EtI ENGINEERING AND TECHNOLOGY IN INDIA

Volume 6 | Issue 1 | Apr, 2015 | 12-18
e ISSN-2230-9284 | Visit us : *www.researchjournal.co.in*
DOI : 10.15740/HAS/ETI/6.1/12-18

ARTICLE CHRONICLE :
Received : 10.09.2014;
Revised : 26.02.2015;
Accepted : 07.03.2015

RESEARCH PAPER

Water requirement on drip irrigated tomatoes grown under shade net house

■ **PRIYANKA SHARMA**, MAHESH KOTHARI AND S.S. LAKHAWAT

ABSTRACT

A field experiment was conducted to investigate the effect of irrigation regimes on drip irrigated tomatoes grown under shade net house at the plasticulture farm, CTAE, Udaipur, Rajasthan. Four different levels of drip irrigation equivalent to 100 per cent, 80 per cent, 60 per cent and 40 per cent of crop evapotranspiration (ET_c) with five replications based on gravimetric method were tested for determining the crop water requirement inside the shade net house. Tomato (*Lycopersicon esculentum* Mill., badshah variety) plants were grown under the shade net house of 50 per cent shade and results are compared with the open cultivation system where the ET_c was calculated by Penman–Monteith (PM) method. The results revealed that the optimum water requirement for the tomato under the shade net house is around 80 per cent of ET_c outside the shade net house. Based on this, the actual irrigation water could be recommended between 1.62 and 4.58 mm day^{-1} for tomato crop in the shade net house.

KEY WORDS : Drip irrigation, Water requirement, Shade net house

How to cite this Article : Sharma, Priyanka, Kothari, Mahesh and Lakhawat, S.S. (2015). Water requirement on drip irrigated tomatoes grown under shade net house. *Engg. & Tech. in India,* **6** (1) : 12-18.

INTRODUCTION

Protected cultivation techniques including net house technology provide optimum environmental medium for better crop growth in order to gain maximum yield and high quality products. These require comparatively less land area for agricultural production system resulting in increased land productivity and facilitate year round production of crops (Dunage *et al.*, 2010). During the last decade, the uses of net-houses for plant production have steadily expanded because they offer several environmental and economical benefits. Shade nets are of special importance in warm, sunny climates, where they reduce both light intensity and effective heat during daytime. The shade house protects the crop from adverse climatic conditions like high light intensity and temperature (Mantur and Patil, 2008).

Irrigation system is one of the most important components affecting the yield and quality of agricultural produce from greenhouse farming system. Water should be given in proper amount and accurate time application. Therefore, water management is a key to avoid plant moisture stress during the crop growth stages (Harmanto *et al*., 2005).

Efficient use of water by irrigation is becoming increasingly important, and alternative water application method such as drip, may contribute substantially to the best use of water for agriculture and improving irrigation efficiency. In areas with dry and hot climates, drip irrigation has improved WUE mainly by reducing runoff and evapotranspiration losses. With the drip irrigation systems, water and nutrients can be applied directly to the crop at the root level, having positive effects on yield and water savings and increasing the irrigation performance (Nagaz *et al*., 2012).

Deficit irrigation is a strategy that allows a crop to sustain some degree of water deficit in order to reduce costs and potentially increase income. It can lead to increase net income where water costs are high or where water supplies are limited (Kirda, 2002; Kirda *et al.*, 2004). The adoption of DI implies appropriate knowledge of crop evapotranspiration (ET), crop response to water deficits, including the identification of critical crop growth periods, and the economic impacts of yield reduction strategies; therefore growers may have difficulty in using it (Patane and Cosentino, 2010).

For tomato crops cultivated under Indian greenhouse, it is recommended that daily amount of required water for different growing system varies from 0.89 to 2.31 l/plant^{-1} day^{-1} (Tiwari, 2003 and Tiwari *et al.*, 2000). They also noted that the irrigation water should be given on every alternate day.

