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Research Article

Estimation of Irrigation Water Requirement of Drip Irrigated Bell Pepper (*capsicum annuum* l.var. *Grossum*) in Jhalawar District of Rajasthan

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Abstract

Irrigation water requirement of Capsicum (*Capsicum annuum* L.*var. Grossum*) was estimated for Jhalawar region of Rajasthan. The daily reference evapo-transpiration (ET_0) was estimated by using the 'CROPWAT 8.0' Model based on FAO-56 Penman-Monteith (1998) method. The maximum and minimum ET_0 of 4.59 and 1.72 mm/day were observed on 22nd September and 25th December respectively. Crop coefficient was considered as suggested by Allen *et al.*, (1998) for different growth stages of *Capsicum*. The total water requirement of 380 mm for *Capsicum* was estimated during crop growing period (6th September – 5th March).

Keywords: *Capsicum*, CROPWAT, Irrigation requirement, Reference evapotranspiration

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Introduction

Sustainable development and efficient management of water is an increasingly complex challenge in India. Precision agriculture is that which uses inputs most efficiently and judiciously to maximize productivity and profitability with minimum impact on soil and environment. Efficient use of available irrigation water is essential for increasing agricultural productivity for the alarming Indian population. Precise management of irrigation water is important to obtain desired results in terms of productivity [1].

ET_0 as "the rate of evapotranspiration from a hypothetical reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m^{-1} and an albedo of 0.23 closely resembling the evapotranspiration from an extensive surface of green grass of uniform height actively growing completely shading the ground and with adequate water" [2]. The combination of two processes i.e. evaporation and transpiration is called Evapotranspiration. Evaporation is the process whereby liquid water is converted to water vapour and removed from evaporative surface. Transpiration consists of the vaporization of liquid water contained in plant tissues and vapour removal to the atmosphere. Evaporation and transpiration occur simultaneously and there is no way to distinguish between the two processes. Due to simplicity in indirect methods, weather parameters are used for estimation of ET_0 [3]. In search of the best ET_0 model for Global application, many researchers have compared different reference evapotranspiration models [4, 5]. Researchers have provided the detail reviews on the comparision of different models and concluded the Penman-Monteith model is the most appropriate for determining ET_0 [6-8].

For minimizing the cost of irrigation, adoption of drip irrigation is essential which maximize the productivity while using minimum amount of water [9]. The drip irrigation adoption increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation [10]. In areas with dry and hot climates, drip irrigation has improved WUE mainly by reducing runoff and evapotranspiration losses [11]. The productivity of vegetables can be increased 10-20 times more as compare to their open field cultivation [12]. Vegetable are important constituents of Indian agriculture and nutritional security. Bell pepper (*Capsicum annuum* L.*var. grossum*), popularly known as sweet pepper, capsicum and shimla mirch belongs to family Solanaceae, (as are tomatoes, potatoes and eggplant). The objective of the present study is to estimate irrigation water requirement of drip irrigated capsicum for Jhalawar district (Rajasthan), India.

Materials and Methods

Jhalawar district is located at 23°4' to 24°52' N-Latutude and 75°29' to 76°56' E-Longitude in South Eastern Rajasthan. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The rainfall is mostly concentrated in four monsoon months of June to September besides, some regeneration in the winter months. On the basis of available rainfall data, the average annual rainfall in the study area is 910 mm. Max temperature range in the summer is 43-48° C and minimum 1.0 – 2.6 °C during winter. The district is having conspicuous physiographic variations comprising undulating or flat terrain. About 84.22 percent population of the district is rural whose main occupation is agriculture [13]. The daily meteorological data of maximum temperature, minimum temperature, relative humidity, sunshine hours, wind velocity and evaporation were analysed for the period from 2000 to 2012 (13 years) to estimate daily reference evapotranspiration (ET_0) in mm/day during *Capsicum* growing months (September-March). The average daily meteorological data are shown in **Figure 1**.

