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RESEARCH PAPER

Yield, water use efficiency and crop co-efficient of cucumber (*Cucumis sativus* L.) grown under greenhouse and open field condition

K. Arunadevi*, A.D. Ashok[1] **and** E. Sujitha[1]
Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Kumulur, Trichy (T.N.) India
(Email: arunadeviswce@gmail.com)

Abstract : A field experiment was conducted with Chitra variety of cucumber at Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Kumulur in the year 2019-2020. The cucumber seeds were sown under greenhouse and open field condition under drip irrigation system. The micro climatic parameters like maximum and minimum temperature, relative humidity, light intensity were observed. Cucumber plant growth parameters, yield parameters and water use efficiency were recorded. Early flowering and fruit formation (32 days after sowing) was noticed inside greenhouse condition and fruit formation was noticed 40 days after sowing in out-side cultivation. The average length of the fruit was found 20.5 cm inside greenhouse and 17.6 cm for outside cultivation of cucumber. A maximum yield of 11.6 t/ha was recorded inside greenhouse cultivation whereas 7.84 t/ha was recorded for outside cultivation of cucumber. The water use efficiency of 25.7 kg/ha. mm was obtained under green house cultivation whereas water use efficiency of 16.70 kg/ha.mm was recorded in open field cultivation. The crop co-efficient value of 0.67, 0.87, 1.12 and 0.89 were developed for initial, developmental, middle and end stages of crop growth period for open field cultivation. Similarly crop co-efficient value of 0.63, 0.82, 1.05 and 0.88 were developed for initial, developmental, middle and end stages of crop growth period for polyhouse condition of semi arid region.

Key Words : Cucumber, Greenhouse, Water use efficiency, Micro climatic parameters

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INTRODUCTION

Cucumber is native of India. It belongs to Cucurbitaceae family. It is mostly cultivated during summer season. The area under cucumber cultivation in India was 107,000 ha and the estimated production during 2018 was 1658000 MT (Source: agricoop.nic.in). It is mainly sown during January to February in Southern India as it has the favorable climate during that time. Well drained loamy sand and sandy loam soil is best suitable for cucumber cultivation. As water source is becoming scarce controlled usage of water in vegetable production

***Author for correspondence:**
[1]Institute of Agriculture, Tamil Nadu Agricultural University, Kumulur, Trichy (T.N.) India

especially in summer season is very much essential. Many studies had been focused to determine water requirement of cucumber under drip irrigation, but development of crop co-efficient for cucumber crop for the semi arid region is unavailable. Hence to find out crop co-efficient of cucumber a study was conducted to develop crop co-efficient of cucumber crop as well as to estimate the water use efficiency of cucumber crop for the semi arid region.

Higher Yield and higher water use efficiency with drip irrigation were reported in many crops. Cultivation of vegetables through drip irrigation would be effective way for water saving and for getting profitable yield (Mishra and Paul, 2009). Water saving upto 70% and fertilizer saving upto 38% in drip irrigated potato were reported by Chawla and Narda, 2001. For quality cucumber production controlled water application was very important as the cucumber had very light thin root system and most of the effective root zone was in the upper 30 cm of soil depth (Janoudi *et al.*, 1993. Comparing furrow irrigation method drip irrigated vegetables produced higher yield and higher water use efficiency (Veeranna *et al.,* 2001). Yaghi *et al.* (2013), reported that higher cucumber yield of around 64 tonnes per hectare and water use efficiency of 262 kg per ha.mm under drip irrigation combined with mulching practices. Greenhouse grown cucumber yielded high with good quality with less crop transpiration and minimum water uptake with maximum water use efficiency was reported by Lorenzo *et al.* (2006). Hashem *et al.* (2011) studied different colours greenhouse cladding material with three different drip irrigation levels to estimate the plant growth and crop yield in cucumber and obtained good yield of cucumber under 100% evapotranspiration rate irrigation levels.