Thus, the present investigation aimed with the determination of the optimum irrigation requirements for tomatoes grown under a shade net house in an arid region and to develop relationship between crop evapotranspiration inside and outside the shade net from meteorological parameters.

EXPERIMENTAL PROCEDURE

Field experiment was conducted at the Plasticulture Farm of College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, during the period of February, 2013 to July, 2013. The location corresponds to 24°35' N latitude and 73°44' E longitude and is at an elevation of 582.17 m above the mean sea level (MSL). The soil type in the experiment is sandy loam. The shade net house of dimensions 28 m × 36 m *i.e.* 1008 m^2 with a level of 50 per cent shading (shade factor = 0.50) of green coloured net.

Crop water requirement inside the shade net house was found out by the gravimetric method. The available soil moisture content at which irrigation should be applied is a good criterion as it indicates moisture status of the soil and its availability to plants. Many research workers studied these criteria and for tomato it will be suggested to apply

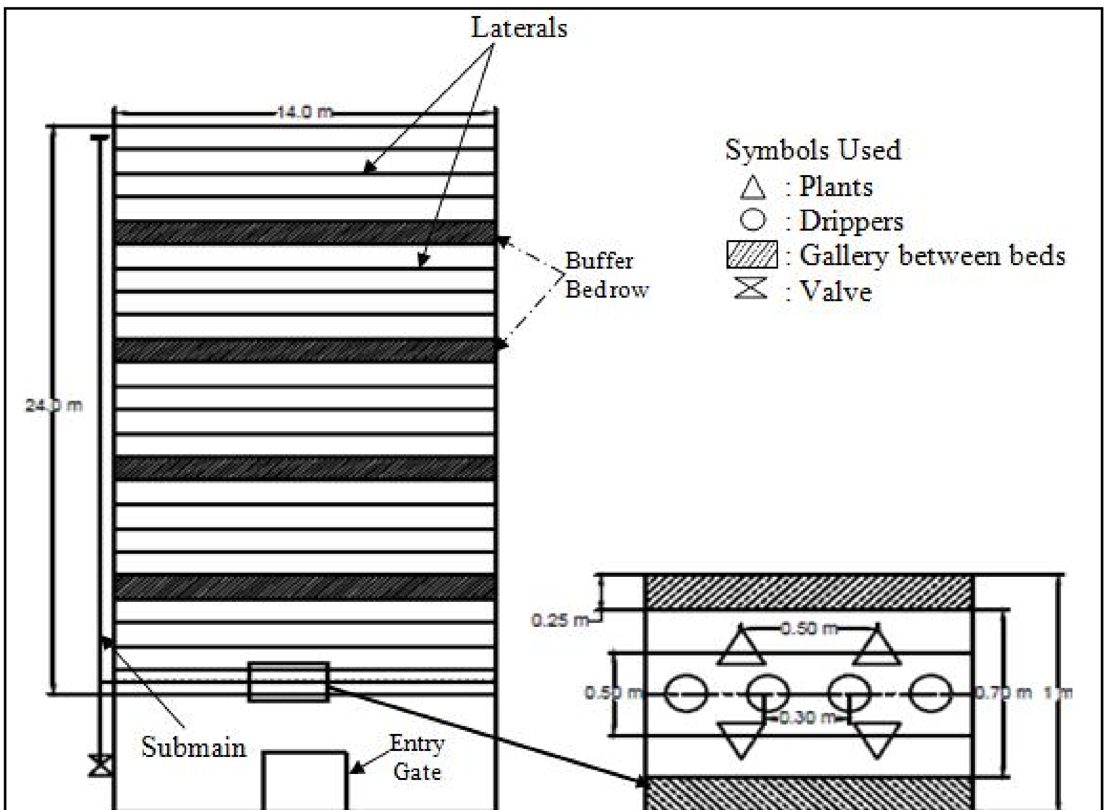

Fig. A : Layout of the shade net house

irrigation when 40 per cent available soil moisture (ASM) is depleted (*i.e.* when ASM is 60 %).