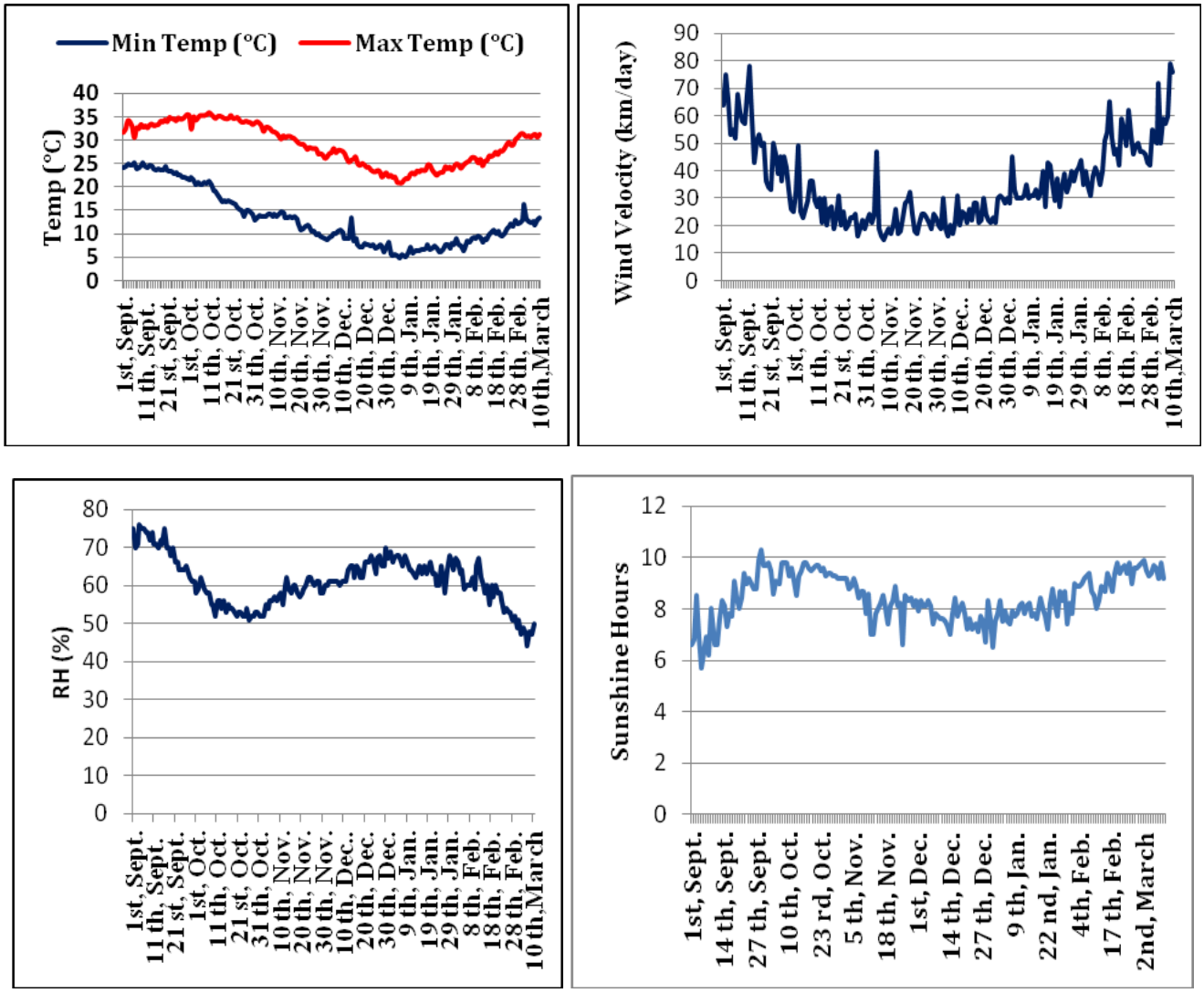

Figure 1 Average daily Meteorological data (2000-2012)

The daily reference evapo-transpiration (ET_0) was estimated by using the 'CROPWAT' Model based on FAO Penman-Monteith method from the available data of temperature, relative humidity, wind speed at 2 m height and sunshine hours.

