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

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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 (ET_o) and crop evapotranspiration (ET_c) for any crops. In this study, crop evapotranspiration (ET_c) 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 ET_o value was determined by the Penman Mondeith method mentioned in the FAO-56 using ET_o calculator. The ET_c 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.

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 ET_o, crop evapotranspiration ET_c and crop coefficient K_c of that particular crop. Miranda *et al.*, 2006 found out the ET and K_c values of pepper seedling variety Tobasco Macllhenny 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.*, 2010found out that by providing irrigation of four days interval the ET_c 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 the ET_c value of hot pepper as 30, 87.5, 174.5, 27.5 mm/day using the irrigation interval of two days during the period of November 2010 to March 2011 and 25, 96, 235, 75.55 mm/day during the period of January 2011 to May 2011. Tiwari *et al.*, 2016 determine the ET_c through soil water balance approach and K_c value for Dutch roses grown in poly house and in open field for the sub humid condition. The maximum values of crop ET were 4.99 and 5.88 mm/day for polyhouse and open field condition. The K_c value ranges from 0.48 – 0.96 and 0.59 – 1.01 respectively. Chopda *et al.*, 2018grown chilli crops in pots in rooftop green house and determined the daily crop evapotranspiration through the soil water balance method by considering the pots as non-weighing lysimeter. The actual crop ET was found to be less in inside rooftop greenhouse than the outside condition. The crop coefficient of Green chilli obtained for the initial, development and mid- season stage as 0.33, 0.71 and 0.91 respectively. The present study was carried out to find out the crop evapotranspiration of green chilli cultivated in polyhouse and open field condition for the semi-arid condition.

Materials and Methods

Study area

The study was conducted in the Central farm, AEC and RI, Kumulur, Tamil Nadu from July 2018 to January 2019. The experimental site is geographically situated at 10.93˚ N latitude and 78.84 ˚ E longitudes at an altitude of 57 m above mean sea level. The climate condition is semi-arid with a rainfall of 520.8 mm was received during the experiment period. The soil samples were collected from the field and the textural analysis was done by the International Pipette Method. The soil samples were also analysed for its physical and chemical properties and were determined as shown in Table 1.

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 ET_0

The microclimatic parameters like maximum and minimum temperature (ºC), 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 ET_0 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 K_c of sweet pepper, as there is no published K_c 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, ET_c

The ET_c 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:

$$ET_c = P + I - R - D - \Delta W \quad (1)$$

Where, 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), ΔW = 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 (K_c) 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 ET_c value from water balance equation and the calculated ET_o value from ET_o calculator by the equation(Allen *et al.*, 1998):

$$K_C = \frac{ET_c}{ET_0} \quad (2)$$

Results and Discussion

Reference evapotranspiration, ET_0

The reference evapotranspiration of the green chilli in inside and outside polyhouse were determined by the ET_o calculator which follows the Penman Monteith equation mentioned in the FAO 56 paper. The variations of ET_o were presented in the Figure 2. The figure depicted that the 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 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 629.92mmin 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

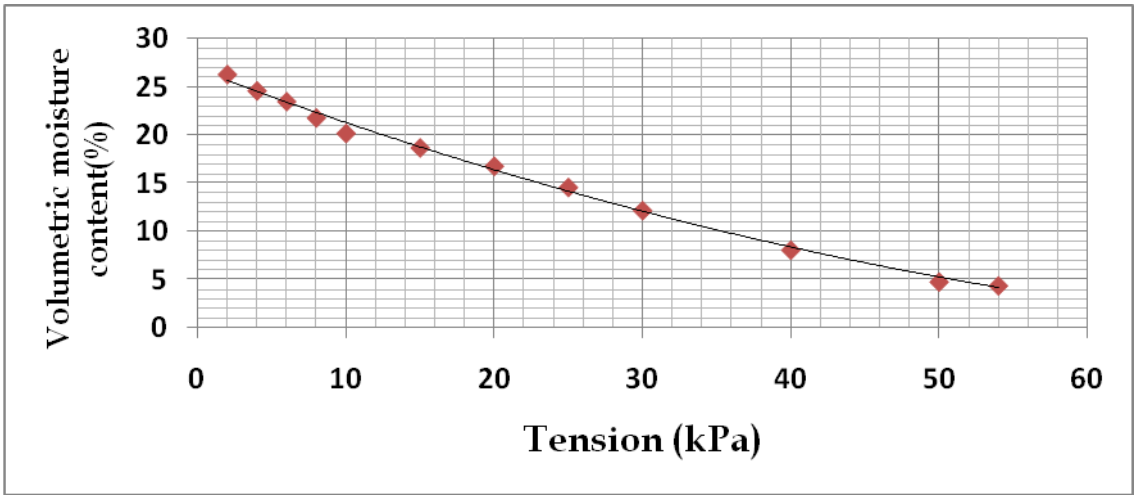


Fig.2 Reference evapotranspiration for green chilli under poly house and open field conditions