ASM content = Field capacity – permanent wilting point

Net depth of irrigation :

The quantity of water will be applied to the field will calculate by the following formula :

$$d = \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times Ai \times Di$$

where,

d = net depth of water applied during an irrigation, (cm)

n = number of soil layers sampled in the root zone depth D

M_{1i} = moisture content in the ith layer of soil at field capacity, per cent

M_{2i} = moisture content in the ith layer of soil before irrigation, per cent

A_i = apparent specific gravity of the ith layer of the soil, g /cm^3

D_i = depth of ith layer of the soil (cm).

The irrigation treatments were based on crop evapotransipiration ET_c for crop was calculated by using climatological parameters inside and outside the shade net house. The detailed of the irrigation treatments are given as under :

T_1: Drip irrigation with 100 per cent of ET_c

T_2: Drip irrigation with 80 per cent of ET_c

T_3: Drip irrigation with 60 per cent of ET_c

T_4: Drip irrigation with 40 per cent of ET_c.

All treatments were arranged randomly with five replication R_1, R_2, R_3, R_4, and R_5 for each treatment as a block as also shown in Fig. A.

The meteorological data on significant weather parameter during the crop growth period were collected on daily basis from the meteorological laboratory of CTAE, Udaipur. The data includes maximum and minimum temperature, minimum and maximum relative humidity, actual sunshine hour and daily wind speed etc.

The weekly reference evapotranspiration (ET_o) was estimated by using FAO based Penman-Monteith (Allen *et al.*, 1998). The proposed equation for estimating the ET_o is given below :

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

where,

ET_o = reference evapotranspiration (mm/day),

G = soil heat flux density (MJ/m^2/day),

R_n = net radiation (MJ/m^2/day),

T = mean daily air temperature (°C),

γ = psychometric constant (kPa/°C),

Δ = slope of saturation vapour pressure function (kPa/°C),

e_s = saturation vapour pressure at air temperature T (kPa),

e_a = actual vapour pressure at dew point temperature (kPa),

u_2 = average daily wind speed at 2 m height (m/sec).

A set of the climatic data, air temperature, relative humidity, wind speed and global solar radiation outside the greenhouse was needed for estimation. Smith (1992) developed the CROPWAT Software version 7.0 under DOS. It was used to calculate the crop water requirement.

The daily crop evapotranspiration was estimated using the equation given below :

$$ET_c = ET_0 \times K_c$$

where,

ET_c = Crop evapotranspiration (mm day^{-1}).

ET_o = Reference evapotranspiration (mm day^{-1})
Kc = Crop co-efficient.

EXPERIMENTAL FINDINGS AND ANALYSIS

The findings of the present study as well as relevant discussion have been presented under following heads :

Crop water requirement inside the shade net house :

Crop water requirement inside the shade net house was determined by using the soil moisture depletion method under 100 per cent, 80 per cent, 60 per cent and 40 per cent of crop evapotranspiration ET_c. The soil samples were regularly taken before irrigation at different depths *i.e.* 7.5 cm, 15 cm, 30 cm and 45 cm with the help of screw type auger hole and then samples were transferred in laboratory. These samples were kept in oven at 105°C for 24 hours. After 24 hours the samples were taken out from the oven and the moisture reduced were calculated by gravimetric method. Soil moisture content has been determined by gravimetric method. The weekly crop evapotranspiration data is depicted in Fig. 1.

The Fig. 2 reveals that, the net water requirement for tomato crop varies from 1.614 mm to 4.582 mm. The higher water requirement in later growth period of tomato may be due to higher temperature, sunshine hours and wind speed during the later growth period of tomato crop.

Reference evapotranspiration outside the shade net house :

Daily climatic data for the period 2008-2012 *i.e.* (5 years) were used to determine daily reference evapotranspiration outside the shade net house for 154 days crop period. The daily reference evapotranspiration was computed using FAO-56 Penman-Monteith Method for Udaipur.

Variation in daily reference evapotranspiration values outside the shade net house over the growth period of tomato is shown in Fig. 2.