As the demand of water is increasing day by day, the available water should be used judicially even for agricultural purpose. Hence the estimation of exact quantity water required for the crop is very much necessary. In order to give precise amount of irrigation through drip irrigation system, it is important to estimate the reference evapotranspiration and crop evapotranspiration for any crops. So far we are using only climatological data to derive crop water requirement. This may not be accurate in all the places as the soil condition is different. Hence there should be a combined approach to estimate the crop water requirement of every crop. In this study the actual crop evapotranspiration (*i.e.* the water requirement) was calculated based on the climatological parameters as well as the soil and crop parameters.

In this study cucumber crop was raised under polyhouse with fogger facility as well as in the open field condition. With the help of soil moisture sensor, per day water consumption of the plant was observed. Then based on the climatological parameter and soil moisture reading the actual crop water requirement was worked out. The crop co-efficient for cucumber crop was developed for different crop growth stages.

MATERIAL AND METHODS

Field experiment was conducted at central farm of Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu during 2020 to estimate the crop evapotranspiration of drip irrigated cucumber under open field and polyhouse conditions during January 2020 to April 2020.

The average maximum temperature was 38^0C and average minimum temperature was 19^0C during the crop season in open field condition. The average maximum and minimum temperatures in polyhouse were 39.5^0C and 22^0C. The average maximum relative humidity was 62% and minimum relative humidity was 41% observed in open field. The average maximum and minimum relative humidity was observed as 83% to 62% in polyhouse. Foggers were used when temperature was high inside polyhouse.

The physical properties and chemical properties of the experimental site soil were observed. The soil type was sandy loam soil with well drained in nature. The soil pH was 7.8 and electrical conductivity was 0.37ds/m. Field was prepared with fine tilth. Drip laterals were laid in raised beds. Drippers of 4 lph capacity were placed at 45 cm spacing in order to cater the irrigation need of the plants. Cucumber variety of Chitra were sown during January 2020 with the crop layout of 60 cm x 45 cm. Irrigation and fertigation are being given as per schedule. Soil moisture sensors EM 50 data logger were placed at 20 cm depth in order to measure the soil moisture depletion data. The sensor probes were connected with data controller. Soil moisture data were recorded at 15 minutes interval in irrigation data controller. Inside greenhouse temperature was observed with Thermometer, relative humidity was observed with sling psychrometer and light intensity were observed with Lux meter.

The reference Evapotranspiration (ET_o) was calculated by the standard method of FAO Penman–Monteith method from the meteorological data. The equation is given as,

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T_{mean}+273} u_2 (e_s - e_a)}{\Delta + \gamma(1+0.34u_2)}$$

where,

ET_0 = Reference evapotranspiration (mm day^{-1}),

R_n = Net radiation at the surface of the plant (MJ m^{-2} day^{-1}),

G = Heat flux density of soil (MJ m^{-2} day^{-1}),

T_{mean} = Mean daily air temperature at the height of 2m (°C),

U_2 = Wind speed at the height of 2m (m s^{-1}),

e_s = Saturation vapor pressure (kPa),

e_a = Actual vapor pressure (kPa),

$e_s - e_a$ = Saturation vapor pressure deficit (kPa),

Δ = Slope vapor pressure curve (kPa °C^{-1}),

γ = Psychrometric constant (kPa °C^{-1}).

The actual crop Evapotranspiration (ET_c) was estimated by soil water balance method. The root zone soil moisture depletion data were read from the sensor data and the change in volumetric moisture content were noted. Based on the soil moisture balance method the Precipitation, runoff and deep percolation components were considered as zero in case of polyhouse grown cucumber whereas for outside cultivation the effective rainfall amount was considered.

The actual crop evapotranspiration was calculated by soil water balance method

$$ET_c = P + I - R - D \pm \Delta W$$

where,

ET_c= Crop evapotranspiration (mm),

P= Precipitation (mm),

I=Irrigation water depth (mm),

R = The surface runoff (mm),

D= Amount of water drained from the root zone (mm),

ΔW= Change in soil water storage (mm).

