full water supply for each growth stages, during the period of October 2009 to February 2010.

Experimental design and field layout

The chilli variety TNAU Hybrid CO1 was taken for the study. On July 2018, 40 days old seedlings were transplanted in both polyhouse and in open field at a spacing of 0.60 m x 0.45 cm. Raised beds of 0.90 m width with furrow of 0.30 m were prepared both in polyhouse and in open field for the study. Drip irrigation system was laid out with paired row geometry with dripper to dripper spacing of 45 cm. The dripper capacity is 4 lph. Tensiometers were installed in both conditions to measure the soil moisture depletion.

Reference evapotranspiration ET0

The microclimatic parameters like maximum and minimum temperature (°C), light intensity (lux), relative humidity (%) in polyhouse and in open field were monitored daily by using Thermometer, Hygrometer and Lux meter. The reference evapotranspiration of the chilli crop was calculated from the daily meteorological data by using the program ET0 Calculator which runs by the Penman-Monteith method described in FAO Irrigation and Drainage Paper 56 (Allen et al., 1998).

Irrigation scheduling

Irrigation was given through drip system every alternate day. The amount of water
applied at each stages of the crop varies. The quantum of water required was calculated by multiplying the reference evapotranspiration and Kc of sweet pepper, as there is no published Kc value for green chilli in FAO-56, with the area of wetting.

**Tensiometer installation**

Tensiometers were installed at different depths (10cm, 20cm and 30 cm) to observe the change in soil moisture content before and after irrigation. Soil samples were collected at different depths with different tension reading shown in Tensiometers. Soil moisture was assessed by gravimetric method. The soil moisture characteristic curve was derived for different tension and different moisture content as shown in Figure 1. The initial reading of the tensiometer before irrigation was noted down. The final reading of tension was noted down after 24 hours of irrigation. For the respective tension the exact moisture content percentage was read from the soil moisture characteristic curve. The effective root zone of the chilli crop was found to be 0 to 20 cm (Sharma et al., 2013; Ertek, 2017).

**Measurement of crop evapotranspiration, ETc**

The ETc of chilli is estimated by using the water balance method (Tahashildar et al., 2015; Hazrat Ali et al., 2000; Folegatti et al., 2005). Drip irrigation was given as per the calculated amount of water. The amount of water depleted was read from the Tensiometer readings. The crop Evapotranspiration was calculated based on ΔW from the equation:

\[ \text{ET}_c = P + I - R - D - \Delta W \]  

Where,\( \text{ET}_c \) = Crop evapotranspiration (mm/day), \( P \) = Precipitation (mm/day), \( I \) = Irrigation water depth (mm), \( R \) = surface runoff (mm), \( D \) = Amount of water drained from the root zone (mm), \( \Delta W \) = change in soil water storage (mm).

In drip irrigation, the contribution of surface runoff and quantum of water drained from the root zone was assumed to be zero. Contribution of precipitation inside green house was taken as zero.

**Establishment of crop coefficient (Kc) of green chilli**

The crop coefficient values of green chilli cultivated in poly house and in open field conditions were computed on a daily basis by substituting the actual observed \( \text{ET}_c \) value from water balance equation and the calculated \( \text{ET}_o \) value from \( \text{ET}_o \) calculator by the equation (Allen et al., 1998):

\[ K_c = \frac{\text{ET}_c}{\text{ET}_o} \]  