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

Where, ET_0 = Reference evapotranspiration [mm day^{-1}], R_n = net radiation at the crop surface [$MJm^{-2}day^{-1}$], G = soil heat flux density [MJ m^{-2} day^{-1}], T = mean daily air temperature at 2 m height [°C], u_2 = wind speed at 2 m height [m s^{-1}], e_s = saturation vapour pressure [kPa], e_a = actual vapour pressure [kPa], e_s - e_a = saturation vapour pressure deficit [kPa].

Crop Water Requirement

As per the FAO-56, crop water requirement is defined as "the depth of water needed to meet the water loss through crop evapo-transpiration (ET_{crop}) of a disease free crop, growing in large fields under non restricting soil conditions including soil water and fertility and achieving full production potential under a given environment". The crop water requirement under drip irrigation was estimated by following equation.

$$WR = ET_0 \times K_c \qquad (1)$$

Where, WR = Estimated crop water requirement, (mm/day), ET_0 = Reference evapo-transpiration (mm/day), K_c = Crop coefficient

Crop coefficient was considered for different growth stages of *Capsicum* based on FAO- 56 and given in **Table 1**.

Table 1 Growth stage wise Crop coefficient of Capsicum crop

Days after Transplanting	Growth stages	Crop coefficient (K_c)
1 – 25	Initial	0.6
26 – 55	Development	0.6 – 1.05
56 – 155	Mid	1.05
156-185	Late	0.9

Irrigation Scheduling

The daily volume of water (water requirement) to be applied was estimated using the ET_0 estimated by FAO Penman-Monteith method. The volume of water requirement for each plant was calculated by using following equation:

$$V = ET_0 \times K_c \times S_p \times S_r \times W_p / EU_f \qquad (2)$$

Where, V = Estimated Crop Water Requirement, (Liter/day/plant), ET_0 = Reference crop evapo-transpiration (mm/day), Kc = Crop coefficient, S_p = Plant to plant spacing (m), S_r = Row to row spacing (m), W_p = Percentage wetted area, Eu = Emission Uniformity of drip system Application time,

$$T = V/q \qquad (3)$$

Where, q = the average emitter discharge, liter/ hr, T = the time of application, in hour

The water requirement of *Capsicum* crop was estimated on daily basis for growing season (September to March) as considered under this study.

Result and Discussion

Daily ET_0 were calculated on the basis of average daily meteorological data for growing period of *Capsicum* (September to March) by using CROPWAT 8.0 Software. Crop evapotranspiration (ET_c) for field crops (wheat, maize, etc.) and vegetables was estimated by using FAO Penman- Montieth equation based CROPWAT software [14]. Different models were compared to estimate ET_0 at Pantnagar (Uttarakhand), with standard ET_0 estimating

FAO-56 Penman-Monteith method [15]. This is in agreement with the selection of standard FAO-56 Penman-Monteith method.

Reference-evapotranspiration

The pattern of reference evapotranspiration as shown in **Figure 2**, it gradually decreases from October to December and relatively become low from December to January and after that shows an increasing trend. The maximum and minimum Reference evapotranspiration of 4.59 and 1.72 mm/day were observed on 22nd September and 25th December respectively.