The crop co-efficient of cucumber were developed for different crop growth stages by the following formula

$$K_c = \frac{ET_c}{ET_o}$$

where,

K_c = Crop co-efficient; ET_c = Crop evapotranspiration (mm); ET_o = Reference evapotranspiration (mm)

Cucumber growth and yield parameters were observed for both inside and outside polyhouse. Water use efficiency of cucumber were calculated based on yield and water used throughout the season.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Reference evapotranspiration (ETo) (mm/day):

Reference evapotranspiration was found maximum in polyhouse compared to open field cultivation. Arunadevi *et al.* (2017) also reported FAO Penman – Monteith is the best method to estimate Reference Evapotranspiration compared to other methods available for estimating ETo. The total value of ETo during initial stage was 74.40 mm in open field and 74.90 mm in polyhouse. Similarly 120.80 mm and 123.60 mm during developmental stage, 212.80 mm and 220.50 mm during middle stage and 84.40 mm and 80.40 mm during end stage of the crop growth in open field and polyhouse condition, respectively. The comparison of reference evapotranspiration in open field and polyhouse is given in Fig. 1

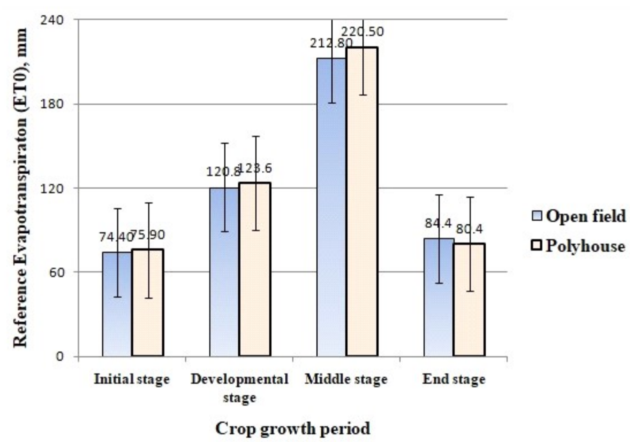

Fig. 1 : Reference evapotranspiration (mm) in open field and polyhouse condition

Crop evapotranspiration (mm/day):

The crop evapotranspiration (ET_c) was calculated from the soil moisture data recorded from sensor probes and estimated by soil water balance method. The crop Evapotranspiration (ET_c) was found less inside polyhouse when compared to open field condition.

The total value of crop evapotranspiration during initial stage was 49.70 mm in open field and 48.10 mm in polyhouse. Similarly 105.40 mm and 101.70 mm during developmental stage, 238.30 mm and 231.30 mm during middle stage and 74.80 mm and 70.60 mm during end stage of the crop growth in open field and polyhouse condition respectively. The comparison of actual evapotranspiration in open field and polyhouse is given in Fig 2.

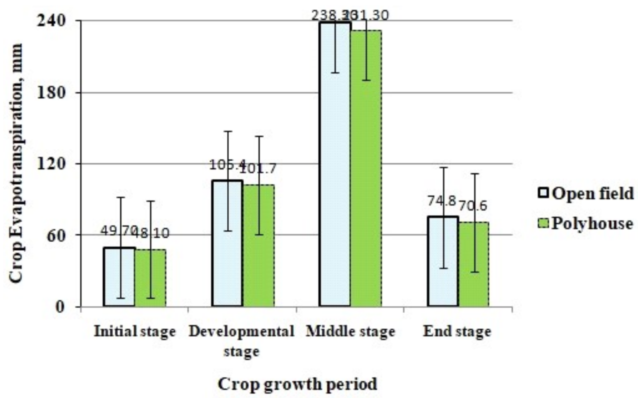

Fig. 2 : Crop evapotranspiration (mm) in open field and polyhouse condition

Development of crop co-efficient of cucumber:

Determining crop co-efficient is very essential to work out the crop water requirement as crop co-efficient involves plant physiological growth parameters. Accurate crop water requirement can be achieved with the inclusion of crop co-efficient in calculation. The crop co-efficient value was worked out for cucumber crop for different crop growth stages based on the reference evapotranspiration value and crop evapotranspiration value obtained from the soil water balance method. The crop co-efficient value of 0.67, 0.87, 1.12 and 0.89 were developed for initial, developmental, middle and end stages of crop growth period for open field cultivation. Similarly crop co-efficient value of 0.63, 0.82, 1.05 and 0.88 were developed for initial, developmental, middle and end stages of crop growth period for polyhouse condition for semi arid region. The comparison of Kc value for open field as well as the polyhouse condition is given in Fig.3

These findings was confirmed from the research by Blanco and Folegatti (2003) that the crop co-efficient was increased from initial stage (0.22) to middle stage (1.26) then it reduced during crop end stages (0.73).

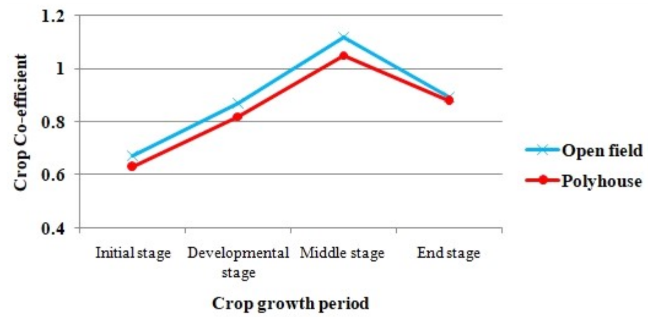

Fig. 3 : Comparison of Crop Co-efficient value in open field and polyhouse condition

Mushab, 2020 predicted crop co-efficient value of cucumber that 0.1 for initial stage, 1.29 for mid crop stage and 0.9 for late growing stages for medium loam soil.

Yield, growth parameters and water use efficiency of cucumber:

Early flowering and fruit formation (32 days after sowing) was noticed inside greenhouse condition and fruit formation was noticed 40 days after sowing in outside cultivation. The average length of the fruit was found 20.5 cm inside greenhouse and 17.6 cm for outside cultivation of cucumber. A maximum yield of 11.6 t/ha was recorded inside greenhouse cultivation where as 7.84 t/ha was recorded for outside cultivation of cucumber. The total water used during crop growing season was 468.20 mm in open field condition and 451.70 mm in poly house condition. The water use efficiency of 25.7 kg/ha.mm was obtained under green house cultivation whereas water use efficiency of 16.70 kg/ha.mm was recorded in open field cultivation. Crop co-efficient value was developed during initial, developmental, middle and end stages of the crop growth. Qu *et al.* (2019) studied different irrigation levels and fertigation levels for cucumber grown under drip irrigation and evaluated the best irrigation levels to maximize yield, water use efficiency and fertilizer use efficiency. Zakka *et al.* (2020) was calculated seasonal crop evapotranspiration rate with pan evaporimeter data and found that 100 % ETo yielded high and 60% ETo gave maximum water use efficiency and water productivity. Two different soil matric potential of 100 hpa and 300 hpa were tried in greenhouse grown cucumber and 100 hpa and 400 hpa for tomato and auto irrigation scheduling was done based on tensiometer reading and achieved water saving of 35

– 45 % for tomato and cucumber crop (Buttaro *et al.*, 2015).

Conclusion:

Cucumber crop was raised to study the effect of drip irrigation under polyhouse and open field condition. Reference evapotranspiration and actual crop evapotranspiration were estimated. Actual crop evapotranspiration was estimated based on soil water balance method. Growth parameters and yield were estimated. Water use efficiency was calculated based on yield and water used in open field cultivation and polyhouse cultivation. A maximum yield of 11.6 t/ha was recorded inside greenhouse cultivation whereas 7.84 t/ha was recorded for outside cultivation of cucumber. The water use efficiency of 25.7 kg/ha.mm was obtained under green house cultivation whereas water use efficiency of 16.70 kg/ha.mm was recorded in open field cultivation. These crop co-efficients for different stages can be applicable for the locality which has similar soil and climatic conditions which can be used to work out the actual water requirement of the crop.

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