Total reference evapotranspiration under open condition was recorded 803.48 mm during the crop period *i.e.* 154 days.

From Fig. 2 it is observed that the maximum reference evapotranspiration over the crop growth period is 7.62 mm day^{-1} while the minimum value is 2.52 mm day^{-1}. Higher value of ET_o during the latter crop growth period is due to higher temperature, low relative humidity, higher sunshine hours and greater wind speed.

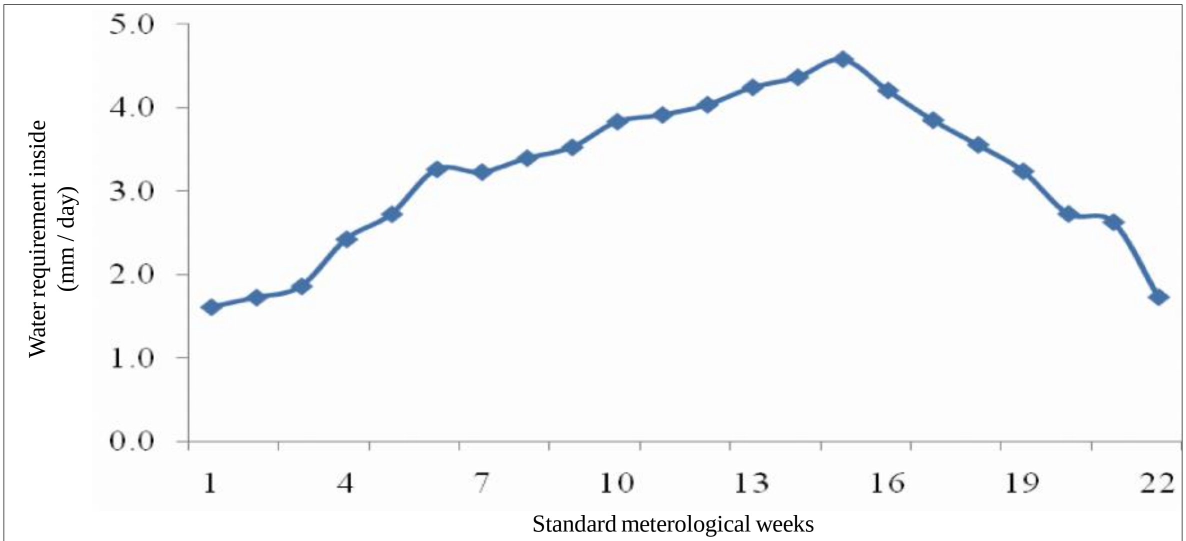

Fig. 1 : Variation in crop water requirement inside the shade net house

Crop evapotranspiration outside the shade net house ($ET_{c\ out}$) :

Variation in daily crop evapotranspiration values outside the shade net house over the growth period of tomato is depicted in Fig. 3.

Total crop evapotranspiration under open condition was recorded 717.20 mm during the crop period *i.e.* 154 days.

From Fig. 3. it is observed that the maximum crop evapotranspiration over the crop growth period is 8.726 mm

Table 1 : Develop relation between crop evapotranspiration (ET_c) inside and outside the shade net house

Met. week	Crop evapotranspiration inside the shade net house ($ET_{c\ in}$), mm/day				
	ET_c	100 %	80 %	60 %	40 %
1		1.614	1.320	1.076	0.907
2.		1.729	1.375	1.201	1.004
3.		1.863	1.776	1.118	1.083
4.		2.426	2.084	1.456	1.203
5.		2.726	2.340	1.636	1.373
6.		3.264	2.464	1.958	1.389
7.		3.231	1.896	1.939	1.517
8.		3.397	2.718	2.038	1.583
9.		3.528	2.822	2.246	1.851
10.		3.834	2.924	2.401	2.489
11.		3.916	3.769	2.466	2.340
12.		4.037	4.219	2.547	1.891
13.		4.246	4.307	3.359	1.970
14.		4.367	3.919	2.817	2.247
15.		4.582	3.666	2.914	2.401
16.		4.209	3.467	3.479	2.480
17.		3.853	3.224	2.561	1.823
18.		3.557	2.845	2.134	1.707
19.		3.241	2.593	2.483	1.655
20.		2.731	2.197	2.346	1.641
21.		2.631	2.105	2.119	1.052
22.		1.734	1.387	1.040	0.694
ETc (mm)		495.013	415.906	297.008	198.005