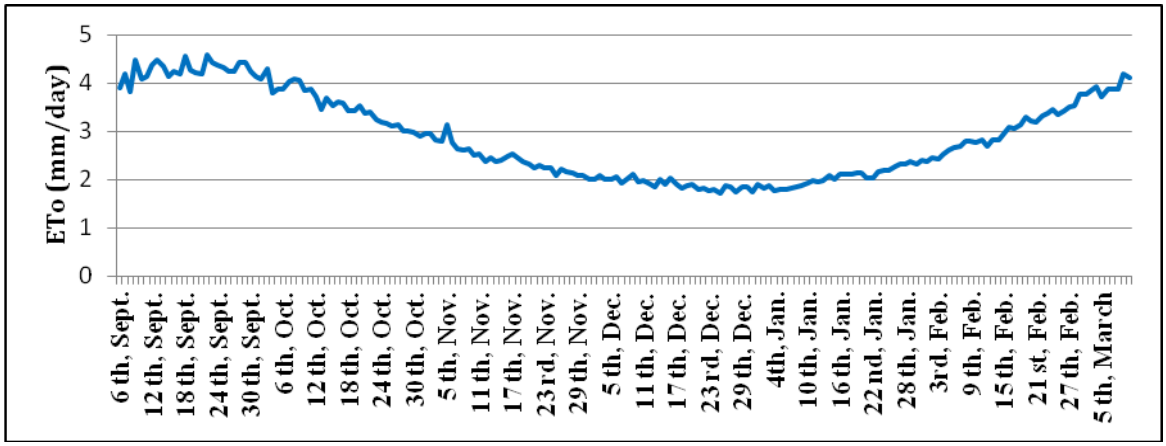

Figure 2 Estimated Daily Reference Evapotranspiration (ET_0) in mm

Irrigation requirement

The average discharge rate of emitters and field emission uniformity was 1.85 litre per hour and 92.92 per cent respectively. The daily crop water requirements of *Capsicum* under drip irrigation were estimated using FAO-56 approach and are plotted in **Figure 3**. The plant to plant and lateral to lateral spacing of Capsicum was 30 x 45 cm in the field. The total water requirement of *Capsicum* during crop growing period (6th September – 5th March) was estimated as 51.36 litre per plant or 380 mm.

The pattern of crop water requirement was nearly on decreasing trend from October to December and it was least between December and January and then subsequently increased up to March. The result of the study is in line with the findings by [16] that, total water requirement of sweet pepper ranges between 300 -700 mm depending on the climatic condition, the season of the crop and the location. Emission uniformity of system as 90.58 per cent [17] and average emission uniformity of the system as 89 per cent [18] were reported which confirms the present findings of the study.

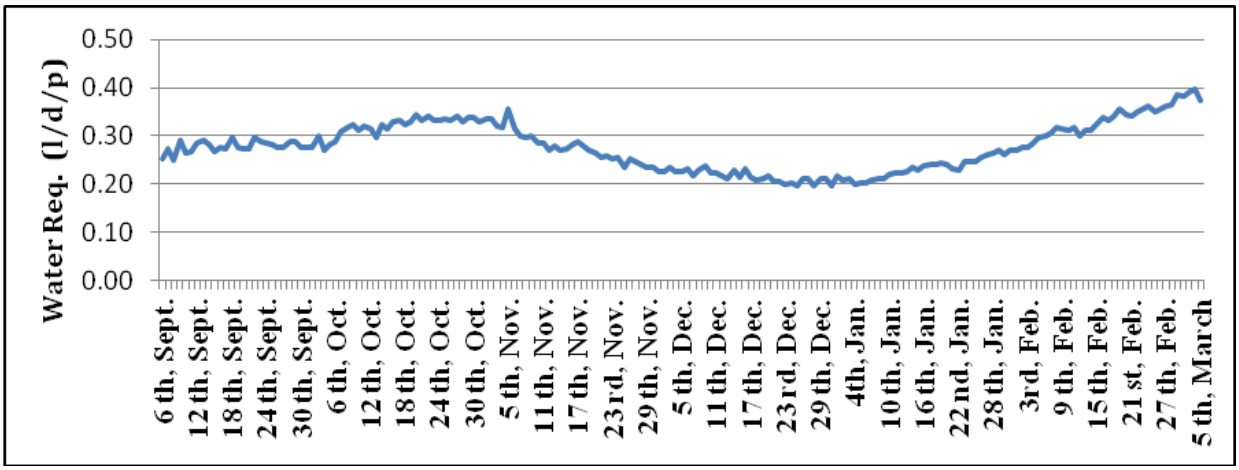

Figure 3 Daily water requirement of the plant during growing period of *Capsicum*

Conclusions

The 'CROPWAT' model based on FAO-56 version of Penman-Monteith equation was used for calculating reference evapotranspiration (ET_0). The total water requirement of *Capsicum* during crop growing period (6^{th} September – 5^{th} March) was estimated as 51.36 litre or 380 mm per plant. The pattern of crop water requirement was nearly on decreasing trend from October to December and it was least during peak winter and then subsequently increased up to March. The operation of drip irrigation system was observed as excellent in the field.

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