**Results and Discussion**

**Reference evapotranspiration, ETo**

The reference evapotranspiration of the green chilli in inside and outside polyhouse were determined by the \( \text{ET}_o \) calculator which follows the Penman Monteith equation mentioned in the FAO 56 paper. The variations of \( \text{ET}_o \) were presented in the Figure 2. The figure depicted that the \( \text{ET}_o \) value for green chilli inside the polyhouse was found to be less when compared to the open field at all the growth stages. The variation in \( \text{ET}_o \) value for initial, development, mid-season and late season stages of green chilli in inside polyhouse and in open field condition were shown in Table 2. This is due to the reduction in the demand for evaporation. The reference evapotranspiration values for the full growth period of green chilli were 629.92mm in inside polyhouse and 733.3 mm in outside polyhouse.
Table 1: Soil physical and chemical properties

| Soil parameters      | Value  |
|----------------------|--------|
| Sand, Percent        | 68.5   |
| Silt, Percent        | 20.5   |
| Clay, Percent        | 10.1   |
| Textural class       | Sandy Loam soil |
| Bulk Density, g cm\(^{-3}\) | 1.28   |
| Field Capacity, Percent | 23.5  |
| Permanent Wilting Point, Percent | 11.4   |
| Infiltration Rate cm hr\(^{-1}\) | 2.67   |
| Available N, Kg ha\(^{-1}\) | 143    |
| Available P, Kg ha\(^{-1}\) | 19     |
| Available K, Kg ha\(^{-1}\) | 121    |
| Soil pH               | 7.56   |
| Electric Conductivity, ds m\(^{-1}\) | 0.13   |

Table 2: Stage wise comparison of ETO, ETC and Kc values of green chilli

| Crop Stages         | ET\(_{o}\) (mm/day) | ET\(_{c}\) (mm/day) | Crop co-efficient (K\(_{c}\)) |
|---------------------|--------------------|--------------------|------------------------------|
|                     | Polyhouse Open field | Polyhouse Open field | Polyhouse Open field         |
| Initial (30 days)   | 4.6                | 5.1                | 2.2                          | 2.6                          | 0.48 | 0.52 |
| Developmental (40 days) | 4.3                | 4.5                | 3.1                          | 3.5                          | 0.74 | 0.8  |
| Middle stage (90 days) | 3.2                | 3.5                | 3.2                          | 3.6                          | 1.01 | 1.05 |
| End stage (25 days)  | 2.0                | 2.1                | 1.4                          | 1.6                          | 0.7  | 0.78 |

Fig.1: Soil moisture characteristic curve
**Fig. 2** Reference evapotranspiration for green chilli under poly house and open field conditions

**Fig. 3** Crop evapotranspiration for green chilli under poly house and open field conditions

**Fig. 4** Crop coefficient for green chilli under poly house and open field condition
Crop evapotranspiration, $ET_c$

The crop evapotranspiration of the green chilli in inside and outside polyhouse were determined by the soil water balance method (equation 1). The variations of $ET_c$ were presented in the Figure 2. The figure 3 depicted that the $ET_c$ value for green chilli inside the polyhouse was found to be less when compared to the open field for all the growth stages due to the less demand for evaporation. The variation in $ET_c$ value for initial, development, mid-season and late season stages of green chilli in inside polyhouse and outside condition were shown in Table 2. The maximum $ET_c$ value was observed during the mid-season stage when the crop reaches its fully matured condition. The maximum $ET_c$ obtained in polyhouse and in open field condition were 3.2 mm/day and 3.6 mm/day respectively. It was also found that the $ET_c$ value in the open field condition is more as compared to the poly house due to the high evaporative demand. The total $ET_c$ obtained was 547.34 mm and 621.99 mm in inside and outside polyhouse respectively for the full growth period of chilli.

Estimation of crop coefficient, $K_c$

The crop coefficients of green chilli cultivated in polyhouse and open field conditions were estimated daily by using the equation (2) for the entire cropping period from July 2018 to January 2019. The stage wise average crop coefficient is depicted in Table 2 and Figure 4.

In greenhouse, the crop coefficient varies from 0.46 – 0.50, 0.52 – 0.96, 0.97 – 1.09, 0.78 – 0.64 during the initial, development, mid-season and late season respectively. In the same way the crop coefficient in open field condition varies from 0.49 – 0.56, 0.57 – 0.96, 0.97 – 1.10, 0.89 – 0.68 during each growth stages respectively.

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