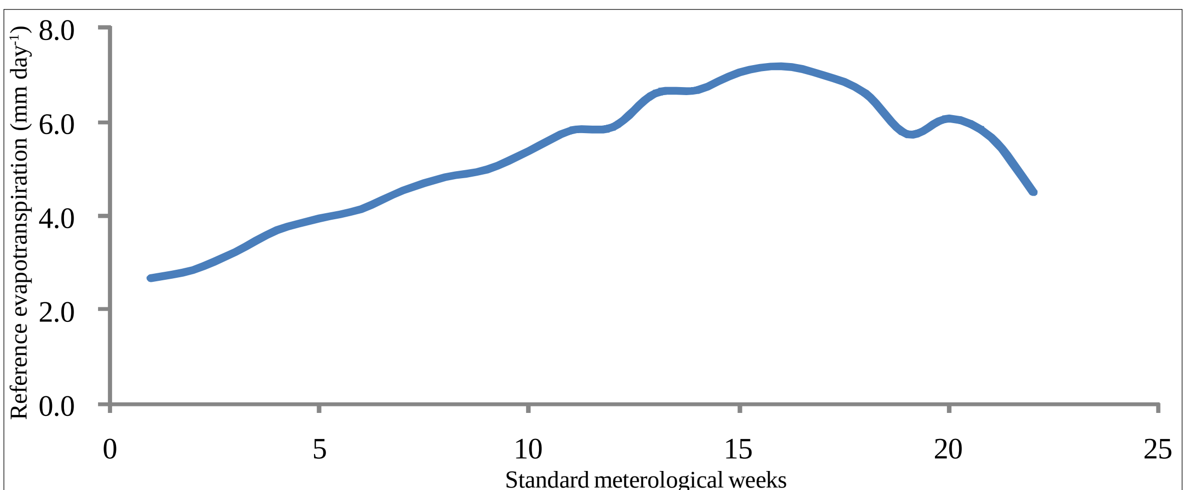

Fig. 2 : Variation in daily values of reference evapotranspiration outside the shade net house

day^{-1} while, the minimum value is 0.997 mm day^{-1}. Higher value of ET_c during the latter crop growth period is due to higher temperature, low relative humidity, higher sunshine hours and greater wind speed.

Relation between crop evapotranspiration (ET_c) inside and outside the shade net :

Regression analysis between weekly crop evapotranspiration (ET_c) inside and outside the shade net house during the experiment is depicted in Fig. 4.

The relationship between the weekly crop evapotranspiration inside and outside the shade net house was found to be :

$$ET_{c\ out} = 2.473\ ET_{c\ in} - 3.313 \qquad (1)$$

where,

$ET_{c\ out}$ = Crop evapotranspiration outside the shade net house, (mm)

$ET_{c\ in}$ = Crop evapotranspiration inside the shade net house, (mm).

The co-efficient of determination (R^2) between crop evapotranspiration (ET_c) inside and outside the shade net house was found to be 0.840 during the growth period. However the correlation between ET_c inside and outside the shade net house (r = 0.917) at the end of stress interval was highly significant.