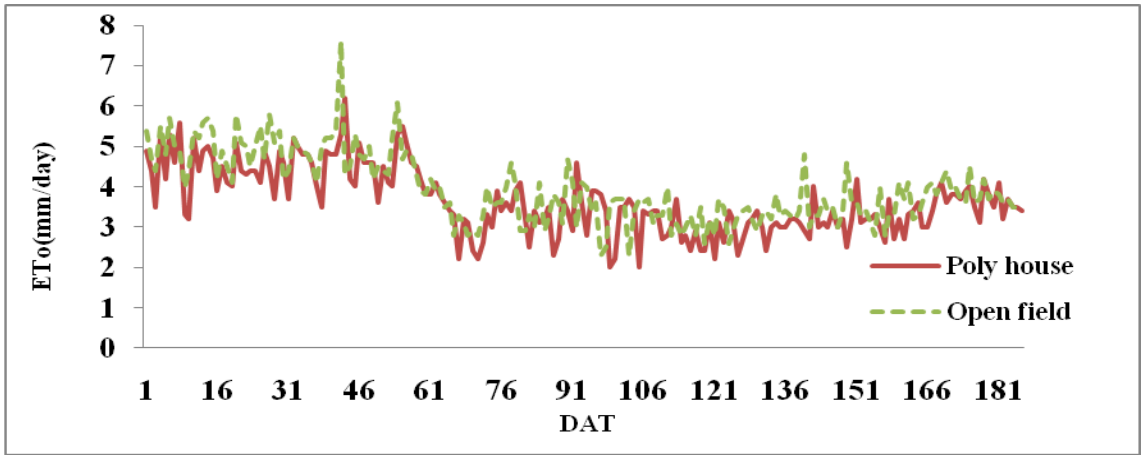


Fig.3 Crop evapotranspiration for green chilli under poly house and open field conditions

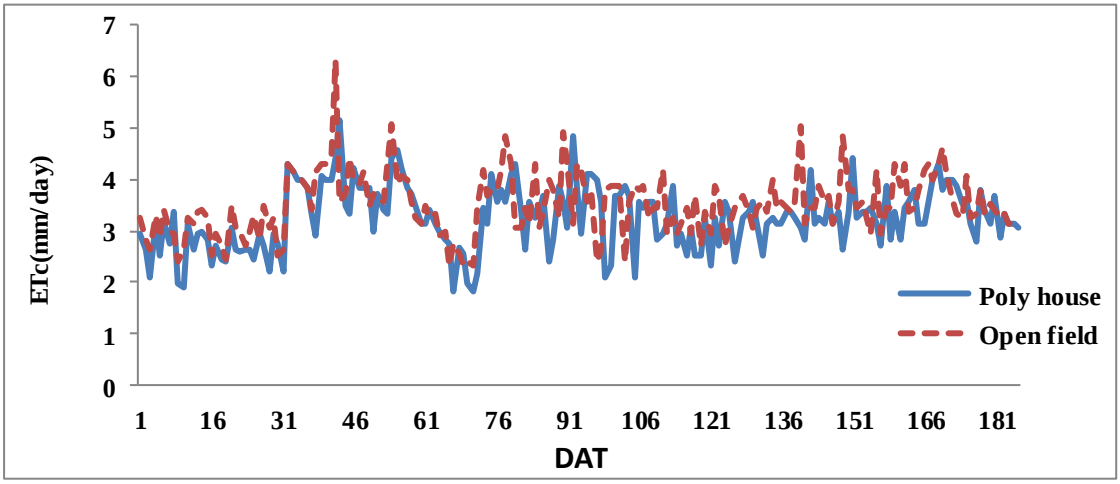
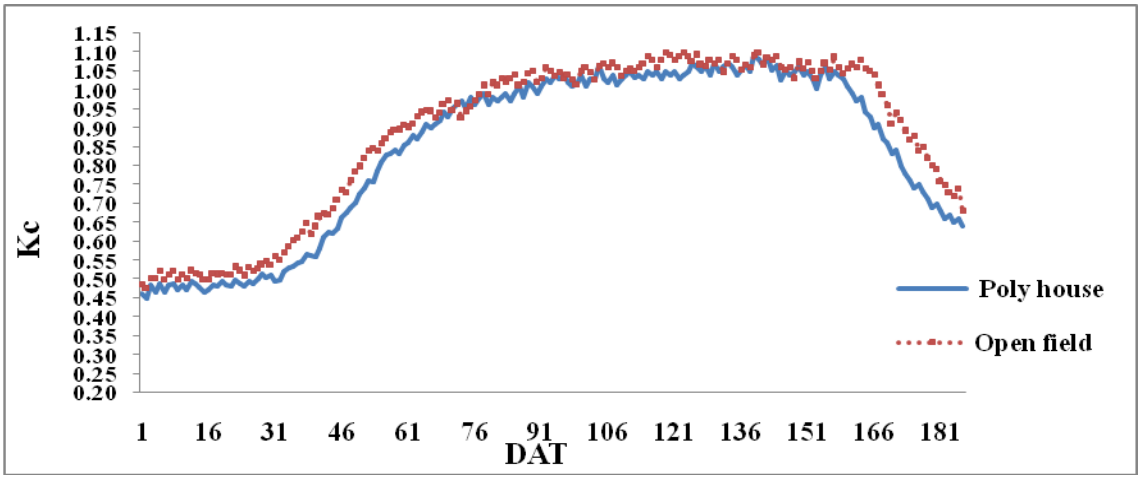


Fig.4 Crop coefficient for green chilli under poly house and open field condition



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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