Results show that the crop evapotranspiration inside the shade net house ($ET_{c\ in}$) values were lower than crop evapotranspiration outside the shade net house ($ET_{c\ out}$). During the initial stage of crop, $ET_{c\ in}$ is greater than the

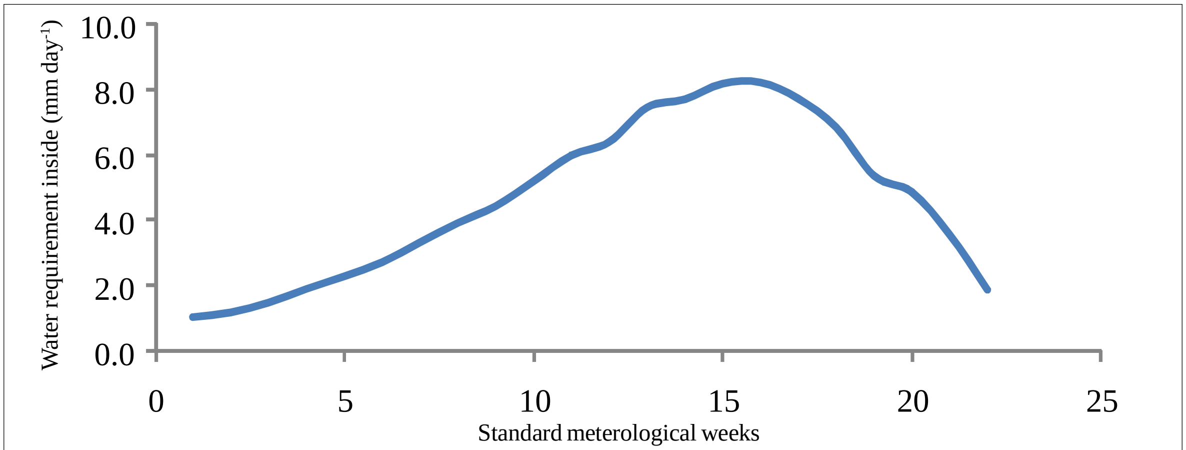

Fig. 3 : Variation in daily values of reference evapotranspiration (mm day^{-1})

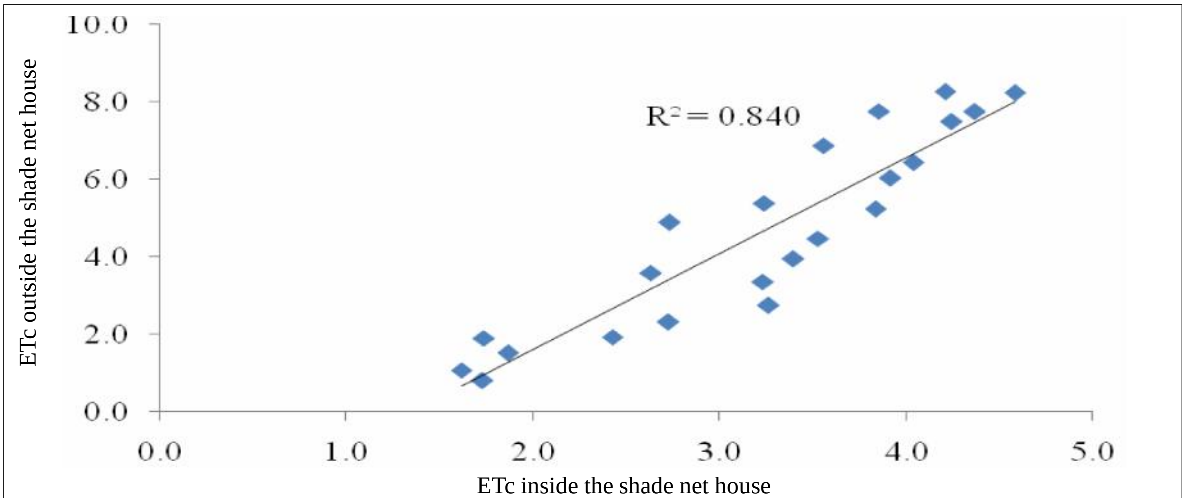

Fig. 4 : Relation of weekly crop evapotranspiration outside and inside the shade net house

$ET_{c\ out}$. At middle and late stages, $ET_{c\ out}$ was gradually increased. On an average, the $ET_{c\ in}$ was about 70 per cent of the $ET_{c\ out}$. It is clear that crop water requirement in the greenhouse was less than crop water requirement outside the greenhouse.

Conclusion :

Based on the results obtained from the present investigation, it has been concluded that the crop water requirement inside the shade net house of drip irrigated tomato crop was recorded 495.00 mm. Total reference evapotranspiration outside the shade net house was found 803.50 mm. It was observed that, the maximum reference evapotranspiration over the crop growth period is 7.62 mm day^{-1} while the minimum value is 2.52 mm day^{-1}. Total crop evapotranspiration (ET_c) outside the shade net house was recorded 717.0 mm during the crop period. Hence, the results revealed that, the crop evapotranspiration inside the shade net house ($ET_{c\ in}$) is lesser and above 70 per cent of the crop evapotranspiration computed with the climatic parameters observed in the open environment ($ET_{c\ out}$), which can be used for other estimation of crop evapotranspiration (ET_c) inside the shade net house using climatological parameters.

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998). Crop evapotranspiration–guidelines for computing crop water requirements. Irrigation and Drainage Paper 56, Food and Agriculture Organization of United Nations, Rome.

Dunage, V., Balakrishnan, P. and Patil, M. (2010). Water use efficiency and economics of tomato using drip irrigation under netthouse conditions. *Karnataka J. Agric. Sci.,* **22**(1) : 133-136.

Kirda, C. (2002). Deficit irrigation scheduling based on plant growth stages showing water stress tolerance, *Deficit Irriga. Practices, FAO Water Reports,* **22** : 3–10.

Kirda, C., Cetin, M., Dasgan, Y., Topcu, S., Kaman, H., Ekici, B., Derici, M.R. and Ozguven, A.I. (2004). Yield response of greenhouse grown tomato to partial root drying and conventional deficit irrigation. *Agric. Water Manage.,* **69** (1) : 191-201.

Harmanto, Salokhe V., Babel, M. and Tantau, H. (2005). Water requirement of drip irrigated tomatoes grown in greenhouse in tropical environment. *Agric. Water Mgmt.,* **71**(3): 225-242.

Mantur, S.M. and Patil, Sateesh R. (2008). Influence of spacing and pruning on yield of tomato grown under shade house. *Karnataka J. Agric. Sci.,* **21**(1): 97-98.

Nagaz, Kamel, Masmoudi, Mohamed Moncef and Mechlia, Netij Ben (2012). Effects of deficit drip-irrigation scheduling regimes with saline water on pepper yield, water productivity and soil salinity under arid conditions of Tunisia. *J. Agric. & Environ. for Internat. Develop. – JAEID,* **106**(2) : 85-103.

Patanè, C. and Cosentino, S. (2010). Effects of soil water deficit on yield and quality of processing tomato under a Mediterranean climate. *Agric. Water Mgmt.,* **97**(1): 131-138.

Smith, M. (1992). CROPWAT: a computer program for irrigation planning and management. FAO Irrigation and Drainage Paper 46. UN-FAO, Rome, Italy.

Tiwari, G.N. (2003). Greenhouse technology for controlled environment. Narosa Publishing House, New Delhi, 67–77pp.

Tiwari, K.N., Singh, A. and Mal, P.K. (2000). Economic feasibility of raising seedlings and vegetables production under low cost plastic tunnel. International Committees of Plastics in Agriculture (CIPA), Paris, plasticulture on-line publication.

MEMBERS OF RESEARCH FORUM

AUTHOR FOR CORRESPONDENCE :

Priyanka Sharma,
Department of Soil and Water Engineering,
College of Technology and Engineering,
Maharana Pratap University of Agriculture and Technology,
UDAIPUR (RAJASTHAN) INDIA
Email: priyankasharma1538@gmail.com

CO-OPTED AUTHORS :

Mahesh Kothari and S.S. Lakhawat,
Department of Soil and Water Engineering,
College of Technology and Engineering,
Maharana Pratap University of Agriculture and Technology,
UDAIPUR (RAJASTHAN) INDIA